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

Brunswick Steam Electric Plant, Unit Nos. 1 and 2
Renewed Facility Operating License Nos. DPR-71 and DPR-62
Docket Nos. 50-325 and 50-324

Catawba Nuclear Station, Unit Nos. 1 and 2
Renewed Facility Operating License Nos. NPF-35 and NPF-52
Docket Nos. 50-413 and 50-414

H. B. Robinson Steam Electric Plant, Unit 2
Renewed Facility Operating License No. DPR-23
Docket No. 50-261

McGuire Nuclear Station, Unit Nos. 1 and 2
Renewed Facility Operating License Nos. NPF-9 and NPF-17
Docket Nos. 50-369 and 50-370

Oconee Nuclear Station, Unit Nos. 1, 2 and 3
Renewed Facility Operating License Nos. DPR-38, DPR-47 and DPR-55
Docket Nos. 50-269, 50-270 and 50-287

Shearon Harris Nuclear Power Plant, Unit 1
Renewed Facility Operating License No. NPF-63
Docket No. 50-400

SUBJECT: Annual Radioactive Effluent Release Report - 2019

Ladies and Gentlemen:

Duke Energy Carolinas, LLC and Duke Energy Progress, LLC (collectively referred to as Duke Energy), in accordance with 10 CFR 50.36a and Technical Specification (TS) 5.6.3 for the Brunswick Steam Electric Plant (BNP) Units 1 and 2, TS 5.6.3 and Selected Licensing Commitment (SLC) 16.11-16 for the Catawba Nuclear Station Units 1 and 2 (CNS), TS 5.6.3 for the H. B. Robinson Steam Electric Plant Unit 2 (RNP), TS 5.6.3 and SLC 16.11.17 for the McGuire Nuclear Station Units 1 and 2 (MNS), TS 5.6.3 and SLC 16.11.9 for the Oconee Nuclear Station Units 1, 2, and 3 (ONS), and TS 6.9.1.4 for the Shearon Harris Nuclear Power Plant Unit 1 (HNP), is submitting the Annual Radioactive Effluent Release Reports (ARERR) for the period from January 1, 2019, through December 31, 2019. The ARERRs are provided in Enclosures 1 through 6.

BNP TS 5.5.1, "Offsite Dose Calculation Manual (ODCM)," requires changes to the ODCM be submitted as part of, or concurrent with, the Radioactive Effluent Release Report. The ODCM was not revised during this report period.

CNS TS 5.5.1, "Offsite Dose Calculation Manual (ODCM)," requires changes to the ODCM be submitted as part of, or concurrent with, the Radioactive Effluent Release Report. ODCM Revision 63 was implemented in 2019 and included with this submittal.

HNP TS 6.14, "Offsite Dose Calculation Manual (ODCM)," requires changes to the ODCM be submitted as part of, or concurrent with, the Radioactive Effluent Release Report. ODCM Revision 28 was implemented in 2019 and included with this submittal.

MNS TS 5.5.1, "Offsite Dose Calculation Manual (ODCM)," requires changes to the ODCM be submitted as part of, or concurrent with, the Radioactive Effluent Release Report. The ODCM was not revised during this report period.

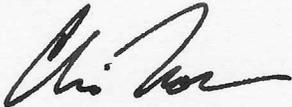
ONS TS 5.5.1, "Offsite Dose Calculation Manual (ODCM)," requires changes to the ODCM be submitted as part of, or concurrent with, the Radioactive Effluent Release Report. The ODCM was not revised during this report period.

RNP TS 5.5.1, "Offsite Dose Calculation Manual (ODCM)," requires changes to the ODCM be submitted as part of, or concurrent with, the Radioactive Effluent Release Report. The ODCM was not revised during this report period.

No regulatory commitments are contained in this submittal.

Please refer any questions concerning this letter and its enclosures to Mr. Art Zaremba, Manager - Nuclear Fleet Licensing, at (980) 373-2062.

Sincerely,



M. Christopher Nolan
Vice President, Nuclear Regulatory Affairs, Policy & Emergency Preparedness

Enclosures:

1. [BNP Annual Radioactive Effluent Release Report - 2019](#)
2. [CNS Annual Radioactive Effluent Release Report - 2019](#)
3. [HNP Annual Radioactive Effluent Release Report - 2019](#)
4. [MNS Annual Radioactive Effluent Release Report - 2019](#)
5. [ONS Annual Radioactive Effluent Release Report - 2019](#)
6. [RNP Annual Radioactive Effluent Release Report - 2019](#)

cc: (all Enclosures unless specified)

L. Dudes, USNRC, Region II Regional Administrator
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M. Mahoney, USNRC NRR Project Manager for CNS, MNS, and ONS
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Enclosure 1

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Enclosure 6

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Enclosure 1, 3, and 5

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Enclosure 1
RA-20-0078

ENCLOSURE 1: [BNP Annual Radioactive Effluent Release Report](#)



Brunswick Steam Electric Plant Units 1 and 2

Annual Radioactive Effluent Release Report

January 1, 2019 through December 31, 2019

Dockets 50-325 and 50-324



Introduction

The Annual Radioactive Effluent Release Report is pursuant to Brunswick Steam Electric Plant Technical Specification 5.6.3 and ODCM Specification 7.4.2. The below listed attachments to this report provide the required information. In addition, if a revision to the ODCM has occurred during the report period, it is included pursuant to Brunswick Steam Electric Plant Technical Specification 5.5.1.

- | | |
|---------------|----------------------------------------------------------------------------------|
| Attachment 1 | Summary of Gaseous and Liquid Effluents |
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| Attachment 3 | Solid Radioactive Waste Disposal |
| Attachment 4 | Meteorological Data |
| Attachment 5 | Unplanned Offsite Releases |
| Attachment 6 | Assessment of Radiation Dose from Radioactive Effluents to Members of the Public |
| Attachment 7 | Information to Support the NEI Ground Water Protection Initiative |
| Attachment 8 | Inoperable Equipment |
| Attachment 9 | Summary of Changes to the Offsite Dose Calculation Manual |
| Attachment 10 | Summary of Changes to the Process Control Program |
| Attachment 11 | Summary of Major Modifications to the Radioactive Waste Treatment Systems |
| Attachment 12 | Errata to a Previous Year's ARERR |

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 1

Summary of Gaseous and Liquid Effluents

This attachment includes a summary of the quantities of radioactive liquid and gaseous effluents as outlined in Regulatory Guide 1.21, Appendix B.

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
1. Total Release	Ci	1.17E+02	7.63E+01	1.53E+02	9.60E+01	4.42E+02
2. Avg. Release Rate	μCi/sec	1.50E+01	9.71E+00	1.93E+01	1.21E+01	1.40E+01
B. Iodine-131						
1. Total Release	Ci	4.29E-03	1.28E-03	2.56E-03	3.48E-03	1.16E-02
2. Avg. Release Rate	μCi/sec	5.52E-04	1.63E-04	3.21E-04	4.38E-04	3.69E-04
C. Particulates Half-Life ≥ 8 days						
1. Total Release	Ci	1.74E-03	2.57E-04	2.14E-04	2.70E-04	2.48E-03
2. Avg. Release Rate	μCi/sec	2.24E-04	3.27E-05	2.69E-05	3.40E-05	7.94E-05
D. Tritium						
1. Total Release	Ci	6.74E+01	2.13E+01	3.43E+01	3.99E+01	1.63E+02
2. Avg. Release Rate	μCi/sec	8.67E+00	2.71E+00	4.31E+00	5.02E+00	5.18E+00
E. Carbon-14						
1. Total Release	Ci	4.62E+00	4.77E+00	5.76E+00	5.99E+00	2.11E+01
2. Avg. Release Rate	μCi/sec	5.94E-01	6.07E-01	7.25E-01	7.54E-01	6.70E-01
F. Gross Alpha						
1. Total Release	Ci	1.17E-08	0.00E+00	0.00E+00	0.00E+00	1.17E-08

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Elevated Releases - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
Ar-41	Ci	0.00E+00	6.46E+00	3.72E+00	2.92E+00	1.31E+01
Kr-85m	Ci	4.67E+00	7.14E+00	5.30E+00	8.36E+00	2.55E+01
Kr-85	Ci	0.00E+00	0.00E+00	1.05E+01	3.82E+00	1.43E+01
Kr-87	Ci	0.00E+00	1.61E+00	3.16E+00	1.71E+00	6.48E+00
Kr-88	Ci	0.00E+00	2.10E+00	0.00E+00	1.27E+00	3.37E+00
Xe-133	Ci	1.64E+01	1.48E+01	3.19E+01	1.84E+01	8.15E+01
Xe-135m	Ci	1.73E+01	7.74E+00	2.64E+01	1.83E+01	6.97E+01
Xe-135	Ci	1.67E+01	5.08E+00	9.19E+00	1.07E+01	4.17E+01
Xe-138	Ci	3.57E+01	2.96E+01	6.03E+01	2.81E+01	1.54E+02
Total for Period	Ci	9.08E+01	7.46E+01	1.50E+02	9.37E+01	4.09E+02
B. Iodines						
I-131	Ci	1.51E-03	1.23E-03	1.65E-03	1.65E-03	6.04E-03
I-133	Ci	8.09E-03	7.39E-03	7.38E-03	8.50E-03	3.14E-02
I-135	Ci	9.04E-03	9.26E-03	8.09E-03	9.66E-03	3.61E-02
Total for Period	Ci	1.86E-02	1.79E-02	1.71E-02	1.98E-02	7.34E-02
C. Particulates Half-Life ≥ 8 days						
Cr-51	Ci	4.50E-06	1.09E-06	0.00E+00	0.00E+00	5.59E-06
Mn-54	Ci	0.00E+00	1.21E-06	0.00E+00	0.00E+00	1.21E-06
Co-57	Ci	9.28E-07	8.30E-07	0.00E+00	0.00E+00	1.76E-06
Co-60	Ci	1.01E-05	3.51E-05	2.54E-06	0.00E+00	4.77E-05
Sr-89	Ci	3.83E-04	6.73E-06	2.87E-05	2.47E-05	4.43E-04
Cs-137	Ci	0.00E+00	0.00E+00	1.32E-05	0.00E+00	1.32E-05
Ba-140	Ci	6.07E-05	8.42E-06	2.25E-05	2.83E-05	1.20E-04
La-140	Ci	9.75E-05	1.15E-05	5.25E-05	7.31E-05	2.35E-04
Total for Period	Ci	5.57E-04	6.48E-05	1.19E-04	1.26E-04	8.67E-04
D. Tritium						
H-3	Ci	8.41E+00	9.08E+00	1.41E+01	1.33E+01	4.49E+01
E. Carbon-14						
C-14	Ci	1.85E+00	1.91E+00	2.30E+00	2.40E+00	8.46E+00
F. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Elevated Releases - Batch Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life \geq 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Brunswick Steam Electric Plant Units 1 and 2 do not have batch elevated releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground Releases - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
Kr-85m	Ci	2.76E-01	0.00E+00	0.00E+00	9.58E-06	2.76E-01
Kr-87	Ci	1.41E+00	0.00E+00	0.00E+00	1.43E-05	1.41E+00
Kr-88	Ci	0.00E+00	0.00E+00	0.00E+00	2.03E-05	2.03E-05
Xe-133	Ci	0.00E+00	0.00E+00	0.00E+00	1.04E-05	1.04E-05
Xe-135	Ci	2.42E+01	1.71E+00	2.72E+00	2.34E+00	3.10E+01
Total for Period	Ci	2.59E+01	1.71E+00	2.72E+00	2.34E+00	3.27E+01
B. Iodines						
I-131	Ci	2.30E-03	2.47E-06	2.14E-06	1.50E-06	2.31E-03
I-133	Ci	1.86E-02	0.00E+00	0.00E+00	1.71E-07	1.86E-02
I-135	Ci	2.82E-02	0.00E+00	0.00E+00	0.00E+00	2.82E-02
Total for Period	Ci	4.91E-02	2.47E-06	2.14E-06	1.67E-06	4.91E-02
C. Particulates Half-Life ≥ 8 days						
Mn-54	Ci	0.00E+00	4.79E-08	0.00E+00	0.00E+00	4.79E-08
Co-60	Ci	5.44E-06	3.62E-07	0.00E+00	0.00E+00	5.80E-06
Sr-89	Ci	9.79E-05	3.10E-07	0.00E+00	0.00E+00	9.82E-05
Ba-140	Ci	1.35E-04	0.00E+00	0.00E+00	0.00E+00	1.35E-04
La-140	Ci	2.28E-04	0.00E+00	0.00E+00	0.00E+00	2.28E-04
Ce-141	Ci	1.52E-07	0.00E+00	0.00E+00	0.00E+00	1.52E-07
Total for Period	Ci	4.67E-04	7.20E-07	0.00E+00	0.00E+00	4.68E-04
D. Tritium						
H-3	Ci	4.23E+01	7.17E+00	1.11E+01	1.26E+01	7.32E+01
E. Carbon-14						
C-14	Ci	9.23E-01	9.54E-01	1.15E+00	1.20E+00	4.23E+00
F. Gross Alpha						
Total for Period	Ci	1.17E-08	0.00E+00	0.00E+00	0.00E+00	1.17E-08

**Attachment 1
Summary of Gaseous and Liquid Effluents**

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground Releases - Batch Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life \geq 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Brunswick Steam Electric Plant Units 1 and 2 do not have batch ground releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Mixed-Mode Releases - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Iodines						
I-131	Ci	4.85E-04	5.05E-05	9.00E-04	1.83E-03	3.27E-03
I-133	Ci	3.72E-03	4.62E-04	9.25E-03	1.78E-02	3.12E-02
I-135	Ci	5.77E-03	8.08E-04	1.88E-02	3.04E-02	5.58E-02
Total for Period	Ci	9.98E-03	1.32E-03	2.89E-02	5.01E-02	9.03E-02
C. Particulates Half-Life ≥ 8 days						
Cr-51	Ci	1.46E-04	5.04E-05	0.00E+00	0.00E+00	1.96E-04
Mn-54	Ci	2.92E-05	1.36E-05	4.52E-06	2.01E-06	4.93E-05
Fe-59	Ci	2.83E-06	0.00E+00	0.00E+00	0.00E+00	2.83E-06
Co-58	Ci	3.32E-05	1.14E-05	2.73E-06	4.17E-06	5.15E-05
Co-60	Ci	5.03E-04	1.16E-04	6.69E-05	5.68E-05	7.43E-04
Ba-140	Ci	5.92E-06	0.00E+00	0.00E+00	2.18E-05	2.77E-05
La-140	Ci	0.00E+00	0.00E+00	2.06E-05	5.93E-05	7.99E-05
Total for Period	Ci	7.19E-04	1.92E-04	9.48E-05	1.44E-04	1.15E-03
D. Tritium						
H-3	Ci	1.67E+01	5.05E+00	9.05E+00	1.40E+01	4.48E+01
E. Carbon-14						
C-14	Ci	1.85E+00	1.91E+00	2.30E+00	2.40E+00	8.46E+00
F. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Mixed-Mode Releases - Batch Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life \geq 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Brunswick Steam Electric Plant Units 1 and 2 do not have batch mixed-mode releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Liquid Effluents - Summation of All Releases - Discharge Canal

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products *						
1. Total Release	Ci	4.98E-04	4.19E-04	8.22E-04	5.33E-04	2.27E-03
2. Avg. Diluted Conc.	µCi/ml	1.33E-12	9.11E-13	1.57E-12	1.14E-12	1.24E-12
B. Tritium						
1. Total Release	Ci	1.78E+01	2.90E+01	3.37E+01	1.85E+01	9.90E+01
2. Avg. Diluted Conc.	µCi/ml	4.73E-08	6.32E-08	6.42E-08	3.93E-08	5.35E-08
C. Dissolved & Entrained Gases						
1. Total Release	Ci	1.04E-04	2.95E-03	3.62E-03	7.27E-04	7.40E-03
2. Avg. Diluted Conc.	µCi/ml	2.77E-13	6.41E-12	6.90E-12	1.55E-12	3.78E-12
D. Gross Alpha						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E. Volume of Liquid Waste						
1. Batch Releases	liters	2.84E+06	3.17E+06	3.69E+06	2.07E+06	1.18E+07
2. Continuous Releases	liters	6.94E+07	6.62E+07	1.20E+08	7.56E+07	3.31E+08
F. Volume of Dilution Water						
1. All Releases	liters	3.75E+11	4.59E+11	5.25E+11	4.70E+11	1.83E+12

* Excludes tritium, dissolved and entrained noble gases, and gross alpha.

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Summation of All Releases - Marsh Area

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products *						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Diluted Conc.	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Tritium						
1. Total Release	Ci	7.06E-03	5.38E-03	0.00E+00	0.00E+00	1.24E-02
2. Avg. Diluted Conc.	µCi/ml	1.41E-07	1.06E-07	0.00E+00	0.00E+00	6.18E-08
C. Dissolved & Entrained Gases						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Diluted Conc.	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Diluted Conc.	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E. Volume of Liquid Waste						
1. Batch Releases	liters	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Continuous Releases	liters	5.02E+07	5.07E+07	5.13E+07	5.13E+07	2.04E+08
F. Volume of Dilution Water						
1. All Releases	liters	5.02E+07	5.07E+07	5.13E+07	5.13E+07	2.04E+08

* Excludes tritium, dissolved and entrained noble gases, and gross alpha.

**Attachment 1
Summary of Gaseous and Liquid Effluents**

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Continuous Mode - Discharge Canal

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Tritium						
H-3	Ci	1.38E-03	0.00E+00	0.00E+00	0.00E+00	1.38E-03
C. Dissolved & Entrained Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Liquid Effluents - Continuous Mode - Marsh Area

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Tritium						
H-3	Ci	7.06E-03	5.38E-03	0.00E+00	0.00E+00	1.24E-02
C. Dissolved & Entrained Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Liquid Effluents - Batch Mode - Discharge Canal

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
Mn-54	Ci	0.00E+00	1.64E-06	0.00E+00	0.00E+00	1.64E-06
Co-60	Ci	8.81E-05	4.40E-05	1.21E-05	9.71E-06	1.54E-04
Sb-124	Ci	0.00E+00	4.41E-06	2.65E-05	0.00E+00	3.09E-05
Sb-125	Ci	0.00E+00	2.98E-06	2.71E-05	0.00E+00	3.01E-05
I-131	Ci	2.18E-04	1.56E-04	3.04E-04	2.61E-04	9.39E-04
I-133	Ci	1.88E-04	2.09E-04	4.45E-04	2.62E-04	1.10E-03
I-135	Ci	6.75E-07	0.00E+00	6.18E-06	0.00E+00	6.86E-06
Cs-137	Ci	2.72E-06	5.38E-07	9.67E-07	7.00E-07	4.93E-06
Total for Period	Ci	4.98E-04	4.19E-04	8.22E-04	5.33E-04	2.27E-03
B. Tritium						
H-3	Ci	1.78E+01	2.90E+01	3.37E+01	1.85E+01	9.90E+01
C. Dissolved & Entrained Gases						
Kr-85	Ci	2.34E-05	4.62E-04	2.60E-04	1.94E-04	9.39E-04
Xe-133m		0.00E+00	0.00E+00	1.05E-05	0.00E+00	1.05E-05
Xe-133	Ci	1.51E-05	4.47E-04	5.94E-04	1.18E-04	1.17E-03
Xe-135m	Ci	0.00E+00	0.00E+00	6.94E-06	0.00E+00	6.94E-06
Xe-135	Ci	6.56E-05	2.04E-03	2.75E-03	4.16E-04	6.84E-02
Total for Period	Ci	1.04E-04	2.95E-03	3.62E-03	7.27E-04	7.40E-03
D. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Attachment 1
Summary of Gaseous and Liquid Effluents**

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Batch Mode - Marsh Area

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Dissolved & Entrained Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Attachment 2
Supplemental Information**

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 2

Supplemental Information

This attachment includes supplemental information to the gaseous and liquid effluents report.

Attachment 2 Supplemental Information

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

I. Regulatory Limits - Per Unit

A. Noble Gases - Air Dose

1. Calendar Quarter Gamma Dose	= 5	mRAD
2. Calendar Quarter Beta Dose	= 10	mRAD
3. Calendar Year Gamma Dose	= 10	mRAD
4. Calendar Year Beta Dose	= 20	mRAD

B. Liquid Effluents - Dose

1. Calendar Quarter Total Body Dose	= 1.5	mREM
2. Calendar Quarter Organ Dose	= 5	mREM
3. Calendar Year Total Body Dose	= 3	mREM
4. Calendar Year Organ Dose	= 10	mREM

C. Gaseous Effluents - Iodine-131 & 133, Tritium, and Particulates with Half-lives > 8 days

1. Calendar Quarter Organ Dose	= 7.5	mREM
2. Calendar Year Organ Dose	= 15	mREM

II. Maximum Permissible Effluent Concentrations

A. Gaseous Effluents

- Information found in Offsite Dose Calculation Manual

B. Liquid Effluents

- Information found in 10 CFR Part 20, Appendix B, Table 2, Column 2

III. Average Energy

(not applicable)

IV. Measurements and Approximations of Total Radioactivity

Analyses of specific radionuclides in selected or composited samples as described in the ODCM are used to determine the radionuclide composition of the effluent. A summary description of the method used for estimating overall errors associated with radioactivity measurements is provided as part of this attachment.

V. Batch Releases

A. Liquid Effluents

		Jan - Jun	Jul - Dec
1. Total Number of Batch Releases	=	102	96
2. Total Time (min) for Batch Releases	=	1.95E+05	2.37E+05
3. Maximum Time (min) for a Batch Release	=	6.23E+04	7.24E+04
4. Average Time (min) for Batch Releases	=	1.92E+03	2.47E+03
5. Minimum Time (min) for a Batch Release	=	1.30E+01	1.20E+01
6. Average Dilution Water Flow During Release (gpm)	=	7.26E+05	8.18E+05

B. Gaseous Effluents

		Jan - Jun	Jul - Dec
1. Total Number of Batch Releases	=	N/A	N/A
2. Total Time (min) for Batch Releases	=	N/A	N/A
3. Maximum Time (min) for a Batch Release	=	N/A	N/A
4. Average Time (min) for Batch Releases	=	N/A	N/A
5. Minimum Time (min) for a Batch Release	=	N/A	N/A

VI. Abnormal Releases

See Attachment 5, Unplanned Offsite Releases.

Attachment 2 Supplemental Information

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Carbon-14

In Regulatory Guide 1.21, Revision 2, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste", the NRC recommends U.S. nuclear power plants evaluate whether C-14 is a "principal radionuclide" in gaseous effluents, and if so, report the amount of C-14 released. Improvements over the years in effluent management practices and fuel performance have resulted in a decrease in gaseous radionuclide (non-C-14) concentrations, and a change in the distribution of gaseous radionuclides released to the environment. As a result, many sites show C-14 has become a "principal radionuclide" for the gaseous effluent pathway, as defined in Regulatory Guide 1.21, Rev. 2. Although committed to Regulatory Guide 1.21, Rev. 1, the Brunswick Steam Electric Plant 2019 ARERR contains estimates of C-14 radioactivity released in 2019, and estimates of public dose resulting from the C-14 effluent.

Because the dose contribution of C-14 from liquid radioactive waste is much less than that contributed by gaseous radioactive waste, evaluation of C-14 in liquid radioactive waste is not required (Ref. Reg. Guide 1.21, Rev. 2). The quantity of gaseous C-14 released to the environment can be estimated by use of a C-14 source term scaling factor based on power generation (Ref. Reg. Guide 1.21, Rev. 2). The Brunswick Steam Electric Plant Updated Final Safety Analysis Report (UFSAR) states the C-14 release rate from a BWR is approximately 9.5 Ci/yr per unit assuming 80% plant capacity factor, or 292 Effective Full Power Days (EFPD). Since Brunswick Steam Electric Plant has two reactors, the total release rate would be 19.0 Ci/yr. Using actual EFPD for Unit 1 and Unit 2, the total C-14 release rate was 2.12E+01 Ci/yr.

Public dose estimates from airborne C-14 are performed using dose models in Regulatory Guide 1.109. The dose models and assumptions used are documented in the Brunswick Steam Electric Plant ODCM 3.3.3, Carbon-14. The estimated C-14 dose impact on the maximum organ dose from airborne effluents released from Brunswick Steam Electric Plant in 2019 is well below the 10CFR50, Appendix I, ALARA design objective (i.e., 15 mrem/yr per unit).

Based on the 2019 Land Use Census, the critical receptor is located in the south sector at 1.0 miles with a garden. There are no meat or milk pathways within 5 miles. Regulatory Guide 1.109 methodology was used to determine the dose to this critical receptor. The bone dose for 2019 was 4.08E+00 mrem and the total body dose was 8.15E-01 mrem.

	<u>Units</u>	<u>Year</u>
1. C-14 Activity Released	Ci	2.12E+01
2. C-14 Total Body Dose	mREM	8.15E-01
3. C-14 Organ Dose	mREM	4.08E+00

Receptor Location **1.0 miles S**

Critical Age **CHILD**

Critical Organ **BONE**

Attachment 2 Supplemental Information

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Discussion of liquid release from the BSEP Sewage Treatment Plant

In accordance with the Brunswick Steam Electric Plant (BSEP) National Pollutant Discharge Elimination System (NPDES) Permit Number NC0007064 the decant from the BSEP Sewage Treatment Plant is released to Outfall Number 004. Outfall Number 004 discharges to the discharge canal which is a designated release point. The BSEP sewage decant is monitored continuously with a composite sampler for gamma and tritium analysis. On December 11, 2013 the monthly effluent sample contained tritium, there was no detectable gamma activity. Condition Report (CR) 651320 was generated and daily sampling was initiated for effluent accountability. Inputs to the system were sampled and it was discovered that tritiated groundwater is leaking into the Number 6 lift station. The source of tritium is from pre-existing groundwater contamination in the general area surrounding the Number 6 lift station. Regulatory Affairs confirmed this was not reportable per NEI 07-07 groundwater reporting. The BSEP sewage treatment plant was decommissioned in January 2019 and no further releases from this point occurred. Approximately $7.20 \text{ E}+04$ gallons containing $1.39 \text{ E}-03$ curies of tritium was released in 2019 to the discharge canal.

Discussion of liquid releases from the Storm Drain Collector Basin (SDCB)

During periods of heavy rain, the contents of the SDCB may be released to the discharge canal in accordance with regulatory requirements to protect plant personnel and equipment. The SDCB was released directly to the discharge canal on 32 occasions in 2019 due to heavy rains. Approximately $4.83 \text{ E}+06$ gallons containing $8.94 \text{ E}-02$ curies of tritium were released. There was no detectable gamma radioactivity.

Discussion of liquid releases from the Storm Drain Stabilization Facility (SDSF)

The SDSF collects rainwater, water from miscellaneous low volume drains on plant site, water from the Groundwater Extraction System, and water from the Unit 1 CST Remediation Facility. Treatment consists of filtration and evaporation. When sufficient water has accumulated in the pond it is released into the intake canal where it is drawn into the plant circulating and service water system and eventually released into the discharge canal. There were 8 SDSF releases in 2019. Approximately $7.83 \text{ E}+07$ gallons containing $2.29 \text{ E}+00$ curies of tritium were released from the SDSF. There was no detectable gamma radioactivity.

Discussion of water evaporation from the Storm Drain Stabilization Pond (SDSP)

It was calculated that $8.00 \text{ E}+06$ cubic feet of tritiated water vapor was released via evaporation from the SDSP in 2019. This yields $7.94 \text{ E}-01$ curies of tritium released to the atmosphere as a ground release. The nearest resident to the pond is in the northwest sector at approximately 0.3 miles. The maximum exposed individuals at that location received a calculated dose of $2.43 \text{ E}-04$ mrem via the inhalation pathway in 2019. Only inhalation dose was determined because the exposed individuals do not have a garden and also do not have any milk or meat animals at this location.

Discussion of water evaporation from the Storm Drain Stabilization Facility (SDSF)

It was calculated that $6.36 \text{ E}+05$ cubic feet of tritiated water vapor was released via evaporation from the SDSF in 2019. This yields $1.42 \text{ E}-01$ curies of tritium released to the atmosphere as a ground release. The nearest resident to the pond is in the north northwest sector at approximately 0.5 miles. The maximum exposed individuals at that location received a calculated dose of $9.16 \text{ E}-05$ mrem via the inhalation pathway in 2019. Only inhalation dose was determined because the exposed individuals do not have a garden and also do not have any milk or meat animals at this location.

Attachment 2 Supplemental Information

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Discussion of liquid releases from the Marsh to Nancy's Creek

Samples are routinely analyzed from the marsh areas that drain into Nancy's Creek during falling tides. The marsh areas are all on company owned property. The marsh land is under the influence of high and low tides and releases to Nancy's Creek, which is offsite. This constitutes a release point for evaluation. The sampling program consists of monthly sampling and analysis at nine locations. All gamma analyses performed in 2019 were less than the Lower Limit of Detection (LLD). Some tritium analyses were greater than the LLD. The average tritium concentration each month, two high tides per day, the area of the marsh at high tide, the days in the month, and a conservative factor of 2 were used to calculate the amount of tritium released each month. In 2019, it was calculated that 5.38 E+07 gallons were released to Nancy's Creek containing 1.25 E-02 curies of tritium. This yielded a Total Body dose of 1.51 E-04 mrem to an adult from eating fish and invertebrate (shrimp, crabs, etc.).

Discussion of liquid releases from the Storm Drain Stabilization Pond (SDSP)

The SDSP collects rainwater as its only input source. Treatment from this location consists of sedimentation, evaporation, and transpiration. When sufficient water has accumulated in the pond, it is released into the intake canal where it is drawn into the circulating and service water system and eventually released into the discharge canal. There was 1 SDSP release in 2019. Approximately 4.36 E+06 gallons were released in 2019 containing 0.00E+00 curies of tritium. There was no detectable gamma radioactivity.

Attachment 2 Supplemental Information

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Overall Estimate of Error for Effluent Radioactivity Release Reported

The estimated percentage of overall error for Gaseous effluent release data at Brunswick Steam Electric Plant is listed below. These values were derived by taking the square root of the sum of the squares of the discrete individual estimates of error.

- | | | |
|---------------------------------|---|-------|
| 1. Fission and Activation Gases | = | ± 25% |
| 2. Particulates and Iodine | = | ± 25% |
| 3. Tritium | = | ± 15% |

The estimated percentage of overall error for Liquid effluent release data at Brunswick Steam Electric Plant is listed below. These values were derived by taking the square root of the sum of the squares of the discrete individual estimates of error.

- | | | |
|-------------------------------------------------------------------------------|---|-------|
| 1. Fission and Activation Products and
Dissolved and Entrained Noble Gases | = | ± 17% |
| 2. Tritium | = | ± 23% |
| 3. Gross Alpha | = | ± 32% |

Overall Estimate of Error for Solid Waste Radioactivity Reported

The estimated percentage of overall error for Solid Waste data at Brunswick Steam Electric Plant has been determined to be ± 10%.

Attachment 2
Supplemental Information

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Summary of Changes in Land Use Census Affecting Effluent Dose Calculations

The 2019 Land Use Census was performed June 10 & 17, 2019. The results were certified and made available for use on June 20, 2019. The following are changes to residences, gardens, and milk animals from the previous year.

Residences

The resident in the NW sector at 0.9 miles was replaced by a resident at 0.8 miles.

Gardens

The garden in the S sector at 1.7 miles was replaced by a garden at 1.9 miles.
The garden in the SSW sector at 1.9 miles was replaced by a garden at 1.7 miles.
The garden in the SW sector at 2.8 miles was replaced by a garden at 1.1 miles.
The garden in the WSW sector at 1.2 miles was replaced by a garden at 1.3 miles.
The garden in the W sector at 1.2 miles was replaced by a garden at 1.3 miles.

Milk Animals

No milk animal was present within 5 miles in each sector.

Environmental Monitoring Locations

No changes to environmental monitoring locations in each sector.

Attachment 3
Solid Radioactive Waste Disposal

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 3

Solid Radioactive Waste Disposal

This attachment includes a summary of the solid waste shipped off-site for burial and/or disposal, including:

- Container volume
- Total Curie content
- Principal Radionuclides
- Source/Type of waste
- Solidification agent or absorbent
- Type of shipping container
- Number of shipments
- Other relevant information as necessary

Attachment 3 Solid Radioactive Waste Disposal

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Type of Waste Shipped	Number of Shipments	Number of Containers	Waste Class	Container Type	Solidification Agent	Burial Volume (m ³)	Total Activity (Curies)
1. <u>Waste from Liquid Systems</u>							
a. Spent Resins, Filters, Sludges (dewatered)	9	9	A	Type A GDP	N/A	34.2	67.1
b. Spent Resins, Filters, Sludges (dewatered)	5	5	B	Type B	N/A	10.2	429
c. Solidified (cement) Acids, Oily Water	0	-	-	-	-	-	-
2. <u>Dry Solid Waste</u>							
a. Dry Active Waste (compacted & non-compacted)	32	47	A	Type A GDP	N/A	1320	2.45
b. Irradiated Components	2	2	C	Type B	N/A	3.17	15700
c. Other Waste (oil/sludge)	0	-	-	-	-	-	-
3. <u>Total Solid Waste</u>	48	63	-	-	-	1367.57	16198.55

NOTE: Total Activity determined by estimate. Solid Waste listed above shipped for processing to various waste processing services or directly shipped to licensed disposal facility.

**Attachment 3
Solid Radioactive Waste Disposal**

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Type of Waste Shipped	Radionuclide	% Abundance
1. <u>Waste from Liquid Systems</u>		
a. Spent Resins, Filters, Sludges (dewatered)	Fe-55	17.43
	Mn-54	5.04
	Co-58	1.58
	Co-60	59.7
	Ni-63	5.74
	Zn-65	4.05
	Cs-137	2.09
	Cs-134	1.19
b. Solidified (cement) Acids, Oily Water	N/A	N/A
2. <u>Dry Solid Waste</u>		
a. Dry Active Waste (compacted & non- compacted)	Fe-55	52.37
	Mn-54	6.12
	Co-60	37.42
	Ni-63	2.07
b. Irradiated Components	Fe-55	65.68
	Co-60	21.94
	Ni-63	5.12
	Mn-54	2.57
	Ta-182	4.43
c. Other Waste	N/A	N/A

**Attachment 4
Meteorological Data**

Brunswick Nuclear Plant
Period 1/1/2019 - 12/31/2019

ATTACHMENT 4

Meteorological Data

This attachment includes a summary of meteorological joint frequency distributions of wind speed, wind direction, and atmospheric stability (hours of occurrence).

Attachment 4 Meteorological Data

Brunswick Nuclear Plant
Period 1/1/2019 - 12/31/2019

The 2019 BNP meteorological tower data recovery did not meet the 90% requirement of NRC Regulatory Guide 1.23 "Onsite Meteorological Programs", Revision 0. Various equipment issues throughout 2019 impacted individual parameter data recovery and overall data recovery.

In October 2019, the meteorological tower was replaced with a new tower and equipment. Due to installation and acceptance testing issues, the new tower was not declared functional until February 2020. Annual joint frequency distributions (JFD) for both the lower-level and upper-level wind speed and wind direction per stability class from the original tower are being provided in this attachment.

Reference NCRs 02287056, 02296881, 02300439, and 02306384.

Attachment 4 Meteorological Data

Brunswick Nuclear Plant
Period 1/1/2019 - 12/31/2019

Lower Level

Stability Class	Wind Speed (mph)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
A	0.75-3.50	0	1	0	0	0	0	1	0	0	3	6	2	0	0	0	1
	3.51-7.50	1	1	2	1	4	6	5	1	1	2	3	6	2	1	1	1
	7.51-12.50	1	0	1	6	3	2	3	3	3	13	31	11	1	1	0	1
	12.51-18.50	0	0	0	2	0	0	0	0	0	9	18	3	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	0.75-3.50	0	1	0	1	0	0	2	0	1	0	0	1	1	1	0	0
	3.51-7.50	6	0	1	2	4	3	5	1	1	5	6	7	3	3	2	2
	7.51-12.50	0	0	3	2	2	3	0	1	4	22	27	10	1	0	2	0
	12.51-18.50	0	0	0	0	0	0	0	0	1	3	17	7	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C	0.75-3.50	1	0	4	3	0	0	0	0	2	0	3	1	1	3	0	0
	3.51-7.50	7	5	4	2	10	3	4	5	5	6	12	6	1	3	4	9
	7.51-12.50	10	2	6	8	3	2	3	0	2	10	26	12	0	0	3	2
	12.51-18.50	3	0	0	1	0	0	0	0	1	5	11	1	0	0	0	1
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D	0.75-3.50	18	22	17	15	4	6	4	4	1	4	11	7	7	8	7	19
	3.51-7.50	42	60	68	100	32	18	11	24	30	21	99	68	14	10	26	48
	7.51-12.50	20	48	21	36	18	4	10	10	24	44	118	41	3	4	3	19
	12.51-18.50	1	4	0	1	1	0	0	0	4	12	25	1	0	0	2	1
	18.51-25.00	0	0	0	0	0	0	0	0	2	1	1	1	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Attachment 4 Meteorological Data

Brunswick Nuclear Plant
Period 1/1/2019 - 12/31/2019

Lower Level

Stability Class	Wind Speed (mph)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
E	0.75-3.50	21	18	18	20	11	17	19	11	11	8	18	30	27	19	25	29
	3.51-7.50	31	35	5	30	32	23	11	13	35	27	96	62	12	9	18	42
	7.51-12.50	4	3	5	6	4	6	7	5	19	28	50	13	1	1	3	3
	12.51-18.50	0	0	0	0	0	0	1	0	9	10	5	1	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	5	3	0	0	0	1	2	0
F	0.75-3.50	28	20	11	10	12	6	7	7	12	3	15	25	18	19	14	40
	3.51-7.50	6	2	0	0	3	0	1	2	7	3	7	5	1	3	5	6
	7.51-12.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12.51-18.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	0.75-3.50	43	6	5	3	4	1	2	3	4	2	11	6	16	22	41	61
	3.51-7.50	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0
	7.51-12.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12.51-18.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Attachment 4 Meteorological Data

Brunswick Nuclear Plant
Period 1/1/2019 - 12/31/2019

Upper Level

Stability Class	Wind Speed (mph)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
A	0.75-3.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3.51-7.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7.51-12.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12.51-18.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	0.75-3.50	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	3.51-7.50	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0
	7.51-12.50	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	2
	12.51-18.50	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C	0.75-3.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3.51-7.50	0	1	2	4	0	0	0	0	2	0	0	4	1	0	2	0
	7.51-12.50	5	1	1	1	0	0	0	0	0	0	0	2	0	0	0	0
	12.51-18.50	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
	18.51-25.00	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D	0.75-3.50	3	0	4	0	1	1	0	0	0	1	1	4	0	1	2	1
	3.51-7.50	7	18	26	11	8	0	3	0	1	1	3	12	6	2	5	10
	7.51-12.50	11	12	32	35	5	1	0	0	0	0	5	20	5	1	2	2
	12.51-18.50	0	0	1	20	11	0	0	0	0	0	1	6	1	1	1	1
	18.51-25.00	0	0	0	0	3	0	0	0	0	0	2	5	1	1	0	0
	25+	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0

Attachment 4 Meteorological Data

Brunswick Nuclear Plant
Period 1/1/2019 - 12/31/2019

Upper Level

Stability Class	Wind Speed (mph)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
E	0.75-3.50	1	1	1	2	0	0	0	1	0	1	0	1	5	1	0	1
	3.51-7.50	4	3	3	9	3	4	4	1	4	1	4	13	15	5	4	4
	7.51-12.50	7	7	2	3	2	2	2	1	0	1	14	29	7	9	8	8
	12.51-18.50	0	0	0	1	8	0	0	1	0	0	4	7	2	1	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	1	1	7	0	2	1	1
	25+	0	0	0	0	0	0	0	0	1	3	2	1	0	0	0	1
F	0.75-3.50	2	1	0	1	0	1	1	0	0	0	1	0	2	0	0	1
	3.51-7.50	1	3	2	2	2	2	1	2	4	3	3	5	10	4	1	4
	7.51-12.50	2	1	1	1	0	0	0	2	2	3	4	3	5	8	4	2
	12.51-18.50	0	0	0	2	0	0	0	0	0	0	2	1	2	2	0	1
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	0.75-3.50	6	2	1	0	1	2	3	0	0	0	0	5	5	3	1	2
	3.51-7.50	11	6	3	0	1	3	7	14	8	1	5	9	2	4	3	6
	7.51-12.50	1	1	2	1	0	0	0	0	2	2	3	1	0	3	5	2
	12.51-18.50	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0
	18.51-25.00	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

**Attachment 5
Unplanned Offsite Releases**

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 5

Unplanned Offsite Releases

This attachment includes a summary of the unplanned offsite releases of gaseous and liquid radioactive effluents.

Attachment 5
Unplanned Offsite Releases

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Brunswick Steam Electric Plant did not experience any unplanned offsite gaseous or liquid effluent releases in 2019.

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 6

Assessment of Radiation Dose from Radioactive Effluents to Members of the Public
(includes fuel cycle dose calculation results)

This attachment includes an assessment of radiation doses to the maximum exposed member of the public due to radioactive liquid and gaseous effluents released from the site for each calendar quarter for the calendar year of the report as well as the total dose for the calendar year.

This attachment also includes an assessment of radiation doses to the maximum exposed member of the public from all uranium fuel cycle sources within 8 km of the site for the calendar year of this report to show conformance with 40 CFR Part 190.

Methods for calculating the dose contribution from liquid and gaseous effluents are given in the Offsite Dose Calculation Manual (ODCM).

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Noble Gases						
1. Maximum Beta Air	mRAD	1.45E-02	1.04E-03	1.72E-03	1.35E-03	1.86E-02
(a) Limit	mRAD	2.00E+01	2.00E+01	2.00E+01	2.00E+01	4.00E+01
(b) % of Limit		7.23E-02	5.19E-03	8.59E-03	6.73E-03	4.64E-02
2. Maximum Gamma Air	mRAD	1.23E-02	2.43E-03	4.03E-03	2.58E-03	2.14E-02
(a) Limit	mRAD	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(b) % of Limit		1.23E-01	2.43E-02	4.03E-02	2.58E-02	1.07E-01

Receptor Location **0.7 miles ENE**

B. Iodine, H-3, & Particulates						
1. Maximum Organ Dose	mREM	6.00E-02	9.56E-03	2.70E-02	4.29E-02	1.39E-01
(a) Limit	mREM	1.50E+01	1.50E+01	1.50E+01	1.50E+01	3.00E+01
(b) % of Limit		4.00E-01	6.37E-02	1.80E-01	2.86E-01	4.65E-01

Receptor Location **4.75 miles NE**

Critical Age **INFANT**

Critical Organ **THYROID**

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Liquid Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Batch & Continuous Mode						
1. Maximum Organ Dose	mREM	1.83E-05	1.64E-05	3.09E-05	1.40E-05	7.96E-05
(a) Limit	mREM	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(b) % of Limit		1.83E-04	1.64E-04	3.09E-04	1.40E-04	3.98E-04
2. Maximum Total Body Dose	mREM	7.11E-06	7.49E-06	1.00E-05	3.93E-06	2.86E-05
(a) Limit	mREM	3.00E+00	3.00E+00	3.00E+00	3.00E+00	6.00E+00
(b) % of Limit		2.37E-04	2.50E-04	3.35E-04	1.31E-04	4.76E-04

Critical Age **ADULT**

Critical Organ **THYROID**

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

40 CFR Part 190 Uranium Fuel Cycle Dose Calculation Results

In accordance with the requirements of 40 CFR Part 190, the annual dose commitment to any member of the general public shall be calculated to assure that doses are limited to 25 millirems to the total body or any organ with the exception of the thyroid which is limited to 75 millirems. The fuel cycle dose assessment for Brunswick Steam Electric Plant includes liquid and gaseous effluent dose contributions from Brunswick Steam Electric Plant and direct and air-scatter dose from the onsite ISFSI and Turbine Buildings. No other uranium fuel cycle facility contributes significantly to the maximum exposed individual. Also included is dose from Carbon-14, evaporation of tritium from both the SDSF and SDSF, and marsh releases containing tritium to Nancy's Creek (Ref. Attachment 2, Supplemental Information, of this report for further information). The combined dose to a maximum exposed individual from effluent releases and direct and air-scatter dose is below 40 CFR Part 190 limits as shown by the following summary.

Note: The 40 CFR Part 190 effluent dose analysis to the maximum exposed individual from liquid and gas releases does not include the dose from noble gases (i.e., total body and skin) due to the low significance compared to other dose pathways.

40 CFR Part 190 Effluent Dose Summary																																																																																																																									
<p>A. Gaseous Effluent Dose</p> <table style="width: 100%; border: none;"> <tr><td style="width: 30%;">1. Location</td><td style="width: 30%;">4.75 mi. NE</td><td style="width: 30%;"></td><td style="width: 10%;"></td></tr> <tr><td>2. Critical Age</td><td>INFANT</td><td></td><td></td></tr> <tr><td>3. Critical Organ</td><td>THYROID</td><td></td><td></td></tr> <tr><td>4. Organ Dose (mREM)</td><td>1.39E-01</td><td></td><td></td></tr> <tr><td>5. Total Body Dose (mREM)</td><td>3.73E-03</td><td></td><td></td></tr> </table> <p>B. Liquid Effluent Dose</p> <table style="width: 100%; border: none;"> <tr><td style="width: 30%;">1. Location</td><td style="width: 30%;">0.10 mi. SW</td><td style="width: 30%;"></td><td style="width: 10%;"></td></tr> <tr><td>2. Critical Age</td><td>ADULT</td><td></td><td></td></tr> <tr><td>3. Critical Organ</td><td>THYROID</td><td></td><td></td></tr> <tr><td>4. Organ Dose (mREM)</td><td>7.96E-05</td><td></td><td></td></tr> <tr><td>5. Total Body Dose (mREM)</td><td>2.86E-05</td><td></td><td></td></tr> </table> <p>C. Carbon-14 Dose</p> <table style="width: 100%; border: none;"> <tr><td style="width: 30%;">1. Location</td><td style="width: 30%;">1.00 mi. S</td><td style="width: 30%;"></td><td style="width: 10%;"></td></tr> <tr><td>2. Critical Age</td><td>CHILD</td><td></td><td></td></tr> <tr><td>3. Critical Organ</td><td>BONE</td><td></td><td></td></tr> <tr><td>4. Organ Dose (mREM)</td><td>4.08E+00</td><td></td><td></td></tr> <tr><td>5. Total Body Dose (mREM)</td><td>8.15E-01</td><td></td><td></td></tr> </table>	1. Location	4.75 mi. NE			2. Critical Age	INFANT			3. Critical Organ	THYROID			4. Organ Dose (mREM)	1.39E-01			5. Total Body Dose (mREM)	3.73E-03			1. Location	0.10 mi. SW			2. Critical Age	ADULT			3. Critical Organ	THYROID			4. Organ Dose (mREM)	7.96E-05			5. Total Body Dose (mREM)	2.86E-05			1. Location	1.00 mi. S			2. Critical Age	CHILD			3. Critical Organ	BONE			4. Organ Dose (mREM)	4.08E+00			5. Total Body Dose (mREM)	8.15E-01			<p>D. SDSF Evaporation H-3 Dose</p> <table style="width: 100%; border: none;"> <tr><td style="width: 30%;">1. Location</td><td style="width: 30%;">0.30 mi. NW</td><td style="width: 30%;"></td><td style="width: 10%;"></td></tr> <tr><td>2. Critical Age</td><td>TEEN</td><td></td><td></td></tr> <tr><td>3. Critical Organ</td><td>N/A</td><td></td><td></td></tr> <tr><td>4. Organ Dose (mREM)</td><td>2.43E-04</td><td></td><td></td></tr> <tr><td>5. Total Body Dose (mREM)</td><td>2.43E-04</td><td></td><td></td></tr> </table> <p>E. SDSF Evaporation H-3 Dose</p> <table style="width: 100%; border: none;"> <tr><td style="width: 30%;">1. Location</td><td style="width: 30%;">0.50 mi. NNW</td><td style="width: 30%;"></td><td style="width: 10%;"></td></tr> <tr><td>2. Critical Age</td><td>TEEN</td><td></td><td></td></tr> <tr><td>3. Critical Organ</td><td>N/A</td><td></td><td></td></tr> <tr><td>4. Organ Dose (mREM)</td><td>9.16E-05</td><td></td><td></td></tr> <tr><td>5. Total Body Dose (mREM)</td><td>9.16E-05</td><td></td><td></td></tr> </table> <p>F. Nancy's Creek Marsh H-3 Dose</p> <table style="width: 100%; border: none;"> <tr><td style="width: 30%;">1. Location</td><td style="width: 30%;">Nancy's Creek</td><td style="width: 30%;"></td><td style="width: 10%;"></td></tr> <tr><td>2. Critical Age</td><td>ADULT</td><td></td><td></td></tr> <tr><td>3. Critical Organ</td><td>N/A</td><td></td><td></td></tr> <tr><td>4. Organ Dose (mREM)</td><td>1.51E-04</td><td></td><td></td></tr> <tr><td>5. Total Body Dose (mREM)</td><td>1.51E-04</td><td></td><td></td></tr> </table>	1. Location	0.30 mi. NW			2. Critical Age	TEEN			3. Critical Organ	N/A			4. Organ Dose (mREM)	2.43E-04			5. Total Body Dose (mREM)	2.43E-04			1. Location	0.50 mi. NNW			2. Critical Age	TEEN			3. Critical Organ	N/A			4. Organ Dose (mREM)	9.16E-05			5. Total Body Dose (mREM)	9.16E-05			1. Location	Nancy's Creek			2. Critical Age	ADULT			3. Critical Organ	N/A			4. Organ Dose (mREM)	1.51E-04			5. Total Body Dose (mREM)	1.51E-04		
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Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Brunswick Steam Electric Plant Units 1 & 2 Period 1/1/2019 - 12/31/2019

Direct and air-scatter radiation dose contributions from the onsite ISFSI and Turbine Buildings are shown in plant operating manual 0PLP-36, 10 CFR 72.212 Report, revision 6. The maximum dose rate to the nearest real individual from the ISFSI and Turbine Buildings is conservatively calculated to be less than 14.8 mrem/yr. The below excerpt from plant operating manual 0PLP-36, 10 CFR 72.212 Report, revision 4, Attachment 1, is provided to document the method used to calculate the dose from the onsite ISFSI and Turbine Buildings as less than 14.8 mrem/yr to the nearest real individual.

5.2.2 Dose from Normal Operations and Anticipated Occurrences

5. *The real dose contribution from direct radiation sources during plant operations at BSEP is taken at 14.8 mrem/year.*

Dose contributions from Carbon-14 in gaseous effluents have been determined from ODCM 3.3.3, Carbon-14. The maximum dose rate to the nearest real individual from the release of Carbon-14 in gaseous effluents is conservatively calculated to be less than 4.08E+00 mrem/yr based on 2.12E+01 Curies released in 2019 (Ref. Attachment 2, Supplemental Information, of this report).

Dose contributions from evaporation of the Storm Drain Stabilization Pond (SDSP) have been determined from ODCM 3.3.2, I-131, I-133, Particulates, and Tritium, equation 3.2-19. The maximum dose rate to the nearest real individual from evaporation of tritium in the SDSP is conservatively calculated to be less than 2.43 E-04 mrem/yr based on 7.94 E-01 Curies released in 2019 (Ref. Attachment 2, Supplemental Information, of this report).

Dose contributions from evaporation of the Storm Drain Stabilization Facility (SDSF) have been determined from ODCM 3.3.2, I-131, I-133, Particulates, and Tritium, equation 3.2-19. The maximum dose rate to the nearest real individual from evaporation of tritium in the SDFS is conservatively calculated to be less than 9.16 E-05 mrem/yr based on 1.42 E-01 Curies released in 2019 (Ref. Attachment 2, Supplemental Information, of this report).

Dose contributions from marsh releases to Nancy's Creek from ODCM 2.1.5, Marsh Releases. The maximum dose rate to the nearest real individual from marsh releases to Nancy's Creek is conservatively calculated to be less than 1.51 E-04 mrem/yr based on 1.25 E-02 Curies released in 2019 (Ref. Attachment 2, Supplemental Information, of this report).

Total dose from liquid and gaseous effluents from Brunswick Steam Electric Plant and the additional pathways mentioned above is conservatively estimated to be less than 20 mrem/yr for total body and organ. It is recognized summing dose for different organs and age groups is not entirely accurate. However, the sum of the organ and age specific doses will always be less than the sum of the maximums of each. Therefore, summing the maximum values of each provides the most conservative value to ensure compliance with 40 CFR 190. The dose from all pathways related to operation of Brunswick Steam Electric Plant meets the 40 CFR Part 190 requirements of an annual dose commitment to any member of the general public of less than 25 mrem total body or any organ and 75 mrem to the thyroid.

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 7

Information to Support the NEI Ground Water Protection Initiative

This attachment includes a summary of voluntary reports made in accordance with the NEI Ground Water Protection Initiative and a summary of ground water well sample data.

Attachment 7 Information to Support the NEI Ground Water Protection Initiative

Brunswick Steam Electric Plant Units 1 & 2 Period 1/1/2019 - 12/31/2019

The Brunswick Steam Electric Plant groundwater sampling and analysis program is a significant surveillance program. Wells are installed around the Storm Drain Stabilization Pond (SDSP), in the Protected Area (PA), and throughout the Owner Controlled Area (OCA). The wells listed in the ODCM are collected as part of the Radiological Environmental Monitoring Program (REMP) and reported in the Annual Radiological Environmental Operating Report (AREOR). The monitoring wells not described in the ODCM are listed below. The list consists of shallow and intermediate wells in different locations around the OCA and PA. They are used to evaluate groundwater movement and for remediation of the Unit 1 Condensate Storage Tank (CST) leak and the SDSP.

Unit 1 CST Groundwater Wells - The investigation into groundwater impacts resulting from the December 2010 Unit 1 Condensate Storage Tank line leak resulted in the installation of numerous monitoring/recovery wells. Two of these wells (U1CSTREM-07BCH and U1CSTREM-09BCH) are installed in the Castle Hayne aquifer (greater than 70' below ground surface) to investigate and monitor potential impacts to the aquifer. Ten of these wells (U1CSTREM-05, U1CSTREM-02B, U1CSTREM-08/GWM-17, U1CSTREM-09B, U1CSTREM-15/GWM-15, U1CSTREM-21B, U1CSTREM-22B, U1CSTREM-27B, MW-01B, and MWPA-111B/GWM-01) are installed in the dense sand unit (45' - 70' below ground surface) to investigate and monitor impacts to this flow zone comprised of native material beneath the plant excavation backfill. Three of these dense sand wells are currently being used as recovery wells as part of the groundwater remediation effort (GWM-01, GWM-15, GWM-17). Twenty-four of these wells (U1CSTREM-02C/GWM-01, U1CSTREM-09C, U1CSTREM-10/GWM-04, U1CSTREM-11, U1CSTREM-12, U1CSTREM-13/GWM-13, U1CSTREM-14/GWM-15, U1CSTREM-16/GWM-16, U1CSTREM-18/GWM-18, U1CSTREM-19/GWM-19, U1CSTREM-21C, U1CSTREM-22C/GWM-07, U1CSTREM-23/GWM-11, U1CSTREM-24/GWM-22, U1CSTREM-25/GWM-21, U1CSTREM-26/GWM-06, U1CSTREM-27C/GWM-05, U1CSTREM-28/GWM-03, U1CSTREM-29/GWM-02, U1CSTREM-30/GWM-08, U1CSTREM-31/GWM-09, U1CSTREM-32, U1CSTREM-33/GWM-10, and MWPA-112C/GWM-12) are installed in the plant excavation backfill (up to 45' below ground surface) to investigate and monitor impacts to this flow zone where the leak occurred. Fifteen of these wells are currently used as recovery wells as part of the groundwater remediation effort.

Wells are typically sampled quarterly or semi-annually. Ground water samples are regularly analyzed for tritium and all wells are analyzed for gamma emitters. No gamma emitters, other than naturally occurring radionuclides, were identified in well samples during 2019.

Results from sampling during 2019 are shown in the table below.

Brunswick Steam Electric Plant had a voluntary notification per NEI 07-07, Industry Ground Water Protection Initiative in 2019. The notification was for a leak around Storm Drain Discharge Line and can be referenced from NCR #02296050. The leak generated greater than 100 gallons of water to the soil in the immediate area of the piping. Water samples in the area showed no gamma emitters and tritium concentrations were below the EPA drinking water limit of 20,000 pCi/L. The area of the plant where the leak occurred is not located near any waters of the State.

Key to below table

NS	-	Not scheduled to be sampled, not sampled due to insufficient volume in well, or well inaccessible during outage.
pCi/l	-	picocuries per liter.
< LLD	-	less than lower limit of detection, typically 250 pCi/l.
20,000 pCi/l	-	the Environmental Protection Agency drinking water standard for tritium. This standard applies only to water used for drinking.
1,000,000 pCi/l	-	the 10 CFR Part 20, Appendix B, Table 2, Column 2, Effluent Concentration Limit for tritium.

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Brunswick <u>Shallow</u> Wells for Plant Site						
Well Name	Number of Samples in 2019	Number of Positive H-3 Samples in 2019	Average H-3 Activity (pCi/L)	Minimum H-3 Activity (pCi/L)	Maximum H-3 Activity (pCi/L)	Depth of Well (ft)
ESS-2C	4	4	3.42E+03	1.93E+03	5.66E+03	27
ESS-3C	2	2	2.50E+02	2.01E+02	2.99E+02	14
ESS-12C	1	1	2.78E+02	2.78E+02	2.78E+02	15
ESS-13C	1	0	< LLD	< LLD	< LLD	25
ESS-16	4	4	1.35E+03	9.80E+02	2.07E+03	27
ESS-17C	4	4	7.50E+03	6.12E+03	8.29E+03	26
ESS-18C	4	3	7.51E+02	3.25E+02	1.10E+03	20
ESS-19C	2	2	7.29E+04	5.84E+04	8.74E+04	20
ESS-20C	4	4	4.22E+03	2.88E+03	7.09E+03	20
ESS-21C	1	0	<LLD	<LLD	<LLD	20
ESS-22C	1	0	< LLD	< LLD	< LLD	20
ESS-23C	2	2	2.27E+04	4.62E+03	4.08E+04	23
ESS-24C	4	4	4.27E+03	2.57E+03	5.76E+03	18
ESS-25C	1	0	< LLD	< LLD	< LLD	22
ESS-26C	2	2	3.94E+03	2.26E+03	5.62E+03	15
ESS-27C	2	2	7.99E+04	7.95E+04	8.03E+04	16
ESS-28C	2	1	2.81E+02	2.81E+02	2.81E+02	23
ESS-29C	2	0	< LLD	< LLD	< LLD	28
ESS-30C	2	1	4.21E+02	4.21E+02	4.21E+02	15
ESS-31C	2	0	< LLD	< LLD	< LLD	15
ESS-38C	1	0	<LLD	<LLD	<LLD	15
ESS-39C	1	0	<LLD	<LLD	<LLD	20
ESS-40C	1	0	< LLD	< LLD	< LLD	30
ESS-41C	1	0	< LLD	< LLD	< LLD	27
ESS-42C	1	0	< LLD	< LLD	< LLD	30
ESS-44C	1	0	< LLD	< LLD	< LLD	15
ESS-45C	1	0	< LLD	< LLD	< LLD	21
ESS-46C	1	0	< LLD	< LLD	< LLD	18
ESS-48C	1	0	< LLD	< LLD	< LLD	18
ESS-49C	1	0	< LLD	< LLD	< LLD	19
ESS-50C	1	0	< LLD	< LLD	< LLD	22
ESS-51C	1	0	< LLD	< LLD	< LLD	22
ESS-54C	1	0	< LLD	< LLD	< LLD	24
ESS-55C	1	0	< LLD	< LLD	< LLD	38
ESS-56C	1	0	< LLD	< LLD	< LLD	32
ESS-58C	1	0	< LLD	< LLD	< LLD	18

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Brunswick <u>Shallow</u> Wells for Plant Site - continued						
Well Name	Number of Samples in 2019	Number of Positive H-3 Samples in 2019	Average H-3 Activity (pCi/L)	Minimum H-3 Activity (pCi/L)	Maximum H-3 Activity (pCi/L)	Depth of Well (ft)
ESS-59C	1	0	< LLD	< LLD	< LLD	18
ESS-60C	1	0	< LLD	< LLD	< LLD	18
ESS-67C	2	0	< LLD	< LLD	< LLD	25
ESS-68C	1	0	< LLD	< LLD	< LLD	19
ESS-69C	1	0	< LLD	< LLD	< LLD	30
ESS-70C	1	0	< LLD	< LLD	< LLD	18
ESS-71C	1	0	< LLD	< LLD	< LLD	19
ESS-72C	2	0	< LLD	< LLD	< LLD	18
ESS-73C	1	0	< LLD	< LLD	< LLD	15
ESS-74C	1	0	< LLD	< LLD	< LLD	25
ESS-201C	4	4	3.21E+03	9.43E+02	7.54E+03	19
ESS-202C	4	4	1.87E+04	9.30E+03	3.23E+04	19
ESS-203C	4	4	1.47E+03	1.41E+03	1.51E+03	19
ESS-STAB	2	1	4.17E+02	4.17E+02	4.17E+02	31
ESS-NC-4A	2	2	1.24E+04	1.07E+04	1.40E+04	17
MW-2	2	2	3.67E+02	3.09E+02	4.24E+02	24
MW-3	2	2	3.46E+02	2.77E+02	4.15E+02	26
MWPA-100C	2	2	3.17E+02	3.03E+02	3.31E+02	30
MWPA-101C	2	2	5.45E+02	5.25E+02	5.64E+02	29
MWPA-102C	2	2	3.20E+02	3.16E+02	3.24E+02	30
MWPA-103C	2	1	1.92E+02	1.92E+02	1.92E+02	30
MWPA-104C	4	4	1.59E+03	1.33E+03	1.82E+03	29
MWPA-105C	2	2	8.31E+02	8.23E+02	8.38E+02	30
MWPA-106C	2	2	3.27E+02	3.02E+02	3.51E+02	29
MWPA-107C	4	4	2.56E+03	2.12E+03	3.00E+03	29
MWPA-108C	4	4	5.22E+02	3.88E+02	6.12E+02	29
MWPA-109C	2	2	1.49E+03	1.35E+03	1.63E+03	29
MWPA-110C	4	4	7.37E+02	4.60E+02	8.79E+02	29
MWPA-113C	2	2	1.89E+03	1.76E+03	2.01E+03	25
MWPA-114C	4	4	2.65E+03	1.89E+03	3.18E+03	30
MWPA-115C	5	5	3.82E+03	2.16E+03	5.23E+03	34
MWPA-116C	2	1	3.66E+02	3.66E+02	3.66E+02	30
MWPA-117C	2	2	6.67E+02	6.39E+02	6.95E+02	30
MWPA-118C	2	2	6.68E+02	6.36E+02	6.99E+02	30

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Brunswick <u>Intermediate</u> Wells for Plant Site						
Well Name	Number of Samples in 2019	Number of Positive H-3 Samples in 2019	Average H-3 Activity (pCi/L)	Minimum H-3 Activity (pCi/L)	Maximum H-3 Activity (pCi/L)	Depth of Well (ft)
ESS-2B	1	0	< LLD	< LLD	< LLD	58
ESS-3B	1	0	< LLD	< LLD	< LLD	52
ESS-18B	4	4	6.84E+02	5.86E+02	7.58E+02	63
ESS-19B	4	4	1.79E+04	9.98E+03	2.89E+04	42
ESS-20B	4	0	< LLD	< LLD	< LLD	43
ESS-22B	4	4	3.38E+03	3.25E+03	3.49E+03	76
ESS-38B	1	0	< LLD	< LLD	< LLD	55
ESS-39B	1	0	< LLD	< LLD	< LLD	55
ESS-51B	1	0	< LLD	< LLD	< LLD	45
ESS-52B	1	0	< LLD	< LLD	< LLD	51
ESS-53B	1	0	< LLD	< LLD	< LLD	76
MWPA-104B	4	4	3.02E+03	2.76E+03	3.50E+03	59
MWPA-107B	4	4	5.40E+03	4.57E+03	6.47E+03	60

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Brunswick Steam Electric Plant Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Brunswick <u>Unit 1</u> CST Groundwater Wells						
Well Name	Number of Samples in 2019	Number of Positive H-3 Samples in 2019	Average H-3 Activity (pCi/L)	Minimum H-3 Activity (pCi/L)	Maximum H-3 Activity (pCi/L)	Depth of Well (ft)
GWM-01	35	35	2.78E+03	1.10E+03	3.67E+03	61
GWM-02	16	16	1.98E+04	4.35E+03	4.04E+04	45
GMW-06	0	-	-	-	-	45
GWM-08	35	33	1.68E+03	5.60E+02	2.33E+03	45
GWM-09	35	32	6.86E+02	4.42E+02	1.36E+03	46
GWM-10	35	35	3.43E+03	1.28E+03	8.49E+03	45
GWM-11	34	34	2.37E+03	9.65E+02	3.00E+03	45
GWM-12	36	36	2.05E+03	9.41E+02	3.10E+03	33
GMW-13	33	33	1.88E+04	1.30E+04	2.82E+04	44
GWM-14	34	34	2.61E+04	1.10E+04	5.69E+04	44
GMW-15	35	35	6.91E+03	4.71E+03	1.29E+04	59
GWM-16	34	34	8.78E+04	2.36E+04	1.37E+05	40
GMW-17	33	33	3.66E+03	1.86E+03	1.30E+04	68
GWM-18	32	32	1.06E+05	1.03E+04	1.84E+05	29
GMW-19	34	34	1.22E+04	7.99E+03	1.60E+04	40
GMW-20	35	35	9.33E+03	3.32E+03	2.31E+04	45
GMW-21	34	34	1.28E+04	6.98E+03	2.04E+04	45
GWM-22	31	31	1.66E+04	1.32E+04	2.36E+04	29
MW-1	12	10	1.06E+03	3.75E+02	5.07E+03	24
MW-1B	11	1	7.00E+02	7.00E+02	7.00E+02	45
U1CSTREM-02B	11	2	1.10E+03	3.77E+02	1.82E+03	68
U1CSTREM-05B	11	0	<LLD	< LLD	<LLD	65
U1CSTREM-07BCH	11	10	6.64E+02	3.03E+02	1.09E+03	85
U1CSTREM-09B	11	11	3.95E+03	3.41E+03	4.47E+03	68
U1CSTREM-09BCH	11	11	3.66E+03	2.82E+03	4.65E+03	85
U1CSTREM-09C	11	11	5.36E+03	2.50E+03	7.36E+03	45
U1CSTREM-10C	11	4	8.58E+02	6.20E+02	1.10E+03	45
U1CSTREM-11C	11	1	3.24E+02	3.24E+02	3.24E+02	40
U1CSTREM-12C	11	4	1.24E+03	3.79E+02	2.83E+03	34
U1CSTREM-21B	11	11	4.20E+03	2.99E+03	5.32E+03	69
U1CSTREM-21C	11	11	4.95E+03	3.99E+03	6.28E+03	45
U1CSTREM-22B	11	2	7.91E+02	4.64E+02	1.12E+03	69
U1CSTREM-27B	11	2	6.56E+02	4.45E+02	8.67E+02	68
U1CSTREM-27C	11	1	1.00E+03	1.00E+03	1.00E+03	45
U1CSTREM-28C	11	11	1.55E+04	1.02E+04	2.62E+04	45
U1CSTREM-32C	11	11	8.40E+02	6.28E+02	1.36E+03	45

**Attachment 8
Inoperable Equipment**

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 8

Inoperable Equipment

This attachment includes an explanation of inoperable instruments related to effluent monitoring in excess of allowed time defined by licensing bases and an explanation of liquid hold-up tanks exceeding 10 Curies total activity (excluding tritium and dissolved or entrained noble gases).

**Attachment 8
Inoperable Equipment**

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

Brunswick Steam Electric Plant did not experience any instances of inoperable equipment relevant to effluent monitoring in excess of ODCM Specification 7.3.0 limits during 2019.

Brunswick Steam Electric Plant experienced no Liquid Hold-Up Tank exceeding the 10 Curie limit of ODCMS 7.3.6 during 2019.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 9

Summary of Changes to the Offsite Dose Calculation Manual

This attachment includes a summary of changes to the ODCM and Radiological Effluent Controls.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ODCM Revision 38

The Brunswick Steam Electric Plant ODCM was not revised in 2019. The most recent revision is 38.

Attachment 10
Summary of Changes to the Process Control Program

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 10

Summary of Changes to the Process Control Program

This attachment includes a summary of changes to the PCP.

Attachment 10
Summary of Changes to the Process Control Program

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

The Brunswick Steam Electric Plant PCP was not revised in 2019. The most recent revision is 5.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 11

Summary of Major Modifications to the Radioactive Waste Treatment Systems

This attachment includes a description of major modifications to the radioactive waste treatment systems that are anticipated to affect effluent releases.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

No major modifications to Brunswick Steam Electric Plant liquid, gaseous, solid, or mobile radioactive waste treatment systems occurred in 2019.

Attachment 12
Errata to a Previous Year's ARERR

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 12

Errata to a Previous Year's ARERR

This attachment includes any amended pages from a previous year's ARERR.

Attachment 12
Errata to a Previous Year's ARERR

Brunswick Steam Electric Plant Units 1 & 2
Period 1/1/2019 - 12/31/2019

There are no changes to a previous year's ARERR.

Enclosure 2
RA-20-0078

ENCLOSURE 2: [CNS Annual Radioactive Effluent Release Report](#)



Catawba Nuclear Station Units 1 and 2

Annual Radioactive Effluent Release Report

January 1, 2019 through December 31, 2019

Dockets 50-413 and 50-414



Introduction

The Annual Radioactive Effluent Release Report is pursuant to Catawba Nuclear Station Technical Specification 5.6.3 and Selected Licensee Commitment 16.11-16. The below listed attachments to this report provide the required information. In addition, the ODCM is included pursuant to Catawba Nuclear Station Technical Specification 5.5.1.

- Attachment 1 Summary of Gaseous and Liquid Effluents
- Attachment 2 Supplemental Information
- Attachment 3 Solid Radioactive Waste Disposal
- Attachment 4 Meteorological Data
- Attachment 5 Unplanned Offsite Releases
- Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public
- Attachment 7 Information to Support the NEI Ground Water Protection Initiative
- Attachment 8 Inoperable Equipment
- Attachment 9 Summary of Changes to the Offsite Dose Calculation Manual
- Attachment 10 Summary of Changes to the Process Control Program
- Attachment 11 Summary of Major Modifications to the Radioactive Waste Treatment Systems
- Attachment 12 Errata to a Previous Year's ARERR

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 1

Summary of Gaseous and Liquid Effluents

This attachment includes a summary of the quantities of radioactive liquid and gaseous effluents as outlined in Regulatory Guide 1.21, Appendix B.

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
1. Total Release	Ci	2.14E+00	2.00E+00	2.01E+00	1.94E+00	8.08E+00
2. Avg. Release Rate	μCi/sec	2.75E-01	2.54E-01	2.52E-01	2.44E-01	2.56E-01
B. Iodine-131						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	μCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life ≥ 8 days						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	μCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
1. Total Release	Ci	4.67E+01	4.85E+01	5.51E+01	3.93E+01	1.90E+02
2. Avg. Release Rate	μCi/sec	6.00E+00	6.16E+00	6.93E+00	4.95E+00	6.01E+00
E. Carbon-14						
1. Total Release	Ci	5.45E+00	5.44E+00	4.88E+00	5.26E+00	2.10E+01
2. Avg. Release Rate	μCi/sec	7.01E-01	6.92E-01	6.14E-01	6.62E-01	6.67E-01
F. Gross Alpha						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	μCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Elevated Releases - Continuous Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life ≥ 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Catawba Nuclear Station Units 1 and 2 do not have elevated releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Elevated Releases - Batch Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life ≥ 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Catawba Nuclear Station Units 1 and 2 do not have elevated releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground Releases - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Iodines						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life ≥ 8 days						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
H-3	Ci	4.64E+01	4.80E+01	5.48E+01	3.91E+01	1.88E+02
E. Carbon-14 *						
C-14	Ci	1.63E+00	1.63E+00	1.46E+00	1.58E+00	6.31E+00
F. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

* 30% of total C-14 released is assumed to be in continuous mode. See Attachment 2, Supplemental Information, of this report.

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground Releases - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
AR-41	Ci	1.36E+00	1.60E+00	1.60E+00	1.41E+00	5.96E+00
KR-85	Ci	0.00E+00	4.78E-02	4.54E-04	6.56E-02	1.14E-01
XE-133	Ci	7.41E-01	3.17E-01	3.68E-01	4.10E-01	1.84E+00
XE-135	Ci	3.94E-02	3.24E-02	3.90E-02	5.85E-02	1.69E-01
Total for Period	Ci	2.14E+00	2.00E+00	2.01E+00	1.94E+00	8.08E+00
B. Iodines						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life ≥ 8 days						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
H-3	Ci	2.60E-01	4.58E-01	3.22E-01	2.44E-01	1.28E+00
E. Carbon-14 *						
C-14	Ci	3.81E+00	3.81E+00	3.42E+00	3.68E+00	1.47E+01
F. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

* 70% of total C-14 released is assumed to be in batch mode. See Attachment 2, Supplemental Information, of this report.

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Mixed-Mode Releases - Continuous Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life ≥ 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Catawba Nuclear Station Units 1 and 2 do not have mixed-mode releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Mixed-Mode Releases - Batch Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life ≥ 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Catawba Nuclear Station Units 1 and 2 do not have mixed-mode releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Liquid Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products *						
1. Total Release	Ci	7.79E-03	3.92E-03	4.57E-03	2.24E-03	1.85E-02
2. Avg. Diluted Conc.	µCi/ml	3.30E-10	1.31E-10	1.09E-10	8.26E-11	1.51E-10
3. Batch Releases	µCi/ml	3.30E-10	1.31E-10	1.09E-10	8.26E-11	1.51E-10
B. Tritium						
1. Total Release	Ci	2.21E+02	1.37E+02	2.39E+02	1.27E+02	7.24E+02
2. Avg. Diluted Conc.	µCi/ml	9.34E-06	4.59E-06	5.69E-06	4.68E-06	5.90E-06
3. Batch Releases	µCi/ml	9.34E-06	4.59E-06	5.69E-06	4.68E-06	5.90E-06
C. Dissolved & Entrained Gases						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Diluted Conc.	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Batch Releases	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
1. Total Release	Ci	0.00E+00	9.55E-06	0.00E+00	0.00E+00	9.55E-06
2. Avg. Diluted Conc.	µCi/ml	0.00E+00	3.19E-13	0.00E+00	0.00E+00	7.78E-14
3. Batch Releases	µCi/ml	0.00E+00	3.19E-13	0.00E+00	0.00E+00	7.78E-14
E. Volume of Liquid Waste						
1. Continuous Releases	liters	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Batch Releases	liters	7.35E+05	4.26E+05	1.09E+06	5.21E+05	2.77E+06
F. Volume of Dilution Water						
1. Continuous Releases	liters	2.36E+09	2.99E+09	4.21E+09	2.71E+09	1.23E+10
2. Batch Releases	liters	2.36E+10	2.99E+10	4.21E+10	2.71E+10	1.23E+11

* Excludes tritium, dissolved and entrained noble gases, and gross alpha.

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Liquid Effluents - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Dissolved & Entrained Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
BE-7	Ci	0.00E+00	0.00E+00	1.28E-04	0.00E+00	1.28E-04
BI-214	Ci	6.81E-06	0.00E+00	3.00E-05	0.00E+00	3.69E-05
CO-58	Ci	4.65E-04	3.99E-05	2.10E-04	1.67E-04	8.82E-04
CO-60	Ci	9.83E-04	1.66E-03	1.52E-03	8.07E-04	4.97E-03
CR-51	Ci	3.42E-04	0.00E+00	1.11E-04	1.04E-05	4.64E-04
CS-137	Ci	0.00E+00	0.00E+00	1.33E-05	4.98E-06	1.83E-05
FE-55	Ci	7.72E-04	4.60E-04	1.16E-03	2.60E-04	2.65E-03
FE-59	Ci	0.00E+00	0.00E+00	7.15E-06	0.00E+00	7.15E-06
MN-54	Ci	4.75E-05	4.35E-05	4.33E-05	3.46E-05	1.69E-04
NB-95	Ci	2.48E-06	0.00E+00	0.00E+00	0.00E+00	2.48E-06
NI-63	Ci	4.95E-03	1.49E-03	1.13E-03	9.42E-04	8.50E-03
PB-214	Ci	2.70E-05	0.00E+00	6.06E-05	1.65E-05	1.04E-04
SB-125	Ci	2.02E-04	2.32E-04	1.61E-04	0.00E+00	5.96E-04
Total for Period	Ci	7.79E-03	3.92E-03	4.57E-03	2.24E-03	1.85E-02
B. Tritium						
H-3	Ci	2.21E+02	1.37E+02	2.39E+02	1.27E+02	7.24E+02
C. Dissolved & Entrained Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
Total for Period	Ci	0.00E+00	9.55E-06	0.00E+00	0.00E+00	9.55E-06

**Attachment 2
Supplemental Information**

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 2

Supplemental Information

This attachment includes supplemental information to the gaseous and liquid effluents report.

Attachment 2 Supplemental Information

Catawba Nuclear Station Units 1 & 2 Period 1/1/2019 - 12/31/2019

I. Regulatory Limits - Per Unit

A. Noble Gases - Air Dose

1. Calendar Quarter Gamma Dose	= 5	mRAD
2. Calendar Quarter Beta Dose	= 10	mRAD
3. Calendar Year Gamma Dose	= 10	mRAD
4. Calendar Year Beta Dose	= 20	mRAD

B. Liquid Effluents - Dose

1. Calendar Quarter Total Body Dose	= 1.5	mREM
2. Calendar Quarter Organ Dose	= 5	mREM
3. Calendar Year Total Body Dose	= 3	mREM
4. Calendar Year Organ Dose	= 10	mREM

C. Gaseous Effluents - Iodine-131 & 133, Tritium, and Particulates with Half-lives > 8 days

1. Calendar Quarter Organ Dose	= 7.5	mREM
2. Calendar Year Organ Dose	= 15	mREM

II. Maximum Permissible Effluent Concentrations

A. Gaseous Effluents

1. Information found in Offsite Dose Calculation Manual

B. Liquid Effluents

1. Information found in 10 CFR Part 20, Appendix B, Table 2, Column 2

III. Average Energy

(not applicable)

IV. Measurements and Approximations of Total Radioactivity

Analyses of specific radionuclides in selected or composited samples as described in the Selected Licensee Commitments are used to determine the radionuclide composition of the effluent. A summary description of the method used for estimating overall errors associated with radioactivity measurements is provided as part of this attachment.

V. Batch Releases

A. Liquid Effluents

1. Total Number of Batch Releases	=	53
2. Total Time (min) for Batch Releases	=	4.48E+03
3. Maximum Time (min) for a Batch Release	=	1.09E+03
4. Average Time (min) for Batch Releases	=	8.46E+01
5. Minimum Time (min) for a Batch Release	=	3.40E+01
6. Average Dilution Water Flow During Release (gpm)	=	6.17E+04

B. Gaseous Effluents

1. Total Number of Batch Releases	=	61
2. Total Time (min) for Batch Releases	=	1.04E+06
3. Maximum Time (min) for a Batch Release	=	4.46E+04
4. Average Time (min) for Batch Releases	=	1.70E+04
5. Minimum Time (min) for a Batch Release	=	2.00E+00

VI. Abnormal Releases

See Attachment 5, Unplanned Offsite Releases.

Attachment 2 Supplemental Information

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Carbon-14

Carbon-14 (C-14), with a half-life of 5730 years, is a naturally occurring isotope of carbon produced by cosmic ray interactions in the atmosphere. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. C-14 is also produced in commercial nuclear reactors, but the amounts produced are much less than those produced naturally or from weapons testing.

In Regulatory Guide 1.21, Revision 2, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste", the NRC recommends U.S. nuclear power plants evaluate whether C-14 is a "principal radionuclide", and if so, report the amount of C-14 released. Improvements over the years in effluent management practices and fuel performance have resulted in a decrease in gaseous radionuclide (non-C-14) concentrations, and a change in the distribution of gaseous radionuclides released to the environment. As a result, many sites show C-14 has become a "principal radionuclide" for the gaseous effluent pathway, as defined in Regulatory Guide 1.21, Rev. 2. Catawba Nuclear Station 2019 ARERR contains estimates of C-14 radioactivity released in 2019, and estimates of public dose resulting from the C-14 effluent.

Because the dose contribution of C-14 from liquid radioactive waste is much less than that contributed by gaseous radioactive waste, evaluation of C-14 in liquid radioactive waste is not required (Ref. Reg. Guide 1.21, Rev. 2). The quantity of gaseous C-14 released to the environment can be estimated by use of a C-14 source term scaling factor based on power generation (Ref. Reg. Guide 1.21, Rev. 2). Many documents provide information related to the magnitude of C-14 in typical effluents from commercial nuclear power plants. Those documents suggest that nominal annual releases of C-14 in gaseous effluents are approximately 5 to 7.3 curies from PWRs (Ref. Reg. Guide 1.21, Rev. 2). A more recent study recommends a higher C-14 gaseous source term scaling factor of approximately 9.0 to 9.8 Ci/GWe-yr for a PWR (Westinghouse) (Ref. EPRI 1021106). For the Catawba Nuclear Station 2019 ARERR, a source term scaling factor of 9.4 Ci/GWe-yr is assumed. Using a source term scaling factor of 9.4 Ci/GWe-yr and actual electric generation (MWe-hrs) from Catawba Nuclear Station in 2019 results in a site total C-14 gaseous release estimate to the environment of 2.10E+01 Curies. 70% of the C-14 gaseous effluent is assumed to be from batch releases and 30% of C-14 gaseous effluent is assumed to be from continuous releases through the unit vents (ref. IAEA Technical Reports Series no. 421, "Management of Waste Containing Tritium and Carbon-14", 2004).

C-14 releases in PWRs occur primarily as a mix of organic carbon and carbon dioxide released from the waste gas system. Since the PWR operates with a reducing chemistry, most, if not all, of the C-14 species initially produced are organic (e.g., methane). As a general rule, C-14 in the primary coolant is essentially all organic with a large fraction as a gaseous species. Any time the RCS liquid or gas is exposed to an oxidizing environment (e.g. during shutdown or refueling), a slow transformation from an organic to an inorganic chemical form can occur. Various studies documenting measured C-14 releases from PWRs suggest a range of 70% to 95% organic with an average of 80% organic with the remainder being CO₂ (Ref. EPRI TR-105715). For the Catawba Nuclear Station 2019 ARERR a value of 80% organic C-14 is assumed.

Public dose estimates from airborne C-14 are performed using dose models in NUREG-0133 and Regulatory Guide 1.109. The dose models and assumptions used are documented in the Catawba ODCM. The estimated C-14 dose impact on the maximum organ dose from airborne effluents released from Catawba Nuclear Station in 2019 is well below the 10CFR50, Appendix I, ALARA design objective (i.e., 15 mrem/yr per unit).

**Attachment 2
Supplemental Information**

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Overall Estimate of Error for Effluent Radioactivity Release Reported

The estimated percentage of overall error for both Liquid and Gaseous effluent release data at Catawba Nuclear Station has been determined to be $\pm 30.3\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

1. Flow Rate Determining Devices = $\pm 20\%$
2. Counting Statistical Error = $\pm 20\%$
3. Calibration Error = $\pm 10\%$
4. Calibration Source Error = $\pm 2.5\%$
5. Sample Preparation Error = $\pm 3\%$

**Attachment 2
Supplemental Information**

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Summary of Changes in Land Use Census Affecting Effluent Dose Calculations

The 2019 Land Use Census was performed June 18-19, 2019, and the results were certified and made available for use on July 24, 2019. The following are changes to residences, gardens, and milk animals from the previous year.

Residences

No changes to nearest residences in each sector.

Gardens

The garden in the NNE sector (3.09 miles) was replaced with a garden at 2.75 miles.
The garden in the ESE sector (3.54 miles) was replaced with a garden at 3.80 miles.
The garden in the WNW sector (1.27 miles) was replaced with a garden at 1.35 miles.

Milk Animals

No changes to nearest milk animal in each sector.

Environmental Monitoring Locations

No changes to environmental monitoring locations in each sector.

Attachment 2 Supplemental Information

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Note Regarding Unavailable Radioactive Effluent Instrumentation

During the 2019 NRC Inspection for Catawba's radioactive effluents program, the NRC provided a Comment (NCR 02293159) regarding the wording in the Applicability in SLCs 16.11-2 and 16.11-7 allowing effluent monitors to remain non-functional indefinitely and never entering the Condition that would require reporting in the Radioactive Effluent Release Report. The wording of these SLCs for Applicability said, "At all times, except when the effluent pathway is mechanically isolated; thus a release to the environment is not possible." As written, it was possible to have an instrument incapable of performing its design function, i.e. non-functional, for an extended period of time with the effluent pathway mechanically isolated. Since the effluent pathway is mechanically isolated, the station never enters the Condition for the non-functional instrument and by extension does not have to perform the Required Action to restore the non-functional channel to functional within the designated Completion Time.

Based on the NRC's feedback, SLCs 16.11-2 and 16.11-7 were revised to change the applicability for the Condition to restore non-functional channels to functional to "at all times." Likewise, the Remedial Action to report failure to return a non-functional channel to functional within the completion time in the Radioactive Effluent Release Report was changed to "at all times." The Applicability for other Remedial Actions will retain the "...except when the effluent pathway is mechanically isolated..." wording. The revised SLCs were implemented on April 23, 2020.

Though the SLC revision was not implemented until April, 2020, there were four instances during 2019, in which effluent monitoring instruments were not capable of performing their design functions while the effluent pathways were mechanically isolated. Since these cases did not represent entry into active Remedial Actions, they will be documented here rather than Attachment 8, Inoperable Equipment.

SLC # from Table 16.11-7-1	Title	Completion Time	Determination and Data Reviewed
1.b	0WGFT5940	30 days	For WGFT5940, out of service time for 2019 was 40.55 days (11/21/2019 10:52:42 to 12/31/2019 23:59:59) LCOTR T-0-19-01990.
SLC # from Table 16.11-2-1	Title	Completion Time	Determination and Data Reviewed
4.a	1EMF-45A	30 days	For 1EMF-45A, out of service time for 2019 was 217.81 days (05/28/2019 04:31:08 to 12/31/2019 23:59:59) LCOTR T-1-19-00828.
SLC # from Table 16.11-7-1	Title	Completion Time	Determination and Data Reviewed
4.a	1EMF-45B	30 days	For 1EMF-45B, out of service time for 2019 was 36.62 days (01/01/2019 00:00:00 to 02/06/2019 14:59:54) LCOTR T-1-19-01456.
SLC # from Table 16.11-7-1	Title	Completion Time	Determination and Data Reviewed
4.a	2EMF-45B	30 days	For 2EMF-45B, out of service time for 2019 was 57.82 days (04/27/2019 17:30:28 to 06/24/2019 13:11:37) LCOTR T-2-19-00674.

Attachment 3
Solid Radioactive Waste Disposal

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 3

Solid Radioactive Waste Disposal

This attachment includes a summary of the solid waste shipped off-site for burial and/or disposal, including:

- Container volume
- Total Curie content (specify whether determined by measurement or estimate)
- Principal Radionuclides
- Source and Type of waste
- Solidification agent or absorbent
- Type of shipping container
- Number of shipments
- Other relevant information as necessary

Attachment 3 Solid Radioactive Waste Disposal

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Type of Waste Shipped	Number of Shipments	Number of Containers	Waste Class	Container Type	Solidification Agent	Burial Volume (m ³)	Total Activity (Curies)
1. <u>Waste from Liquid Systems</u>							
a. Dewatered Secondary Resins	5	28	A	B-25	NA	109.1	3.98E-02
b. Dewatered Primary Resins	6	6	A / B	HIC	NA	27.71	308
c. Evaporator Concentrates							
d. Dewatered Mechanical Filters	1	1	C	HIC	NA	3.407	75
e. Dewatered Demineralizers							
f. Solidified (cement) Acids, Oils, Sludge							
g. <i>Other (add as necessary)</i>							
2. <u>Dry Solid Waste</u>							
a. Dry Active Waste (compacted)							
b. Dry Active Waste (non-compacted)							
c. Dry Active Waste (brokered)	8	16	A	GDP	NA	338.7	1.31
d. Irradiated Components							
e. <i>Other (add as necessary)</i>							
3. <u>Total Solid Waste</u>	20	51				478.8	385

Attachment 3 Solid Radioactive Waste Disposal

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Type of Waste Shipped	Radionuclide	% Abundance
1. <u>Waste from Liquid Systems</u>		
a. Dewatered Secondary Resins	Mn-54	3.20%
	Co-60	16.0%
	Cs-137	17.5%
	Ce-144	63.3%
b. Dewatered Primary Resins	H-3	0.12%
	Be-7	0.21%
	Mn-54	3.92%
	Co-57	0.20%
	Co-58	3.20%
	Co-60	23.82%
	Zn-65	0.66%
	Sb-125	0.32%
	Cs-134	0.45%
	Cs-137	0.78%
	Eu-154	0.01%
	Ce-144	0.03%
	Pu-238	0.00%
	C-14	0.14%
	Fe-55	13.56%
	Ni-59	0.37%
	Ni-63	52.21%
	Sr-90	0.01%
	Tc-99	0.01%
Am-241	0.00%	
c. Evaporator Concentrates	N/A	N/A
d. Dewatered Mechanical Filters	H-3	1.24%
	Be-7	0.01%
	Cr-51	17.61%
	Mn-54	4.46%
	Co-57	0.12%
	Co-58	18.41%
	Fe-59	0.91%
	Co-60	21.48%
	Zn-65	0.52%
	Nb-95	13.23%
	Zr-95	6.11%
	Ag-110m	0.01%
	Sn-113	0.19%
	Sb-124	0.05%
	Sb-125	0.20%
	I-131	0.00%
	Cs-134	0.01%
	Cs-137	0.52%
	Ce-144	1.19%
	Pu-238	0.00%
	C-14	0.11%
	Fe-55	12.86%
	Ni-59	0.00%
	Ni-63	0.78%
	Sr-89	0.00%
	Sr-90	0.00%
	Tc-99	0.00%
	Cm-242	0.00%
	Cm-244	0.00%
	e. Dewatered Demineralizers	N/A
f. Solidified (cement) Acids, Oils, Sludge	N/A	N/A
g. Other (add as necessary)	N/A	N/A

Attachment 3 Solid Radioactive Waste Disposal

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

2. **Dry Solid Waste**

a. Dry Active Waste (compacted)	N/A	N/A
b. Dry Active Waste (non-compacted)	N/A	N/A
c. Dry Active Waste (brokered)	H-3	0.33%
	Cr-51	25.20%
	Mn-54	2.15%
	Co-57	0.09%
	Co-58	21.91%
	Fe-59	0.77%
	Co-60	8.90%
	Zn-65	0.31%
	Nb-95	16.51%
	Zr-95	9.54%
	Sn-113	0.33%
	Sb-124	0.58%
	Sb-125	0.50%
	Cs-137	0.05%
	Ce-144	0.18%
	C-14	0.04%
	Fe-55	10.16%
	Ni-63	2.44%
d. Irradiated Components	N/A	N/A
e. <i>Other (add as necessary)</i>	N/A	N/A

**Attachment 4
Meteorological Data**

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 4

Meteorological Data

This attachment includes a summary of meteorological joint frequency distributions of wind speed, wind direction, and atmospheric stability (hours of occurrence).

Attachment 4 Meteorological Data

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
A	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
	1.01-1.25	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
	1.26-1.50	0	0	0	0	0	1	1	0	0	1	1	1	0	1	0	
	1.51-2.00	1	1	2	0	0	2	1	8	5	7	8	9	6	3	1	
	2.01-3.00	4	5	2	0	3	0	4	25	17	73	72	26	33	13	6	
	3.01-4.00	20	11	1	0	0	0	4	6	4	25	40	17	3	9	5	
	4.01-5.00	24	23	4	1	0	0	0	0	0	1	3	3	1	5	3	
	5.01-6.00	6	8	1	0	0	0	0	0	0	0	0	0	1	0	1	
	6.01-8.00	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	
	8.01-10.00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
B	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	1.01-1.25	0	0	0	0	1	0	0	0	1	1	1	3	0	0	1	
	1.26-1.50	0	0	1	0	0	0	0	0	3	2	1	1	3	0	1	
	1.51-2.00	2	1	0	0	4	5	4	12	6	13	5	7	2	2	1	
	2.01-3.00	22	6	6	2	3	2	5	19	10	29	26	11	9	6	8	
	3.01-4.00	27	19	3	0	1	0	2	4	9	12	13	3	3	6	5	
	4.01-5.00	18	23	1	1	0	0	0	0	0	0	2	2	3	2	4	
	5.01-6.00	0	7	0	0	0	0	0	0	0	0	0	0	0	0	1	
	6.01-8.00	0	4	0	0	0	0	0	0	0	0	0	0	0	0	1	
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Attachment 4 Meteorological Data

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
C	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.76-1.00	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
	1.01-1.25	1	0	0	0	0	0	1	0	1	1	1	0	1	0	0	0
	1.26-1.50	0	0	0	0	1	0	2	6	4	2	0	1	2	0	2	0
	1.51-2.00	5	2	1	2	5	5	9	18	19	16	17	6	9	5	1	2
	2.01-3.00	48	19	3	1	1	3	3	22	22	44	20	9	6	13	6	12
	3.01-4.00	54	23	7	1	1	0	6	2	9	15	8	1	7	3	12	14
	4.01-5.00	8	33	9	3	0	0	0	0	2	4	4	2	0	4	3	1
	5.01-6.00	6	9	3	0	0	0	0	0	0	0	0	0	0	0	0	2
	6.01-8.00	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
D	0.46-0.75	0	0	0	0	0	0	0	2	1	0	3	0	0	0	0	
	0.76-1.00	0	0	0	0	0	7	1	14	13	17	15	9	5	2	4	4
	1.01-1.25	5	4	1	3	4	5	6	15	31	19	25	20	19	14	7	5
	1.26-1.50	11	4	5	5	12	7	14	37	83	62	37	19	26	19	16	8
	1.51-2.00	60	17	12	20	13	15	25	64	119	93	52	24	28	27	30	59
	2.01-3.00	207	62	30	13	19	13	32	100	101	88	57	18	18	25	32	100
	3.01-4.00	171	151	74	19	3	1	19	20	59	34	16	6	4	12	19	39
	4.01-5.00	83	78	60	18	0	0	2	5	21	4	6	2	2	5	9	17
	5.01-6.00	26	23	11	9	0	0	1	0	8	0	1	0	0	2	2	8
	6.01-8.00	12	12	0	1	0	0	0	0	0	0	0	0	0	0	4	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Attachment 4 Meteorological Data

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
E	0.46-0.75	0	0	0	0	0	0	0	0	3	1	4	3	2	0	1	0
	0.76-1.00	0	1	0	0	1	0	3	10	16	33	25	25	15	15	7	3
	1.01-1.25	5	0	1	1	0	1	2	16	42	59	33	22	22	21	15	6
	1.26-1.50	2	2	1	0	0	0	8	35	78	65	41	22	33	34	25	10
	1.51-2.00	14	3	4	1	5	2	12	42	136	67	17	19	36	28	38	45
	2.01-3.00	75	6	8	10	7	8	27	38	65	28	24	8	13	30	35	114
	3.01-4.00	35	4	2	1	3	1	9	7	12	8	2	0	0	3	11	17
	4.01-5.00	5	1	6	2	0	1	5	2	1	0	2	0	0	2	1	3
	5.01-6.00	0	2	5	0	0	0	0	0	0	0	0	0	0	1	1	1
	6.01-8.00	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
F	0.46-0.75	0	0	0	0	0	0	0	0	0	3	8	2	8	1	1	0
	0.76-1.00	0	0	0	0	0	0	0	3	20	31	32	19	19	17	9	2
	1.01-1.25	1	0	0	0	0	0	0	6	33	37	17	14	10	12	20	3
	1.26-1.50	2	0	0	0	0	0	1	5	47	26	15	12	20	11	31	24
	1.51-2.00	4	1	0	0	0	0	1	7	22	10	9	17	14	16	19	50
	2.01-3.00	20	1	0	0	0	2	5	3	0	0	1	1	8	4	10	38
	3.01-4.00	2	1	0	0	0	0	5	1	0	1	0	0	0	0	0	2
	4.01-5.00	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Attachment 4 Meteorological Data

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
G	0.46-0.75	0	0	0	0	0	0	0	0	2	4	7	9	14	12	2	0
	0.76-1.00	0	0	0	0	0	1	0	2	17	26	32	33	23	39	21	0
	1.01-1.25	0	0	0	0	0	0	0	0	25	40	37	30	16	16	23	5
	1.26-1.50	0	0	0	0	0	0	0	2	28	21	29	14	12	12	32	27
	1.51-2.00	0	0	0	0	0	0	1	4	3	3	10	8	8	6	11	28
	2.01-3.00	3	0	0	0	0	0	0	0	0	0	0	3	9	2	4	11
	3.01-4.00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	4.01-5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Attachment 5
Unplanned Offsite Releases

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 5

Unplanned Offsite Releases

This attachment includes a summary of the unplanned offsite releases of gaseous and liquid radioactive effluents.

Attachment 5 Unplanned Offsite Releases

Catawba Nuclear Station Units 1 & 2 Period 1/1/2019 - 12/31/2019

Catawba Nuclear Station had no unplanned liquid releases in 2019.

Catawba Nuclear Station had one unplanned gaseous release in 2019. As documented in Nuclear Condition Report (NCR 02260916), the Unit 2 control room received annunciator 2RAD-2 A/2, 2EMF-36L Trip 2 (documented in CNS Unit 2 Operations Log 03/05/2019 08:47). Filter paper for 2EMF35 (auxiliary building exhaust particulate monitor) was counted with no detectable activity. Other process monitors including 2EMF42 (Unit 2 spent fuel pool ventilation) and 0EMF41 (auxiliary building ventilation) were reviewed with no discernable increases identified. Review by RP Effluents SME concluded the peak on 2EMF-36L did not exhibit erratic monitor responses and the alarm was treated as a legitimate reading.

Review of the 2EMF-36L trend showed the count rate began to increase at 08:35 and returned to normal at 08:52. The maximum count rate during the release was 282 cpm. For conservatism, the maximum count rate was used to calculate Xe-133 equivalent activity and a release duration of 17 minutes was used to generate a release permit. The average unit vent flowrate was 107,174 cfm throughout the release. The total activity released (assumed to be Xe-133) was 5.02E-01 Ci. Gamma air dose from the unplanned release was 1.97E-04 mrad and beta air dose was 5.86E-04 mrad.

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 6

Assessment of Radiation Dose from Radioactive Effluents to Members of the Public
(includes fuel cycle dose calculation results)

This attachment includes an assessment of radiation doses to the maximum exposed member of the public due to radioactive liquid and gaseous effluents released from the site for each calendar quarter for the calendar year of the report as well as the total dose for the calendar year.

This attachment also includes an assessment of radiation doses to the maximum exposed member of the public from all uranium fuel cycle sources within 8 km of the site for the calendar year of this report to show conformance with 40 CFR Part 190.

Methods for calculating the dose contribution from liquid and gaseous effluents are given in the Offsite Dose Calculation Manual (ODCM).

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Noble Gases						
1. Maximum Gamma Air	mRAD	1.44E-02	1.67E-02	1.68E-02	1.49E-02	6.28E-02
(a) Limit	mRAD	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(b) % of Limit		1.44E-01	1.67E-01	1.68E-01	1.49E-01	3.14E-01
<u>Receptor Location</u>	0.5 miles	NNE	NNE	NNE	NNE	NNE
2. Maximum Beta Air	mRAD	5.93E-03	6.40E-03	6.37E-03	5.92E-03	2.46E-02
(a) Limit	mRAD	2.00E+01	2.00E+01	2.00E+01	2.00E+01	4.00E+01
(b) % of Limit		2.97E-02	3.20E-02	3.18E-02	2.96E-02	6.15E-02
<u>Receptor Location</u>	0.5 miles	NNE	NNE	NNE	NNE	NNE
B. Iodine, H-3, & Particulates						
1. Maximum Organ Dose	mREM	1.28E+00	1.28E+00	1.15E+00	1.24E+00	4.94E+00
(a) Limit	mREM	1.50E+01	1.50E+01	1.50E+01	1.50E+01	3.00E+01
(b) % of Limit		8.52E+00	8.51E+00	7.64E+00	8.24E+00	1.65E+01
<u>Receptor Location</u>	0.5 miles	NE	NE	NE	NE	NE
<u>Critical Age</u>		CHILD	CHILD	CHILD	CHILD	CHILD
<u>Critical Organ</u>		BONE	BONE	BONE	BONE	BONE
<u>Critical Pathway</u>		VEGETATION	VEGETATION	VEGETATION	VEGETATION	VEGETATION

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Liquid Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Batch Mode						
1. Maximum Organ Dose	mREM	2.80E-02	1.38E-02	1.73E-02	1.42E-02	7.13E-02
(a) Limit	mREM	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(b) % of Limit		2.80E-01	1.38E-01	1.73E-01	1.42E-01	3.56E-01
2. Maximum Total Body Dose	mREM	2.76E-02	1.37E-02	1.70E-02	1.40E-02	7.03E-02
(a) Limit	mREM	3.00E+00	3.00E+00	3.00E+00	3.00E+00	6.00E+00
(b) % of Limit		9.20E-01	4.57E-01	5.65E-01	4.66E-01	1.17E+00
<u>Critical Age</u>		CHILD	CHILD	CHILD	CHILD	CHILD
<u>Critical Organ</u>		LIVER	LIVER	LIVER	LIVER	LIVER
<u>Critical Pathway</u>		POTABLE WATER	POTABLE WATER	POTABLE WATER	POTABLE WATER	POTABLE WATER
B. Continuous Mode						
1. Maximum Organ Dose	mREM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
(a) Limit	mREM	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(b) % of Limit		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Maximum Total Body Dose	mREM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
(a) Limit	mREM	3.00E+00	3.00E+00	3.00E+00	3.00E+00	6.00E+00
(b) % of Limit		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Critical Age</u>		N/A	N/A	N/A	N/A	N/A
<u>Critical Organ</u>		N/A	N/A	N/A	N/A	N/A
<u>Critical Pathway</u>		N/A	N/A	N/A	N/A	N/A

Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

40 CFR Part 190 Uranium Fuel Cycle Dose Calculation Results

In accordance with the requirements of 40 CFR Part 190, the annual dose commitment to any member of the general public shall be calculated to assure that doses are limited to 25 millirems to the total body or any organ with the exception of the thyroid which is limited to 75 millirems. The fuel cycle dose assessment for Catawba Nuclear Station includes liquid and gaseous effluent dose contributions from Catawba Nuclear Station and direct and air-scatter dose from the onsite ISFSI. No other uranium fuel cycle facility contributes significantly to the maximum exposed individual. Included in the gaseous effluent dose calculations is an estimate of the dose contributed by Carbon-14 (Ref. Attachment 2, Supplemental Information, of this report for further information). The combined dose to a maximum exposed individual from effluent releases and direct and air-scatter dose from the ISFSI is below 40 CFR Part 190 limits as shown by the following summary.

Note: The 40 CFR Part 190 effluent dose analysis to the maximum exposed individual from liquid and gas releases includes the dose from noble gases (i.e., total body and skin).

40 CFR Part 190 Effluent Dose Summary

A. Maximum Organ Dose (other than TB)	4.965E+00 mrem
1. Location	0.5 miles NE
2. Critical Age	CHILD
3. Critical Organ	BONE
4. Gas Contribution %	99.417%
5. Liquid Contribution %	0.583%
B. Maximum Total Body Dose	2.001E+00 mrem
1. Location	0.5 miles NE
2. Critical Age	CHILD
3. Gas non-NG Contribution %	94.005%
4. Gas NG Contribution %	2.484%
5. Liquid Contribution %	3.512%

Direct and air-scatter radiation dose contributions from the onsite ISFSI have been determined from the 10 CFR 72.212 Evaluation Report, MAGNASTOR®, Revision 2. The maximum dose rate to the nearest real individual from the ISFSI is conservatively calculated to be less than 14.7 mrem/yr.

The attached excerpt from the 10 CFR 72.212 Evaluation Report, MAGNASTOR®, Revision 2 is provided to document the method used to calculate the dose from ISFSI as less than 14.7 mrem/yr to the nearest real individual.

Total dose from liquid and gaseous effluents from Catawba Nuclear Station and direct and air-scatter dose from the onsite ISFSI is conservatively estimated to be less than 20 mrem/yr to the nearest real individual. This meets the 40 CFR Part 190 requirements of an annual dose commitment to any member of the general public of less than 25 mrem total body or any organ and 75 mrem to the thyroid.

Attachment 6

Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

10 CFR 72.212 Evaluation Report, MAGNASTOR®, Revision 2

6.0 10 CFR 72.212(b)(5)(iii)- Radioactive Materials in Effluents and Direct Radiation

6.1 Purpose

10 CFR 72.212(b)(5)(iii) requires the general licensee to perform written evaluations, before use and before applying the changes authorized by an amended CoC to a cask loaded under the initial CoC or an earlier amended CoC, that establish that the requirements of 10 CFR 72.104 have been met. A copy of this record shall be retained until spent fuel is no longer stored under the general license issued under 10 CFR 72.210.

10 CFR 72.104 provides the regulatory criteria for radioactive materials in effluents and direct radiation from an ISFSI during normal operation and anticipated occurrences. Specifically, 10 CFR 72.104(a) limits the annual dose equivalent to any real individual who is located beyond the controlled area to 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other critical organ. This dose equivalent must include contributions from (1) planned discharges of radioactive materials (radon and its decay products excepted) to the general environment, (2) direct radiation from ISFSI operations, and (3) any other radiation from uranium fuel cycle operations within the region. In addition, 10 CFR 72.104(b) requires that operational restrictions be established to meet As Low As is Reasonably Achievable (ALARA) objectives for radioactive materials in effluents and direct radiation levels associated with ISFSI operations. Also, 10 CFR 72.104(c) requires that operational limits be established for radioactive materials in effluents and direct radiation levels associated with ISFSI operations to meet the above-mentioned dose limits.

This section provides the written evaluation required by 10 CFR 72.212(b)(5)(iii), demonstrating Duke Energy's compliance with the requirements of 10 CFR 72.104 for the CNS ISFSI.

6.2 Evaluation

This evaluation addresses the radiological dose rate from a composite population of all CNS ISFSI cask types.

6.2.1 §72.104(a) - Dose Limits

Duke Energy Calculation DPC-1229.00-00-0011, "Distance Measurements from ISFSI to Nearest Residents" determined that the nearest residence to the ISFSI is 0.35 miles (563.27 meters).

Calculation CNC-1229.00-00-0061, "UMS Cask Array Dose Analysis for Duke Catawba (NAC International Calculation 12418-5004, Revision 1)" determined the annual total dose (gamma plus neutron) at a distance of 495 meters from a 2x12 array of NAC-UMS® casks to be approximately 6.7 mrem. The evaluation was conservatively based on full cask loads of 24 bounding fuel assemblies (52,000 MWD/MTU, 3.45 wt% U-235, and 8 years cooling) as well as bounding activated components. The cask decay heat load was conservatively assumed to be 20 kW. The distance at which this dose was calculated (495 meters) is conservative compared to the distance to the closest real individual.

Calculation CNC-1229.00-00-0067, "MAGNASTOR Cask Array Dose Analysis for Duke Catawba" determined the annual total dose (gamma plus neutron) at a distance of 535 meters from a (future) 2x12 array of MAGNASTOR® casks to be approximately 7.97 mrem. The evaluation was conservatively based on full cask loads of 37 bounding fuel assemblies at a decay heat load of 35.5 kW. The distance at which this dose is calculated (535 meters) is conservative compared to the distance to the closest real individual.

The total calculated annual public dose from liquid and gaseous effluent pathways reviewed over the past 10 years is bounded by 5 mrem. No other uranium fuel cycle facility contributes significantly to the dose received by the closest real individual.

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Based on the above, the calculated annual dose to the closest real individual due to the ISFSI, which is comprised of the currently existing 24 NAC-UMS® casks, and up to one 2x12 array of MAGNASTOR® casks, is determined to be less than 14.7 mrem, and the estimated annual dose due to Catawba power generation is less than 5 mrem. Hence, the total annual dose to the closest real individual (less than 19.7 mrem) is within the 10 CFR 72.104(a) limit.

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 7

Information to Support the NEI Ground Water Protection Initiative

This attachment includes a summary of voluntary reports made in accordance with the NEI Ground Water Protection Initiative and a summary of ground water well sample data.

Attachment 7 Information to Support the NEI Ground Water Protection Initiative

Catawba Nuclear Station Units 1 & 2 Period 1/1/2019 - 12/31/2019

Duke Energy implemented a Ground Water Protection program in 2007. This initiative was developed to ensure timely and effective management of situations involving inadvertent releases of licensed material to ground water. As part of this program, Catawba Nuclear Station monitored 49 wells and 1 outfall from the Conventional Wastewater Treatment Ponds in 2019.

Wells are typically sampled quarterly or semi-annually. Ground water samples are regularly analyzed for tritium and gamma emitters, with select wells being analyzed for difficult-to-detect radionuclides. No gamma or difficult-to-detect radionuclides, other than naturally occurring radionuclides, were identified in well samples during 2019. Results from sampling during 2019 confirmed existing knowledge of tritium concentrations in site ground water.

Results from sampling during 2019 are shown in the table below.

No events meeting the criteria for voluntary notification per NEI 07-07, Industry Ground Water Protection Initiative, occurred at Catawba Nuclear Station in 2019.

Key to below table.

NS	-	Not scheduled to be sampled, not sampled due to insufficient volume in well, or well inaccessible during outage.
pCi/l	-	picocuries per liter.
< MDA	-	less than minimum detectable activity, typically 250 pCi/l.
20,000 pCi/l	-	the Environmental Protection Agency drinking water standard for tritium. This standard applies only to water used for drinking.
1,000,000 pCi/l	-	the 10 CFR Part 20, Appendix B, Table 2, Column 2, Effluent Concentration Limit for tritium.

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Well Name	Location / Description	Tritium Concentration (pCi/l)				# of Samples
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	
C-100DR	CNS GWPI / C-100DR / U-1 SFP	<MDA	2.36E+02	5.54E+02	3.55E+02	4
C-101DR	CNS GWPI / C-101DR / U-1 SFP	3.50E+02	2.26E+02	2.36E+02	3.42E+02	4
C-101R	CNS GWPI / C-101R / U-1 SFP	6.83E+02	5.26E+02	4.56E+02	7.40E+02	4
C-102	CNS GWPI / C-102 / E of U1 SFP O/S protected area	4.08E+02	NS	1.93E+02	NS	2
C-103	CNS GWPI / C-103 / E of U1 SFP @ Cooling Towers	3.51E+02	NS	3.16E+02	NS	2
C-104	CNS GWPI / C-104 / U-1 RMWST	7.06E+02	4.33E+02	3.81E+02	7.39E+02	4
C-105	CNS GWPI / C-105 / Engr. Bldg.	5.06E+02	3.95E+02	<MDA	5.62E+02	4
C-105R	CNS GWPI / C-105R / Engr. Bldg.	6.70E+02	4.21E+02	3.45E+02	3.28E+02	4
C-106	CNS GWPI / C-106 / W Parking Lot	<MDA	NS	<MDA	NS	2
C-106R	CNS GWPI / C-106R / W Parking Lot	<MDA	NS	<MDA	NS	2
C-107	CNS GWPI / C-107 / MET Tower Hill	9.77E+02	6.42E+02	4.74E+02	5.46E+02	4
C-108	CNS GWPI / C-108 /	<MDA	NS	<MDA	NS	2
C-109	CNS GWPI / C-109 /	6.83E+02	NS	6.20E+02	NS	2
C-110	CNS GWPI / C-110 /	1.20E+03	1.22E+03	1.38E+03	1.38E+03	4
C-200DR	CNS GWPI / C-200DR / U-2 SFP	2.68E+02	3.47E+02	2.79E+02	3.59E+02	4
C-200R	CNS GWPI / C-200R / U-2 SFP	4.26E+02	4.74E+02	5.20E+02	5.30E+02	4
C-201DR	CNS GWPI / C-201DR / U-2 SFP	2.90E+02	3.69E+02	3.90E+02	3.50E+02	4
C-201R	CNS GWPI / C-201R / U-2 SFP	8.06E+02	7.14E+02	8.25E+02	1.14E+03	4
C-202	CNS GWPI / C-202 / S of RMC Tent	3.24E+02	NS	5.97E+02	NS	2
C-203	CNS GWPI / C-203 / E of RMC Tent @ Cooling Towers	<MDA	NS	2.73E+02	NS	2
C-204	CNS GWPI / C-204 / S of RMC Tent	3.48E+02	NS	5.17E+02	NS	2
C-205	CNS GWPI / C-205 / Adm. Parking	<MDA	<MDA	<MDA	<MDA	4
C-205R	CNS GWPI / C-205R / Adm. Parking	<MDA	<MDA	<MDA	<MDA	4
C-206	CNS GWPI / C-206 / W Parking Lot	<MDA	NS	<MDA	NS	2
C-207	CNS GWPI / C-207 / Mon. Tank B	2.01E+02	3.08E+02	2.24E+02	2.43E+02	4
C-207R	CNS GWPI / C-207R / Mon. Tank B	<MDA	<MDA	<MDA	<MDA	4
C-208	CNS GWPI / C-208 / N of MTB	<MDA	NS	<MDA	NS	2
C-209	CNS GWPI / C-209 / MTUville S of light pole 23A	2.37E+02	<MDA	<MDA	2.50E+02	4
C-210	CNS GWPI / C-210 / N of U2 Mech Equip Bldg	<MDA	NS	<MDA	NS	2
C-211	CNS GWPI / C-211 / W of RL Intake O/S Protected Area	5.31E+02	NS	NS	7.30E+02	2
C-212	CNS GWPI / C-212 / Behind Aquatic Center	<MDA	<MDA	<MDA	<MDA	4
C-213R	CNS GWPI / C-213R / Mon. Tank B	2.80E+02	<MDA	<MDA	<MDA	4
C-214	CNS GWPI / C-214 / N of U2 TB	8.79E+02	7.14E+02	5.02E+02	6.65E+02	4
C-215	CNS GWPI / C-215 / N of U2 TB	7.21E+02	3.66E+02	3.91E+02	4.55E+02	4
C-217	CNS GWPI / C-217 / N of U2 TB	5.88E+02	NS	5.17E+02	NS	2
C-218	CNS GWPI / C-218 / N of U2 TB	5.07E+02	4.65E+02	2.63E+02	4.25E+02	4
C-221	CNS GWPI / C-221 / N of U2 TB	4.60E+02	3.74E+02	3.34E+02	3.73E+02	4

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Catawba Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Well Name	Location / Description	Tritium Concentration (pCi/l)				# of Samples
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	
LMW-1B	CNS Landfill / LMW-1B / Landfill	NS	<MDA	NS	<MDA	2
LMW-2A	CNS Landfill / LMW-2A / Landfill	NS	<MDA	NS	<MDA	2
LMW-3A	CNS Landfill / LMW-3A / Landfill	NS	<MDA	NS	<MDA	2
LMW-4	CNS Landfill / LMW-4 / Landfill	NS	1.69E+02	NS	2.70E+02	2
LMW-5D	CNS Landfill / LMW-5D / Landfill	NS	<MDA	NS	<MDA	2
LMW-5S	CNS Landfill / LMW-5S / Landfill	NS	<MDA	NS	<MDA	2
OUTFALL01	CNS WC Ponds / OUTFALL-017 / WC Ponds	1.17E+03	2.34E+03	9.92E+02	1.10E+03	4
WCMW-2	CNS WC Ponds / WCMW-2 / WC Ponds	1.97E+03	1.87E+03	1.57E+03	1.43E+03	4
WCMW-3	CNS WC Ponds / WCMW-3 / WC Ponds	1.05E+03	9.10E+02	1.04E+03	1.06E+03	4
WCMW-4	CNS WC Ponds / WCMW-4 / WC Ponds	4.61E+02	3.11E+02	4.30E+02	2.91E+02	4
WCMW-5	CNS WC Ponds / WCMW-5 / WC Ponds	<MDA	<MDA	<MDA	<MDA	4

Well Name	Location / Description	Tritium Concentration (pCi/l)			# of Samples
		Minimum	Average	Maximum	
C-213	CNS GWPI / C-213 / Mon. Tank B	6.31E+03	8.28E+03	1.05E+04	6
C-220	CNS GWPI / C-220 / N of U2 TB	8.15E+02	1.80E+03	2.98E+03	6

**Attachment 8
Inoperable Equipment**

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 8

Inoperable Equipment

This attachment includes an explanation of inoperable instruments related to effluent monitoring in excess of allowed time defined by licensing bases and an explanation of temporary outside liquid storage tanks exceeding 10 Curies total activity (excluding tritium and dissolved or entrained noble gases).

Attachment 8 Inoperable Equipment

Catawba Nuclear Station Units 1 & 2 Period 1/1/2019 - 12/31/2019

Catawba Nuclear Station had one instance of any inoperable equipment relevant to effluent monitoring in excess of SLC 16.11 limits during 2019. Details are discussed below.

Catawba Nuclear Station did not experience any temporary unprotected outside liquid storage tanks exceeding 10 Curies total activity (excluding tritium and dissolved or entrained noble gases) during 2019.

SLC # from Table 16.11-7-1	Title	Completion Time	Determination and Data Reviewed
1.a	EMF-50 - Low Range	14 days	For 0EMF-50L, out of service time for 2019 was 51.28 days (04/15/2019 08:47:31 to 06/05/2019 15:34:07) LCOTR A-0-19-00610.

Work Request 20139963 (0EMF-50: HIGH RAD ALARM) was generated on 04/15/2019. This Work Request was converted to Work Order 20323206. It was identified that EMF50 was functioning correctly and that operation of the Waste Gas System was at fault. The initial activity spike on 0EMF50L may be due to residual higher activity gas trapped inside WG piping between WGDT C and 1WG160. Based on the pre-release sample, 5.94E-04 uCi/cc Kr-85 (Xe-133 equivalent 6.46E-03 uCi/cc), the expected count rate on 0EMF50L was 9.07E+03 with Trip 1 and Trip 2 setpoints of 1.26E+04 cpm and 1.80E+04 cpm respectively. On the initial release attempt, 0EMF50L count rate rapidly increased and exceeded its setpoints. This trip 2 signal caused 1WG160 to close and 0EMF50L was left monitoring a dead leg of pipe with count rate reaching 47 kcpm. Based on this, the Trip 2 setpoint on 0EMF50L was increased to 54 kcpm to allow for the release to continue. After purging the detector, the release was attempted again, and 0EMF50L activity plateaued at 15 kcpm and stayed stable throughout the release. The 15 kcpm is within the correlation tolerance band for the EMF (50% expected count rate to 200% expected count rate) and within the calculated Trip 2 value. Based on this information, 0EMF50 is functioning as required.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 9

Summary of Changes to the Offsite Dose Calculation Manual

This attachment includes a summary of changes to the ODCM and Radiological Effluent Controls.

Attachment 9 Summary of Changes to the Offsite Dose Calculation Manual

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ODCM Revision 63

ODCM Revision 63 is provided in entirety in this section.

Summary of ODCM Revision 63 Changes

ODCM Revision 63 was approved by the Radiation Protection Manager on 12/12/2019. Some changes reflected were implemented prior to the above date under a different change and approval process (e.g., land use census), and in those cases the implementation date is noted below. Changes driven by Document Revision Requests (DRR) are noted with DRR number.

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Updated page numbers as necessary.

Section 6 - Page 3

Table 6.0-1:

- Removed point surface water control point 215C (River Pointe -Hwy 49 (4.21 mi NNE)) and added new surface water control point 263C (Liberty Hill Road (0.59 mi NNE)). The previous control point was located on private property. The new control point is located in the York County Sheriff's Office (YCSO) Lake Enforcement boat house on Duke Energy property. A Memorandum of Understanding has been established with the YCSO for monthly surface water sampling to be performed at this location. Changes took effect on 01/03/2019 as documented in DRR 02247815.
- Changed Location Description for point 262C from "T-Bones Restaurant / Lake Wylie Marina - Hwy 49 (4.19 mi NNE)" to "Lake Wylie Marina - Hwy 49 (4.19 mi NNE)." The T-Bones restaurant was sold to new owners who changed the name of the establishment to Papa Doc's Shore Club; removed name of restaurant from sample location.

Section 6 - Page 6

Updated Figure 6.0-1 Sampling Locations Map (Site Boundary), to add sample location 263. Change to sampling location took effect on 01/03/2019 as documented in DRR 02247815. Updated Map generated December 2019.

Section 6 – Page 7

Updated Figure 6.0-2 Sampling Locations Map (Ten Mile Radius), to remove sample location 215. Change to sampling location took effect on 01/03/2019 as documented in DRR 02247815. Updated Map generated December 2019.

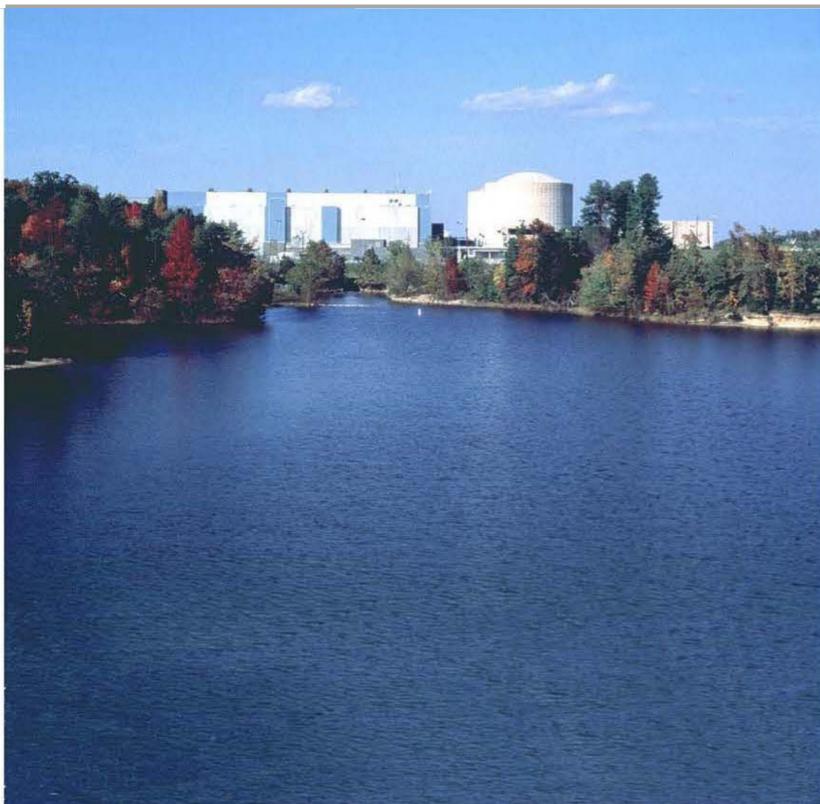
Radiological Effluent Controls (SLC 16.11)

The Catawba Nuclear Station Radiological Effluent Controls are contained in SLC 16.11 shown in this section.

There was one revision to the Catawba Nuclear Station Updated Final Safety Analysis Report, Section 16.11, Radiological Controls, in 2019. SLC 16.11-20, Explosive Gas Monitoring Instrumentation, Revision 3, was approved on 11/21/2019. Changes to TR 16.11-20-3 and the Bases were made based on replacement of obsolete instruments under Engineering Change (EC) 415235; further details on the EC are provided in Attachment 11, Summary of Major Modifications to the Radioactive Waste Treatment Systems, of this report.

As per TS 5.5.5.b, "Licensee initiated changes to the Radiological Effluent Controls of the UFSAR," Catawba is attaching the entire Section 16.11 of the UFSAR and the List of Effective Sections which will demonstrate when each section was revised.

Catawba Nuclear Station Units 1 and 2



ODCM

Offsite Dose
Calculation Manual



**Catawba Nuclear Station
Units 1 and 2**

**OFFSITE DOSE CALCULATION MANUAL
(ODCM)**

Revision 63

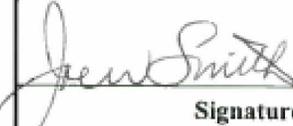
Prepared By: Jonathan B. Hanni CNS Station Sciences (RP)	 Signature	12/10/2019 Date
Reviewed By: Daniel J. Sullivan CNS Station Sciences (RP)	 Signature	12/10/19 Date
Approved By: Joe W. Smith CNS Radiation Protection Manager	 Signature	12/12/19 Date



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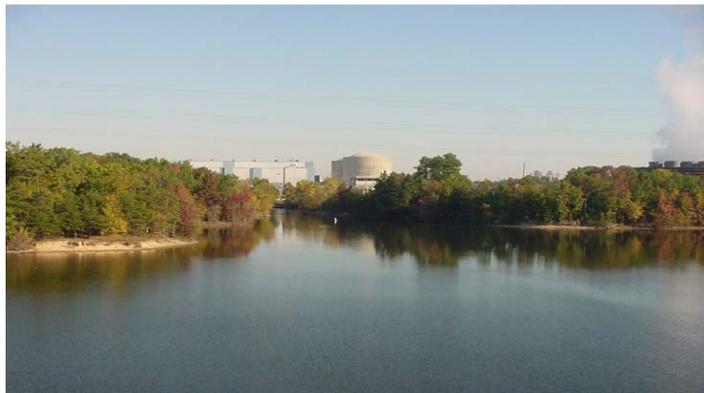
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EXECUTIVE SUMMARY

The Catawba Nuclear Station (CNS) Offsite Dose Calculation Manual (ODCM) provides the methodology and parameters to be used in the calculation of offsite doses due to normal operation radioactive liquid and gaseous effluents to assure compliance with the dose limitations of the Selected Licensee Commitments (SLCs, UFSAR Chapter 16) and Technical Specifications (TSs). These dose limitations assure that:

- (1) the concentration of radioactive liquid effluents released from the site to the unrestricted area will be limited to 10 times the effluent concentration (EC) levels of 10CFR20, Appendix B, Table 2, and 2.0E-04 $\mu\text{Ci/ml}$ for dissolved and entrained noble gases (TS 5.5.5(a)(2), SLC 16.11-1);
- (2) the exposures to any individual member of the public from radioactive liquid effluents will not result in doses greater than the ALARA design objectives of 10CFR50, Appendix I or the 10CFR20 limits (TS 5.5.5(a)(4), SLC 16.11-3);
- (3) the dose rate at any time at the site boundary from radioactive gaseous effluents will be limited to: for noble gases; less than or equal to 500 mrem/yr to the whole body, and less than or equal to 3000 mrem/yr to the skin; and for iodine-131 and iodine-133, for tritium, and for all radioactive materials in particulate form with half-lives greater than 8 days; less than or equal to 1500 mrem/yr to any organ (TS 5.5.5(a)(7), SLC 16.11-6);
- (4) the exposure to any individual member of the public from radioactive gaseous effluents will not result in doses greater than the ALARA design objectives of 10CFR50, Appendix I or the 10CFR20 limits (TS 5.5.5(a) (8 and 9), SLCs 16.11-8 and 16.11-9); and
- (5) the dose to any individual member of the public from the nuclear fuel cycle will not exceed the limits of 40CFR190 (TS 5.5.5(a)(10), SLC 16.11-12).

The methodology and parameters used to assure compliance with the dose limitations described above shall be used to prepare the radioactive liquid and gaseous effluent reports required by the SLCs and Technical Specifications. Dose calculations that demonstrate compliance with 40CFR190 will be considered to demonstrate



Catawba Nuclear Station
Offsite Dose Calculation Manual (ODCM)

compliance with the 10CFR20 0.1-rem annual dose limit. The ODCM also provides the methodology and parameters to be used in the calculation of radioactive liquid and gaseous effluent monitoring instrumentation alarm/trip setpoints to assure compliance with the concentration and dose rate limitations of the SLCs and Technical Specifications. Software implementing NUREG-0133 methodology is used for the calculation of offsite doses, but the ODCM also provides a method for the calculation of offsite doses when the software is not available..

The ODCM has been prepared as generically as possible in order to minimize the need for revisions. Any changes to the methodology and parameters to be used in this ODCM shall be reviewed by knowledgeable individual(s), and approved by the Station Manager or Radiation Protection Manager prior to implementation. Changes to the ODCM shall be submitted to the Nuclear Regulatory Commission in accordance with the SLCs and Technical Specifications.

The ODCM does not replace any station implementing procedures. Programmatic controls for radioactive effluents and radiological environmental monitoring are contained in the Administrative Controls chapter of the Technical Specifications. Procedural details for radioactive effluents and radiological environmental monitoring consisting of licensee commitments, applicability, remedial actions, surveillance requirements, and the bases for these requirements are contained in Section 16.11 of the SLCs.

1.0 RADWASTE SYSTEMS

1.0.1 LIQUID RADWASTE PROCESSING

The liquid radwaste system at Catawba Nuclear Station is used to collect and treat liquid chemical and radiochemical byproducts of unit operation. The system produces effluents that can be reused in the plant or discharged in small, dilute quantities to the environment. The means of treatment vary with waste type and desired product in the various systems:

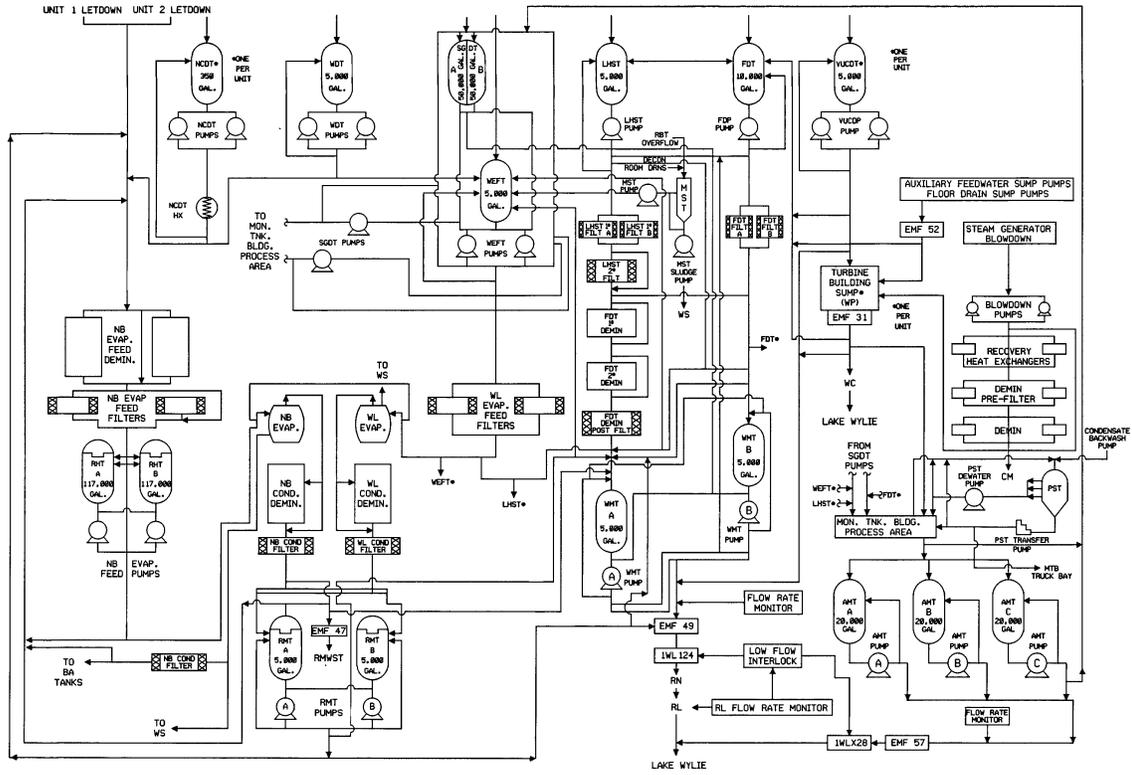
- (A) Filtration - Waste sources may be filtered during processing.
- (B) Adsorption - Adsorption of halides and organic chemicals by activated charcoal (carbon filter) may be used as needed in treating waste streams in the Liquid Radwaste System (WL). The carbon filter is designed to remove organophosphates and free chlorine. Activated charcoal need not be used when these chemicals are not present (e.g., phosphate detergents are not used at the station). Ion exchange resin or other media may be used in the carbon filter vessel as desired.
- (C) Ion Exchange - Ion exchange is used to remove radioactive ions from solution, as in the case of the Floor and Equipment drain waste in WL, after removal of organics by carbon filtration (adsorption). Ion exchange is also used in removing both radioactive and non-radioactive ions from evaporator distillates in order to purify the distillates for reuse as makeup water. Distillate from the Boron Recycle Evaporator in the Boron Recycle System (NB) can be treated by this method, as well as WL waste, and reactor bleed.
- (D) Gas Stripping - Removal of gaseous radioactive fission products is accomplished in recycled water by the NB Evaporator.
- (E) Distillation - Production of pure water from reactor coolant by boiling it away from the contaminated solution which it was originally contained is accomplished by the NB evaporator. Proper control of the process will yield water that can be reused for makeup. Polishing of this product can be achieved by ion exchange as discussed above.
- (F) Concentration - In the NB Evaporator dissolved chemicals are concentrated in the lower shell as water is boiled away. The WL Evaporator is no longer utilized due to more cost effective process options for floor and equipment drains, e.g., ion exchange. In the NB Evaporator the dilute boron is normally concentrated to 4% so that it may be reused for makeup to the reactor coolant system.

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Figure 1.0-1 is a schematic representation of the liquid radwaste system at Catawba.

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Offsite Dose Calculation Manual (ODCM)

Figure 1.0-1 Catawba Nuclear Station Liquid Radwaste System



1.0.2 GASEOUS RADWASTE PROCESSING

The Gaseous Waste System (WG) for Catawba is designed with the capability of processing the fission product gases from contaminated reactor coolant fluids resulting from operation. The design basis for the WG shown schematically in Figure 1.0-2 is the retention, through the plant lifetime, of all the gaseous fission products to be discharged from the reactor coolant system to the Chemical and Volume Control System (NV) and other plant systems to eliminate the need for intentional discharge of radioactive gases from the waste gas holdup tanks. Actual system operation is aimed at maximizing storage time for decay prior to infrequent releases. Unavoidable sources of low level radioactive gaseous discharge to the environment will be from periodic purging operations of the containment, and through the secondary system air ejector. With respect to the former, the potential contamination is expected to arise from non-recyclable reactor coolant leakage. With respect to the air ejector, the potential source of contamination will be from leakage of the reactor coolant to the secondary system through defects in steam generator tubes. The gaseous waste disposal system includes two waste gas compressors, two catalytic hydrogen recombiners, six gas decay storage tanks for use during normal power generation, and two gas decay storage tanks for use during shutdown and startup operations, and for pressure relief.

1.0.2.1 GAS COLLECTION SYSTEM

The gas collection system combines the waste hydrogen and fission gases from the volume control tanks, the boron recycle and liquid waste gas stripper evaporators, and other sources produced during normal operation or the gas collected during the shutdown degasification (high percentage of hydrogen), and cycles it through the catalytic recombiners to convert hydrogen to water. After the water vapor is removed, the resulting gas stream is transferred from the recombiner into the waste gas decay tanks (WGDTs), where the accumulated activity may be contained in six approximately equal parts. From the decay tanks, the gas flows back to the compressor suction to complete the circuit.

1.0.2.2 CONTAINMENT AND AUXILIARY BUILDING VENTILATION

Non-recyclable reactor coolant leakage occurring either inside the containment or inside the auxiliary building will generate gaseous activity. Gases resulting from leakage inside the containment will be contained until the containment air is released through either the Containment Air Release and Addition System (VQ) or the Containment Purge System (VP). The containment atmosphere will be discharged through charcoal adsorbers and HEPA filters to reduce releases to the environment.

Gases resulting from leakage inside the auxiliary building are released, without further decay, to the atmosphere. The ventilation exhaust from potentially contaminated areas in the auxiliary building is passed through charcoal adsorbers and HEPA filters to reduce releases to the atmosphere upon a radiation monitor alarm.

1.0.2.3 SECONDARY SYSTEMS

Normally, condensate flow and steam generator blowdown will go parallel through 4 of the 5 condensate polishing demineralizers to remove activity and harmful ions from the water. Non-condensable gases will be taken from the secondary system by the condenser steam air ejector, and are passed through a radiation monitor to the unit vent.

Some low radioactivity secondary system steam releases can occur at the site such as from infrequent lifts of the main steam relief valves and testing of the main steam manual atmospheric dump valves. Radioactivity released from secondary system steam releases is documented and included in the site effluent release total.

Figure 1.0-2 is a schematic representation of the gaseous radwaste system at Catawba.

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**Figure 1.0-2 Catawba Nuclear Station Gaseous Radwaste System
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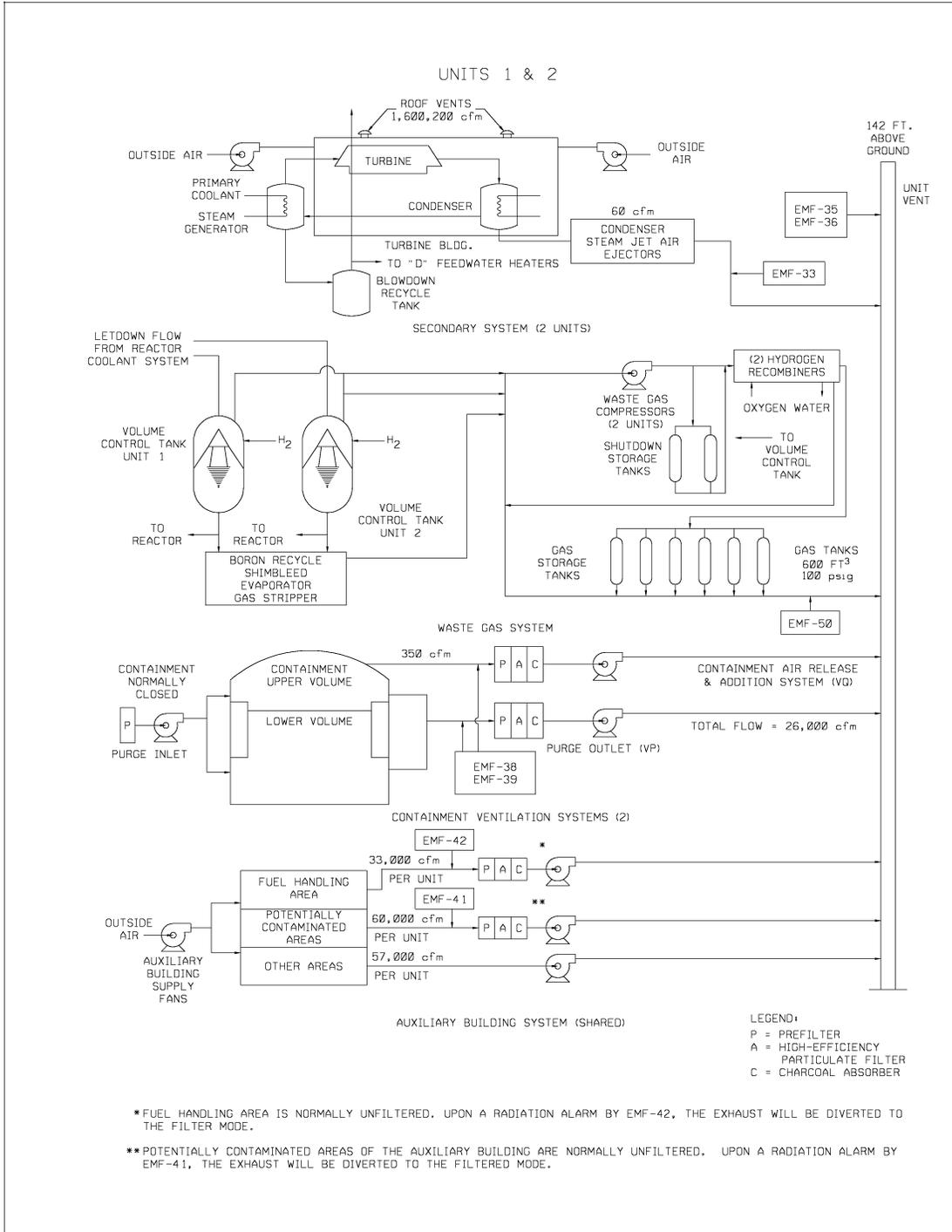
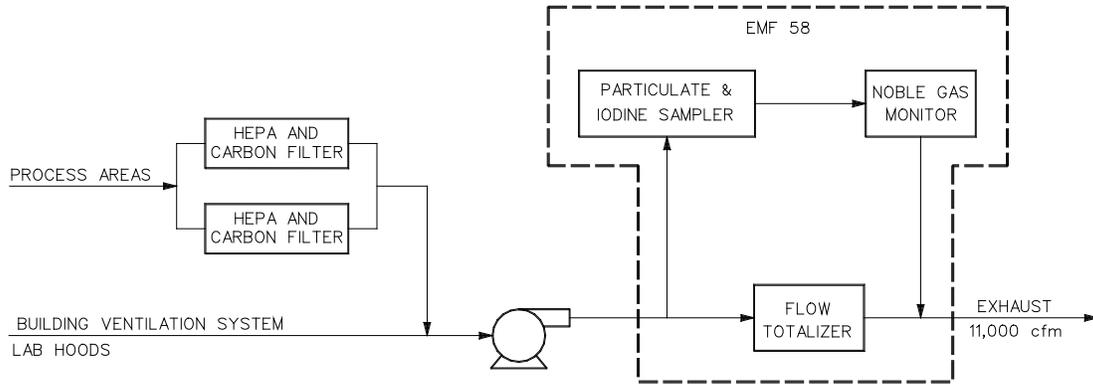


Figure 1.0-2 Catawba Nuclear Station Gaseous Radwaste System
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AUXILIARY MONITOR TANK BUILDING



2.0 RELEASE RATE CALCULATIONS

2.0.1 LIQUID RELEASE RATE LIMIT CALCULATIONS

There are two liquid radwaste discharge points to the environment at Catawba; (1) the Low Pressure Service Water System (RL) and Nuclear Service Water System (RN) discharge point to Lake Wylie, and (2) the Conventional Waste Water Treatment System (WC) discharge point to Lake Wylie (See Figure 2.0-1).

2.0.1.1 RL/RN DISCHARGE RELEASE RATE LIMIT CALCULATION

Liquid releases to Lake Wylie through the RL/RN pathway normally contain the radioactive releases from the site including effluents from the waste monitor tanks, recycle monitor tanks, and auxiliary monitor tanks. The RL/RN discharge point can also contain turbine building sump (TBS) releases, however TBS effluent is normally released through the WC discharge point. There are three RL pumps with a minimum flow rate of 19,000 gpm each, and four RN pumps with a minimum flow rate of 8,600 gpm each which provide the required dilution water needed for a release. Each release path has a radiation monitor (EMF) that is used to monitor the liquid effluent (See Figure 2.0-2).

To comply with Technical Specifications and Selected Licensee Commitments, and to assure that the concentration of radioactive liquid effluents released from the site to the unrestricted area is limited to 10 times the effluent concentrations (ECs) of 10CFR20, Appendix B, Table 2, Column 2, and $2.0E-04$ $\mu\text{Ci/ml}$ for dissolved and entrained noble gases, the following release rate limit calculation shall be performed for liquid releases to Lake Wylie via the RL/RN discharge point:

$$f \leq (F \div (DF - 1)) \quad \text{Condition: } DF > 1.0 \quad \text{Equation 2.1}$$

where:

f = the undiluted effluent flow, in gpm.

F = the dilution flow available depending on the number of RL/RN pumps in service, in gpm for batch releases, e.g., Waste Monitor Tank.

DF = required dilution factor to be applied to the undiluted effluent flow, unitless.

$$DF = \sigma \times \sum_i \frac{C_i}{(10 \times EC_i)} \quad \text{Equation 2.2}$$

Note:

If $DF \leq 1.0$ then no dilution is required and the release rate is unrestricted.

If $DF > 1.0$ then dilution flow is required and the release rate is calculated using Equation 2.1. Equation 2.1 is used only when $DF > 1.0$.

σ = the most restrictive recirculation factor at equilibrium, (dimensionless). The recirculation factor accounts for the fraction of discharged water reused by the station. For Catawba the recirculation factor equals 1.0 since discharged liquid effluent is not reused by the station.

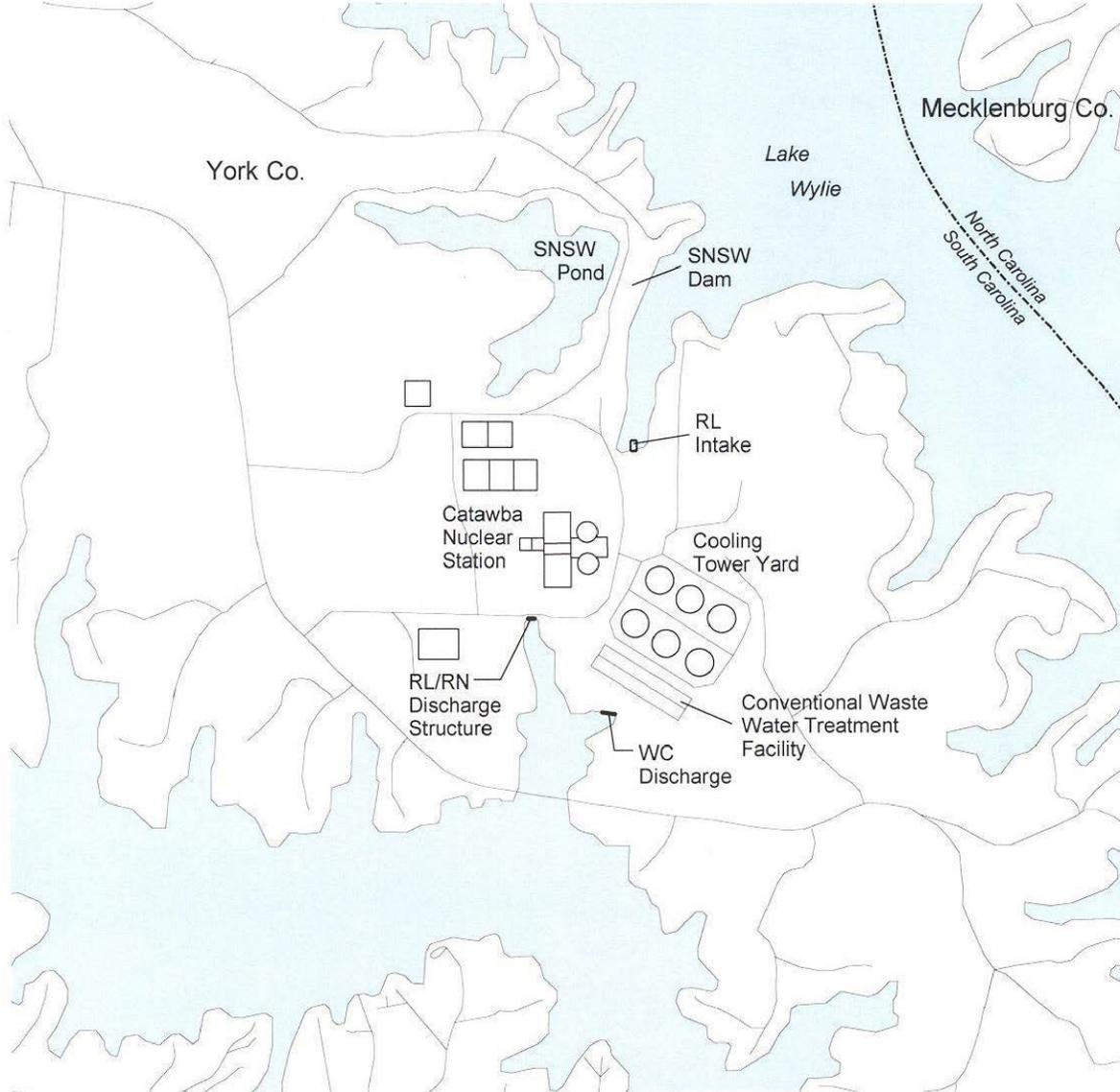
C_i = the concentration of radionuclide, 'i', in the undiluted liquid effluent, in $\mu\text{Ci/ml}$.

EC_i = the concentration of radionuclide, 'i', from 10CFR20, Appendix B, Table 2, Column 2, in $\mu\text{Ci/ml}$. Note: if radionuclide, 'i', is a dissolved noble gas, then $EC_i = 2.00\text{E-}05 \mu\text{Ci/ml}$.

2.0.1.2 WC DISCHARGE CONTINUOUS RELEASES

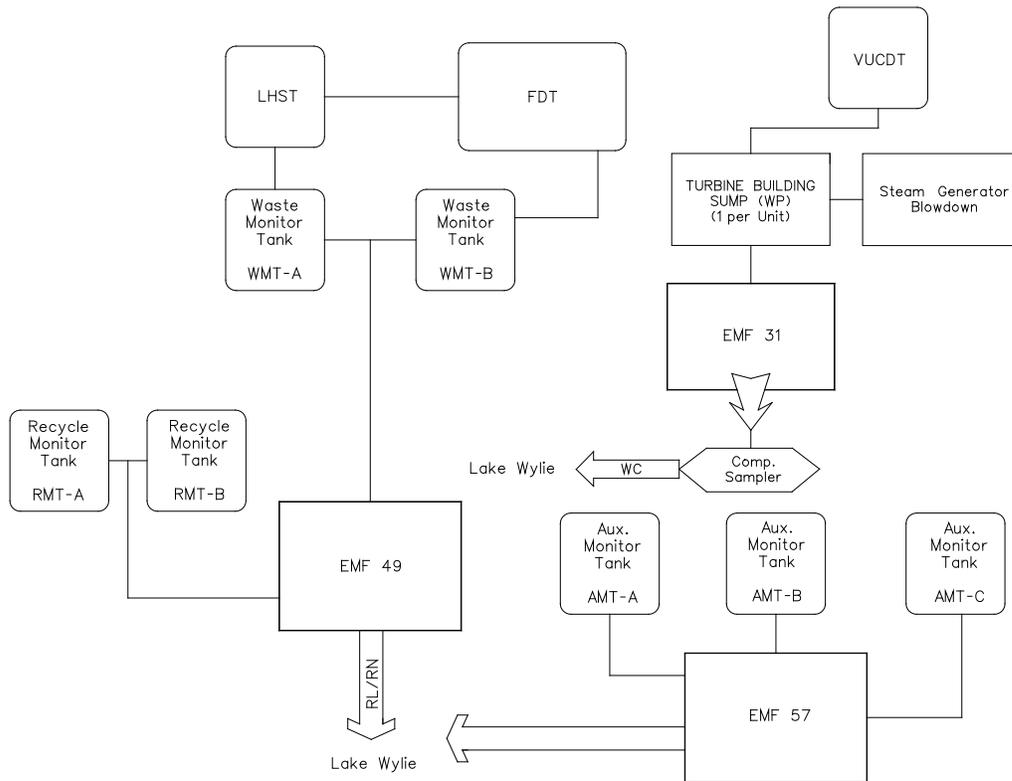
Liquid releases to Lake Wylie via the WC discharge point normally contain little measurable activity above background. Although designed for continuous discharge, inputs to WC, primarily from the Unit 1 and Unit 2 turbine building sumps, are normally held up in one of three WC Ponds, then released as a batch. There is a composite sampler at the discharge to the lake. An EMF monitors the TBS/Condenser Drain output (See Figure 2.0-2). It is assumed that no activity is present in the TBS effluent until indicated by radiation monitoring measurements. If radioactivity is detected above the monitor's alarm setpoint, an alternate discharge route may be used. A control room alarm indicates this radioactivity. At this time the discharge may be routed to WL for processing rather than through WC. Liquid effluent releases through WC typically account for less than 1% of tritium releases from Catawba.

Figure 2.0-1 Liquid Radwaste Discharge Locations



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Figure 2.0-2 Liquid Radwaste Discharge to Lake Wylie



2.0.2 GASEOUS RELEASE RATE LIMIT CALCULATIONS

The two unit vents are the primary gaseous radioactive release points at Catawba. The unit vents are the release points for waste gas decay tanks, containment building purges, auxiliary building ventilation, and the condenser air ejector (see Figure 2.0-3). Each unit vent has multi-range radiation monitors and flow rate measuring instrumentation.

There is one other separate gaseous effluent release point at Catawba, the Auxiliary Monitor Tank Building (AMTB), that is normally considered non-radioactive; that is, it is possible but unlikely that the effluent will contain measurable activity above background. However, the potential for release of radioactive effluents remains with certain job evolutions that may take place in the AMTB. The process areas of the AMTB ventilation pass through particulate and charcoal filters. The AMTB release point has an EMF, effluent sampler, and flow totalizer (see Figure 1.0-2).

2.0.2.1 UNIT VENT DISCHARGE RELEASE RATE LIMIT CALCULATION

In order to comply with Technical Specifications and SLCs and to assure that the dose rate, at any time, at or beyond the site boundary due to radioactive materials released in gaseous effluents from the site is limited to: ≤ 500 mrem/yr to the total body, and ≤ 3000 mrem/yr to the skin for the noble gases, and is limited to ≤ 1500 mrem/yr to any organ for radioiodine and for radioactive materials in particulate form, and radionuclides other than noble gases with half lives greater than 8 days, the following release rate and radiation monitor setpoint calculations shall be performed for releases from the waste gas decay tanks and the containment building. The release rate calculations when solved for the flow rate, 'f', are the release rates for noble gases and for radioiodines, particulates and other radionuclides with half-lives greater than 8 days. The most conservative release rate calculated shall control the flow rate. The following equations are based on the site dose rate limits. When applied to the individual release points the site dose rate values are apportioned 49% to each unit vent and 2% to the AMTB vent assuring that simultaneous releases from all release points do not exceed the controlling release rate for a single point.

a. Noble Gases

Total Body:

$$\sum_i \left(K_i \times \frac{\lambda}{Q} \times Q_i \right) < 500 \text{ mrem/yr} \quad \text{Equation 2.3}$$

Skin:

$$\sum_i \left((L_i + 1.1M_i) \times \frac{\lambda}{Q} \times Q_i \right) < 3000 \text{ mrem/yr} \quad \text{Equation 2.4}$$

b. Radioiodines, Particulates, and Others

Inhalation, Ingestion and Ground Organ Pathways:

$$\sum_p \sum_i (P_{opi} \times W \times Q_i \times E_i) < 1500 \text{ mrem/yr}$$

To include both the food and ground organ dose and the inhalation organ dose the equation can be expanded to:

$$\sum_p \sum_i \{ (P_{opi})_{\text{food/gr}} \times W_{D/Q} + (P_{opi})_{\text{inhal}} \times W_{\chi/Q} \} \times Q_i \times E_i < 1500 \text{ mrem/yr}$$

Equation 2.5

where:

K_i = the total body dose factor due to gamma emissions for each identified noble gas radionuclide, 'i', in mrem/yr per $\mu\text{Ci}/\text{m}^3$ (See Appendix A).

L_i = the skin dose factor due to beta emissions for each identified noble gas radionuclide, 'i', in mrem/yr per $\mu\text{Ci}/\text{m}^3$ (See Appendix A).

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide, 'i', in mrad/yr per $\mu\text{Ci}/\text{m}^3$ (See Appendix A).

1.1 = ratio to convert dose (mrad) to dose equivalent (mrem).

P_{opi} = the dose parameter for radionuclides other than noble gases for the inhalation pathway, in mrem/yr per $\mu\text{Ci}/\text{m}^3$ and for the food and ground plane pathways in ($\text{m}^2 \times (\text{mrem/yr per } \mu\text{Ci}/\text{sec})$) for organ, 'o', and radionuclide, 'i', (See Appendix B for the pathway specific dose commitment factors). Note: NUREG-1301, page 75, specifies use of the Child age group, Inhalation pathway, for the P_{opi} values.

χ/Q = the highest calculated annual average dispersion parameter for any area at or beyond the site boundary in sec/m^3 . For Catawba this value is $3.510\text{E}-5 \text{ sec}/\text{m}^3$. The location is the NNE sector at 0.5 mile. As discussed in Catawba UFSAR Section 2.1.1.3, the boundary for establishing gaseous effluent release limits is the exclusion area boundary (EAB). The EAB is defined as a 2500-ft. (~0.5 mile) radius from the station center.

W = the highest calculated annual average dispersion or deposition parameter for estimating the maximum dose rate to an individual from the total inhalation, food, and ground plane pathways:

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$W_{\chi/Q}$ = 3.510E-5 sec/m³, for the inhalation pathway and the airborne H-3 food pathway. The location is the NNE sector at 0.5 mile.

$W_{D/Q}$ = 1.078E-7 m², for the food and ground plane pathways. The location is the NNE sector at 0.5 mile.

E_i = the filter removal factor for radionuclide, 'i', e.g., for 99% removal $E_i = 0.01$. For VQ, VP and AMTB releases $E_i = 0.1$ for iodine, 0.01 for particulates. There is no filtration for WGDT releases.

Q_i = the release rate of radionuclide, 'i', in gaseous effluent from all release points at the site, in $\mu\text{Ci}/\text{sec}$.

$$Q_i = k_1 C_i f \div k_2 = 472 \times C_i f \quad \text{Equation 2.6}$$

where:

C_i = the concentration of radionuclide, 'i', in undiluted gaseous effluent, in $\mu\text{Ci}/\text{ml}$.

f = the undiluted effluent flow, in ft³/min.

k_1 = conversion factor, 2.83E+04 cc/ft³.

k_2 = conversion factor, 60 sec/min.

Substituting the expression for Q_i in Equation 2.6 into Equations 2.3, 2.4, and 2.5, and solving for the flow rate, ' f ', in each equation gives:

Noble Gases - Total Body Maximum Release Rate:

$$f_{tb} < \frac{500}{472 \times \chi/Q \times \sum_i (K_i \times C_i)}$$

Noble Gases - Skin Maximum Release Rate:

$$f_{sk} < \frac{3000}{472 \times \chi/Q \times \sum_i [(L_i + 1.1M_i) \times C_i]}$$

Radioiodines, Particulates, and Others - Organ Maximum Release Rate:

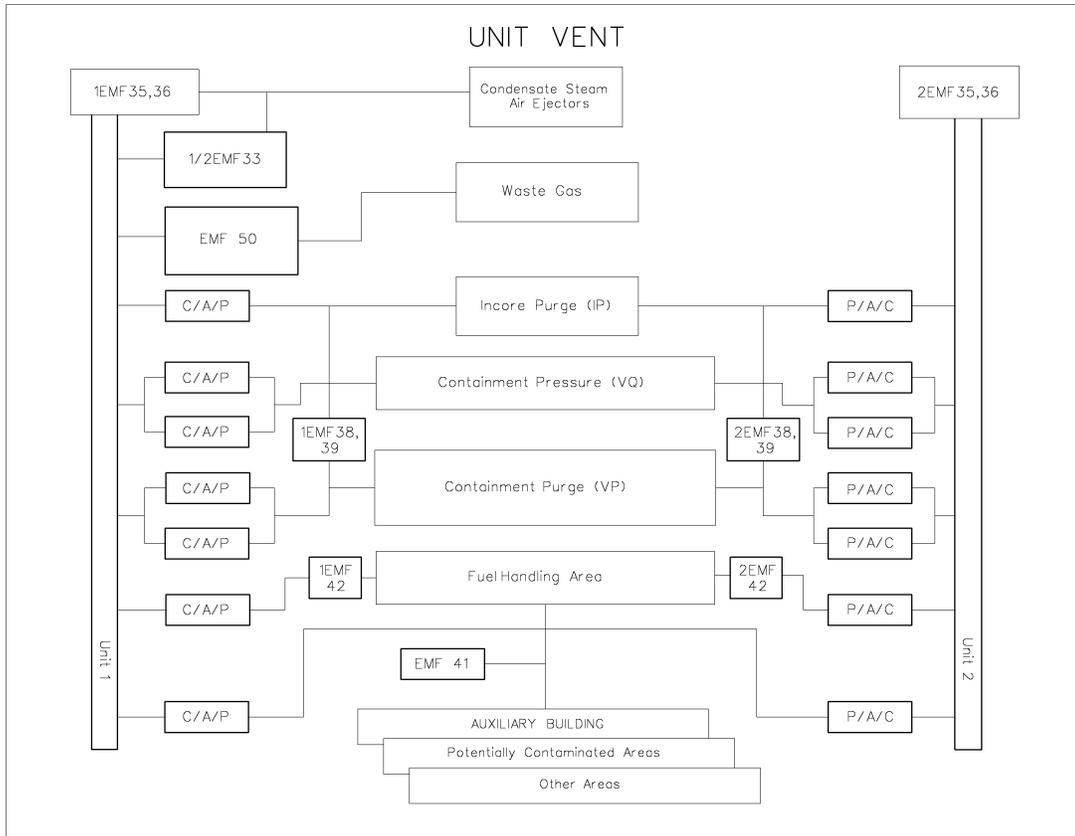
$$f_{or} < \frac{1500}{472 \times \sum_p \sum_i \{ (P_{opi})_{food/gr} \times W_{D/Q} + (P_{opi})_{inhal} \times W_{\chi/Q} \} \times E_i \times C_i}$$

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f_{tb} , f_{sk} , and f_{or} , are calculated for each batch prior to release. The most limiting gaseous release rate is used to assure that no instantaneous dose rate limit is exceeded.

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Figure 2.0-3 Unit Vent Release Points



Derivations of Iodine, Particulate, and H-3 Dose Commitment Factors (P_{opi})

Inhalation Pathway - Child Age Group

$$P_{opi} = K'(BR)(DFA_{oi})$$

Formula: from NUREG-0133, page 25.	
Where:	
P_{opi}	Dose commitment factor for child age group, organ o, nuclide i, for the inhalation pathway (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendix B for the pathway specific dose commitment factors).
K'	Units conversion factor $\text{pCi}/\mu\text{Ci}$ (10^6).
BR	Breathing rate for the child age group (m^3/yr , from Regulatory Guide 1.109): Child – 3700
DFA_{oi}	Organ inhalation dose conversion factor for child age group, organ o, nuclide i, (mrem/pCi), from Table E-9 of Regulatory Guide 1.109.

3.0 SETPOINT CALCULATIONS

3.0.1 LIQUID RADIATION MONITOR SETPOINT CALCULATIONS

Once the liquid release rate parameters have been established radiation monitor setpoints shall be calculated to assure that the concentration of radioactive liquid effluents released from the site to the unrestricted area is limited to ten times the effluent concentrations (ECs) of 10CFR20, Appendix B, Table 2, Column 2, and 2.0E-04 $\mu\text{Ci/ml}$ for dissolved and entrained noble gases. By substituting the dilution factor (DF) from Equation 2.2 into Equation 2.1, solving for the undiluted liquid effluent concentration, C_i , and accounting for the monitor background reading, the liquid radiation monitor setpoint can be readily obtained by multiplying C_i by the radiation monitor correlation factor, CF_i , as follows:

$$C_i \leq \frac{(F + f) \times (10 \times EC_i)}{\sigma \times f} \quad \text{Equation 3.1}$$

$$SP \leq \sum_i (C_i \times CF_i) + bkg \quad \text{Equation 3.2}$$

where:

C_i = the maximum allowable concentration of radionuclide, 'i', in the undiluted liquid effluent, in $\mu\text{Ci/ml}$.

SP = radiation monitor setpoint, in cpm.

CF_i = radiation monitor correlation factor for radionuclide, 'i', in cpm/ $\mu\text{Ci/ml}$.

bkg = background reading for the radiation monitor, in cpm.

All other parameters were previously defined.

Using conservative or "worst-case" parameters in Equation 3.1 and Equation 3.2 can provide a liquid radiation monitor setpoint that does not need to be revised for every release if activity is low enough to allow for this type of operation. Prior to the release to assure that the standard setpoints will not be exceeded for the batch release, the "Expected cpm" is calculated. In general, liquid radiation monitors are calibrated to Cs-137, and their "Expected cpm" is calculated as follows:

$$C_{Cs-137} = \sum_i (C_i \times Eq_i)$$

$$Expected\ cpm = (C_{Cs-137} \times CF_{Cs-137}) + bkg \quad \text{Equation 3.3}$$

where:

C_{Cs-137} = Cs-137 equivalent concentration, in $\mu\text{Ci/ml}$.

Eq_i = Cs-137 equivalence factor for each isotope, excluding tritium, to that of Cs-137 due to different gamma energies and abundance. This factor includes a 4-hour decay time due to the average time between sample and release. (See Table 3.0-1 and Table 3.0-2).

All other parameters were previously defined.

3.0.1.1 WMT AND RMT SETPOINTS (EMF 49)

As shown on Figure 2.0-2, EMF 49 is the controlling radiation monitor for Waste Monitor Tank (WMT) and Recycle Monitor Tank (RMT) releases. As discussed previously, standard setpoints are calculated for EMF 49 based on "worst-case" parameters using Equation 3.1 and Equation 3.2 as follows:

$$C_i \leq \frac{(F + f) \times (10 \times EC_i)}{\sigma \times f}$$

Trip 2 setpoint is the lower of the values calculated below.

Maximum EMF 49 Trip 2 setpoint based on discharge concentration limits

$$C \leq \frac{(27,600 + 100) \times (7 \times 9.0E-07)}{1.0 \times 100} \leq 1.745E-03 \mu\text{Ci/ml}$$

$$SP \leq \sum_i (C_i \times CF_i) + bkg$$

$$Trip\ 2 \cong 1.745E-03 \times 3.49E+08 \cong 6.090E+05\ \text{cpm} + bkg$$

A Trip 2 setpoint of 6.00E+05 cpm is used for conservatism.

$$Trip\ 1 = Trip\ 2 \times 0.75 = 4.50E+05\ \text{cpm}$$

where:

27,600 = RL/RN minimum dilution flow available (gpm) with 1 RL pump at 19,000 gpm minimum, and 1 RN pump at 8,600 gpm minimum.

100 = Flow from WMT or RMT (gpm).

7 = 10CFR20, Appendix B, Table 2, Column 2, EC multiplier used for instantaneous liquid release rate concentration limit. Technical Specifications allow a multiplier of 10. A value of 7 is used for added conservatism.

9.0E-07 = EC for Cs-134 which is the lowest effluent concentration value for any detectable radionuclide not known to be absent from the liquid effluent ($\mu\text{Ci/ml}$).

1.0 = The recirculation value for Catawba (unitless).

3.49E+08 = The radiation monitor correlation value for EMF 49 (cpm/ $\mu\text{Ci/ml}$).

EMF 49 Trip 2 setpoint based on sample concentration

When C_{Cs-137} equivalent concentration $\leq 4.58\text{E}-05 \mu\text{Ci/ml}$:

$Trip\ 2\ setpoint = (C_{Cs-137} \times CF_{Cs-137} \times 2.0) + bkg$ or $3 \times bkg$, whichever is higher.

When C_{Cs-137} equivalent concentration $> 4.58\text{E}-05 \mu\text{Ci/ml}$:

$Trip\ 2\ setpoint = (C_{Cs-137} \times CF_{Cs-137} \times 2.0) + bkg$

$Trip\ 1 = Trip\ 2 \times 0.75$

where:

C_{Cs-137} = Cs-137 equivalent concentration, in $\mu\text{Ci/ml}$.

CF_{Cs-137} = EMF 49 Cs-137 correlation factor, 3.49E+08 cpm/ $\mu\text{Ci/ml}$.

bkg = Background reading from EMF 49 after flushed from previous releases.

If the Cs-137 equivalent concentration is $\leq 4.58\text{E}-05 \mu\text{Ci/ml}$, then 4.58E-05 may be used in the Trip 1 and Trip 2 setpoint calculations. This is an indication of a low activity tank, and normal EMF fluctuation may cause Trip 2 alarms and release termination.

Prior to the release to assure that the standard Trip 1 and Trip 2 setpoints are not exceeded for the batch release, the "Expected cpm" is calculated based on actual tank activity as previously shown in Equation 3.3. For the "Expected cpm" calculation the applicable EMF 49 correlation value is used.

3.0.1.2 AMT SETPOINTS (EMF 57)

As shown on Figure 2.0-2, EMF 57 is the controlling radiation monitor for Auxiliary Monitor Tank (AMT) releases. As discussed previously, standard setpoints are calculated for EMF 57 based on "worst-case" parameters using Equation 3.1 and Equation 3.2 as follows:

$$C_i \leq \frac{(F + f) \times (10 \times EC_i)}{\sigma \times f}$$

Trip 2 setpoint is the lower of the values calculated below.

Maximum EMF 57 Trip 2 setpoint based on discharge concentration limits

$$C \leq \frac{(27,600 + 250) \times (7 \times 9.0E-07)}{1.0 \times 250} \leq 7.018E-04 \text{ } \mu\text{Ci/ml}$$

$$SP \leq \sum_i (C_i \times CF_i) + bkg$$

$$\text{Trip 2} \cong 7.018E-04 \times 9.60E+07 \cong 6.737E+04 \text{ cpm} + \text{bkg}$$

A Trip 2 setpoint of 6.00E+04 cpm is used for conservatism.

$$\text{Trip 1} = \text{Trip 2} \times 0.75 = 4.50E+04 \text{ cpm}$$

where:

27,600 = RL/RN minimum dilution flow available (gpm) with 1 RL pump at 19,000 gpm, and 1 RN pump at 8,600 gpm minimum.

250 = Flow from AMT (gpm).

7 = 10CFR20, Appendix B, Table 2, Column 2, EC multiplier used for instantaneous liquid release rate concentration limit. Technical Specifications allow a multiplier of 10. A value of 7 is used for added conservatism.

9.0E-07 = EC for Cs-134 which is the lowest effluent concentration value for any detectable radionuclide not known to be absent from the liquid effluent ($\mu\text{Ci/ml}$).

1.0 = The recirculation value for Catawba (unitless).

9.60E+07 = The radiation monitor correlation value for EMF 57 (cpm/ $\mu\text{Ci/ml}$).

EMF 57 Trip 2 setpoint based on sample concentration

When $C_{\text{Cs-137}}$ equivalent concentration $\leq 1.66\text{E-}04 \mu\text{Ci/ml}$:

$Trip\ 2\ setpoint = (C_{\text{Cs-137}} \times CF_{\text{Cs-137}} \times 2.0) + bkg$ or $3 \times bkg$, whichever is higher.

When $C_{\text{Cs-137}}$ equivalent concentration $> 1.66\text{E-}04 \mu\text{Ci/ml}$:

$Trip\ 2\ setpoint = (C_{\text{Cs-137}} \times CF_{\text{Cs-137}} \times 2.0) + bkg$

$Trip\ 1 = Trip\ 2 \times 0.75$

where:

$C_{\text{Cs-137}}$ = Cs-137 equivalent concentration, in $\mu\text{Ci/ml}$.

$CF_{\text{Cs-137}}$ = EMF 57 Cs-137 correlation factor, $9.60\text{E+}07$ cpm/ $\mu\text{Ci/ml}$.

bkg = Background reading from EMF 57 after flushed from previous releases.

If the Cs-137 equivalent concentration is $\leq 1.66\text{E-}04 \mu\text{Ci/ml}$, then $1.66\text{E-}04$ may be used in the Trip 1 and Trip 2 setpoint calculations. This is an indication of a low activity tank, and normal EMF fluctuation may cause Trip 2 alarms and release termination.

Prior to the release to assure that the standard Trip 1 and Trip 2 setpoints are not exceeded for the batch release, the "Expected cpm" is calculated based on actual tank activity as previously shown in Equation 3.3. For the "Expected cpm" calculation the applicable EMF 57 correlation value is used.

3.0.1.3 TURBINE BUILDING SUMP TO WC SETPOINTS (EMF 31)

As shown on Figure 2.0-2, EMF 31 is the controlling radiation monitor for releases from the Turbine Building Sump (TBS) to the Conventional Waste Water Treatment System (WC). EMF 31 setpoints are used to terminate the release to WC if there is any detectable activity in the effluent. The setpoints are calculated using Equation 3.2 as follows:

Typical EMF 31 Setpoint without a Liquid Waste Release (LWR)

$$\text{Trip 2} = 1.0E - 06 \times 3.49E + 08 + \text{existing reading}$$

$$\text{Trip 2} = 3.49E + 02 \text{ cpm} + \text{existing reading}$$

$$\text{Trip 1} = \text{Trip 2} \times 0.70$$

where:

1.0E-06 = Minimum practical detectable Cs-137 equivalent concentration, in $\mu\text{Ci/ml}$.

3.49E+08 = EMF 31 Cs-137 correlation factor, in $\text{cpm}/\mu\text{Ci/ml}$.

Existing reading = Reading from EMF 31.

Special EMF 31 Setpoint without a Liquid Waste Release (LWR)

During heavy rains, both units' EMF 31 sometimes alarm due to the high input of water into the sumps agitating sediment in the sumps. Therefore, the EMF 31 setpoints can be increased for up to 6 hours as described below with Radiation Protection Supervision approval. The EMF 31 setpoints are determined as described below in this situation.

$$C \leq \frac{(50\{dil\} + 50\{tbs\}) \times (7 \times 9.0E-07)}{1.0 \times 50\{tbs\}} \leq 1.260E - 05 \mu\text{Ci/ml}$$

$$SP \leq \sum_i (C_i \times CF_i) + bkg$$

$$\text{Trip 2} \cong 1.260E - 05 \times 3.49E + 08 \cong 4.39E + 03 \text{ cpm} + \text{bkg}$$

$$\text{Trip 1} = \text{Trip 2} \times 0.70 = 3.07E + 03 \text{ cpm}$$

where:

50 {dil} = 50 gpm is the assumed average available non-radioactive dilution flow into the WC ponds. Based on $9.6E+7$ gallons released from WC ponds in 231.5 days or ~ 271 gpm total input. $271 \text{ gpm} - 50 \text{ gpm (TBS)} = 221 \text{ gpm}$ available dilution flow. 50 gpm used for conservatism.

50 {tbs} = 50 gpm is the assumed average Turbine Building Sump (TBS) flow. Based on TBS pumps running 945 minutes in 30.55 days (2.15%) at 1,300 gpm or ~ 27.95 gpm effective flow rate. 50 gpm used for conservatism.

7 = 10CFR20, Appendix B, Table 2, Column 2, EC multiplier used for instantaneous liquid release rate concentration limit. Technical Specifications allow a multiplier of 10. A value of 7 is used for added conservatism.

9.0E-07 = EC for Cs-134 which is the lowest effluent concentration value for any detectable radionuclide not known to be absent from the liquid effluent ($\mu\text{Ci/ml}$).

1.0 = The recirculation value for Catawba (unitless).

3.49E+08 = The radiation monitor correlation value for EMF 31 ($\text{cpm}/\mu\text{Ci/ml}$).

EMF 31 Setpoint with a Liquid Waste Release (LWR)

When activity above typical levels is present in the sumps due an LWR may be used to release the activity into the WC ponds. This allows for some operational flexibility while administratively controlling the addition of activity to the WC ponds. The EMF 31 setpoints are determined as described below in this situation.

$$C \leq \frac{(150\{dil\} + 50\{tbs\}) \times (7 \times 9.0E-07)}{1.0 \times 50\{tbs\}} \leq 2.520E - 05 \mu\text{Ci/ml}$$

$$SP \leq \sum_i (C_i \times CF_i) + bkg$$

$$Trip\ 2 \cong 2.520E - 05 \times 3.49E + 08 \cong 8.79E + 03 \text{ cpm} + \text{bkg}$$

$$Trip\ 1 = Trip\ 2 \times 0.75 \text{ cpm}$$

Where:

150 {dil} = 150 gpm is the assumed average available non-radioactive dilution flow into the WC ponds. Based on 9.6E+7 gallons released from WC ponds in 231.5 days or ~271 gpm total input. 271 gpm - 50 gpm (TBS) = 221 gpm available dilution flow. 150 gpm used for conservatism.

50 {tbs} = 50 gpm is the assumed average Turbine Building Sump (TBS) flow. Based on TBS pumps running 945 minutes in 30.55 days (2.15%) at 1,300 gpm or ~27.95 gpm effective flow rate. 50 gpm used for conservatism.

7 = 10CFR20, Appendix B, Table 2, Column 2, EC multiplier used for instantaneous liquid release rate concentration limit. Technical Specifications allow a multiplier of 10. A value of 7 is used for added conservatism.

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9.0E-07 = EC for Cs-134 which is the lowest effluent concentration value for any detectable radionuclide not known to be absent from the liquid effluent ($\mu\text{Ci/ml}$).

1.0 = The recirculation value for Catawba (unitless).

3.49E+08 = The radiation monitor correlation value for EMF 31 ($\text{cpm}/\mu\text{Ci/ml}$).

To assure that the standard Trip 1 and Trip 2 setpoints are not exceeded for TBS releases, the "Expected cpm" is calculated based on actual TBS sample activity as previously shown in Equation 3.3.

Table 3.0-1

EMF 49 and EMF 31 Cs-137 Equivalence Factors

Isotope	Equivalence Factor	Isotope	Equivalence Factor	Isotope	Equivalence Factor
Be-7	0.1282	Mo-99	0.3135	La-141	0.0132
F-18	0.5238	Tc-99m	0.5788	La-142	0.2785
Na-24	1.3013	Tc-101	0.00	Ce-141	0.4966
Cl-38	0.0068	Ru-103	1.1798	Ce-143	0.7066
K-40	0.0913	Ru-105	0.8673	Ce-144	0.1321
Cr-51	0.1207	Ru-106	0.4097	I-130	3.1610
Mn-54	1.0871	Ag-108m	3.2676	I-131	1.2074
Mn-56	0.4826	Ag-110m	3.5043	I-132	1.0137
Fe-59	0.9915	Cd-115	0.4739	I-133	1.0971
Co-57	0.8892	Cd-115m	0.0228	I-134	0.1396
Co-58	1.4883	In-115m	0.3048	I-135	0.8432
Co-60	1.8564	Sb-122	0.8691	Ar-41	0.1987
Cu-64	0.3577	Sb-124	2.0195	Kr-85	0.0054
Ni-65	0.1389	Sb-125	1.0467	Kr-85m	0.5240
Zn-65	0.5278	Sb-126	5.0018	Kr-87	0.1020
Zn-69m	0.9788	Sn-113	0.8413	Kr-88	0.4607
Se-75	1.9710	Sn-123	0.0062	Kr-89	0.00
Br-80m	0.0821	Sn-126	0.1747	Xe-131m	0.0211
Br-82	3.3664	Te-125m	0.0023	Xe-133	0.0520
Br-83	0.0054	Te-127	0.0116	Xe-133m	0.1176
Br-84	0.0056	Te-127m	0.0005	Xe-135	0.8334
Br-85	0.00	Te-129	0.0122	Xe-135m	0.00
Rb-86	0.0873	Te-129m	0.0526	Xe-137	0.00
Rb-88	0.00	Te-131	0.0016	Xe-138	0.00
Rb-89	0.00	Te-131m	1.9281	Nd-147	0.3706
Sr-89	0.0002	Te-132	1.0302	Hf-181	1.7053
Sr-91	0.6398	Te-134	0.0402	W-187	0.8499
Sr-92	0.3415	Cs-134	2.5843	Tl-208	0.00
Y-91	0.0028	Cs-136	3.1799	Bi-212	0.0140
Y-91m	0.0403	Cs-137	1.00	Bi-214	0.0003
Y-92	0.1281	Cs-138	0.0110	Pb-212	0.4507
Y-93	0.1009	Ba-133	1.2331	Pb-214	0.0018
Zr-95	1.1163	Ba-139	0.0255	Ra-226	0.0386
Zr-97	1.1163	Ba-140	0.5022	Ac-228	0.8370
Nb-95	1.1114	Ba-141	0.0002	Th-228	0.0090
Nb-95m	0.2929	Ba-142	0.00	Np-239	0.8989
Nb-97	0.1164	La-140	2.0586		

Table 3.0-2

EMF 57 Cs-137 Equivalence Factors

Isotope	Equivalence Factor	Isotope	Equivalence Factor	Isotope	Equivalence Factor
Be-7	0.1462	Mo-99	0.2668	La-141	0.0155
F-18	0.5788	Tc-99m	0.00	La-142	0.2942
Na-24	0.8519	Tc-101	0.00	Ce-141	0.00
Cl-38	0.0090	Ru-103	1.3368	Ce-143	0.7826
K-40	0.1094	Ru-105	0.8783	Ce-144	0.0273
Cr-51	0.1438	Ru-106	0.4429	I-130	3.3095
Mn-54	1.0617	Ag-108m	3.4473	I-131	1.4051
Mn-56	0.4992	Ag-110m	3.5179	I-132	1.0259
Fe-59	1.0556	Cd-115	0.5201	I-133	1.1857
Co-57	0.0022	Cd-115m	0.0235	I-134	0.1388
Co-58	1.4735	In-115m	0.3631	I-135	0.9374
Co-60	2.0495	Sb-122	0.9218	Ar-41	0.2229
Cu-64	0.3954	Sb-124	2.1617	Kr-85	0.0059
Ni-65	0.1591	Sb-125	1.1308	Kr-85m	0.4280
Zn-65	0.5584	Sb-126	5.1762	Kr-87	0.1213
Zn-69m	1.1391	Sn-113	0.9971	Kr-88	0.5278
Se-75	1.3092	Sn-123	0.0066	Kr-89	0.00
Br-80m	0.0860	Sn-126	0.00	Xe-131m	0.0167
Br-82	3.4691	Te-125m	0.00	Xe-133	0.0006
Br-83	0.0059	Te-127	0.0134	Xe-133m	0.1172
Br-84	0.0053	Te-127m	0.0001	Xe-135	0.8564
Br-85	0.00	Te-129	0.0138	Xe-135m	0.00
Rb-86	0.0894	Te-129m	0.0507	Xe-137	0.00
Rb-88	0.00	Te-131	0.0008	Xe-138	0.00
Rb-89	0.00	Te-131m	1.8463	Nd-147	0.2619
Sr-89	0.0002	Te-132	0.9766	Hf-181	1.4209
Sr-91	0.6460	Te-134	0.0408	W-187	0.8027
Sr-92	0.3900	Cs-134	2.5804	Tl-208	0.00
Y-91	0.0031	Cs-136	3.1916	Bi-212	0.0144
Y-91m	0.0439	Cs-137	1.00	Bi-214	0.0003
Y-92	0.1334	Cs-138	0.0120	Pb-212	0.4497
Y-93	0.1091	Ba-133	1.3648	Pb-214	0.0020
Zr-95	1.0909	Ba-139	0.0203	Ra-226	0.0320
Zr-97	1.1210	Ba-140	0.5307	Ac-228	0.8261
Nb-95	1.0821	Ba-141	0.0002	Th-228	0.0038
Nb-95m	0.2919	Ba-142	0.00	Np-239	0.3996
Nb-97	0.1164	La-140	2.3237		

3.0.2 GASEOUS RADIATION MONITOR SETPOINT CALCULATIONS

In general, gaseous radiation monitors (EMFs) are calibrated to Xe-133, and for continuous release points, e.g., the two unit vents, are preset at a maximum value based on the 500 mrem/year total body gaseous release rate limit according to the following methodology.

Note: when applied to the individual release points the 500 mrem/year site dose rate value is apportioned 49% to each unit vent and 2% to the Auxiliary Monitor Tank Building.

$$K_{Xe-133} \times \chi/Q \times Q_{Xe-133} < 500 \text{ mrem/yr}$$

Solve for Q_{Xe-133} :

$$Q_{Xe-133} < \frac{500}{K_{Xe-133} \times \chi/Q} \quad \text{Equation 3.4}$$

From Equation 2.6:

$$Q_{Xe-133} = 472 \times C_{Xe-133} \times f \quad \text{Equation 3.5}$$

Substitute Equation 3.5 into Equation 3.4:

$$472 \times C_{Xe-133} \times f < \frac{500}{K_{Xe-133} \times \chi/Q}$$

Solve for C_{Xe-133} :

$$C_{Xe-133} < \frac{500}{472 \times f \times K_{Xe-133} \times \chi/Q}$$

$$SP = (C_{Xe-133} \times CF) + bkg \quad \text{Equation 3.6}$$

where:

K_{Xe-133} = 2.94E+02, the total body dose factor due to gamma emissions for Xe-133, in mrem/year per $\mu\text{Ci}/\text{m}^3$ (See Appendix A).

χ/Q = the highest calculated annual average dispersion parameter for any area at or beyond the site boundary in sec/m^3 . For Catawba this value is 3.510E-5 sec/m^3 . The location is the NNE sector at 0.5 mile.

- Q_{Xe-133} = Xe-133 equivalent release rate limit for the noble gas total body dose pathway, in $\mu\text{Ci}/\text{sec}$.
- 472 = conversion factor, $(\text{cc}/\text{ft}^3)/(\text{sec}/\text{min})$.
- C_{Xe-133} = the maximum allowable Xe-133 equivalent concentration in the gaseous effluent, in $\mu\text{Ci}/\text{cc}$.
- f = the gaseous effluent flow from the tank, building, or vent, in ft^3/min .
- SP = radiation monitor setpoint, in cpm.
- CF = the Xe-133 equivalent monitor correlation factor, in $\text{cpm}/\mu\text{Ci}/\text{cc}$.
- bkg = the radiation monitor background reading, in cpm.

Equation 3.6 provides the methodology to calculate the maximum setpoint for continuous releases such as for the unit vent radiation monitors 1 and 2 EMF 36 and Auxiliary Monitor Tank Building (AMTB) vent radiation monitor EMF 58. The maximum setpoints for these EMFs are:

1 and 2 EMF 36 - Maximum Setpoint

If the other unit's EMF 36 Trip 2 setpoint is reduced, the applicable unit's EMF 36 Trip 2 setpoint may be increased by the value the other unit's setpoint was reduced.

$$C_{Xe-133} < \frac{500}{472 \times 1.60E+05 \times 2.94E+02 \times 3.51E-05} = 6.416E-04 \mu\text{Ci}/\text{ml}$$

$$SP \leq \sum_i (C_i \times CF_i \times 0.49) + bkg$$

$$\text{Trip 2} \cong 6.416E-04 \times 2.66E+07 \times 0.49 \cong 8.362E+03 \text{ cpm} + bkg$$

$$\text{Trip 1} = \text{Trip 2} \times 0.7$$

Where:

1.60E+05 = flow in cfm: 1.34E+05 cfm Unit Vent + 2.6E+04 cfm Containment Purge.

2.66E+07 = EMF 36 Xe-133 Correlation Factor, $\text{cpm}/\mu\text{Ci}/\text{ml}$

0.49 = apportioned 49% to each unit vent.

EMF 58 - Maximum Setpoint

$$C_{Xe-133} < \frac{500}{472 \times 1.10E+04 \times 2.94E+02 \times 3.51E-05} = 9.332E-03 \text{ } \mu\text{Ci/ml}$$

$$SP \leq \sum_i (C_i \times CF_i \times 0.02) + bkg$$

$$Trip\ 2 \cong 9.332E-03 \times 1.41E+07 \times 0.02 \cong 2.632E+03 \text{ cpm} + bkg$$

$$Trip\ 1 = Trip\ 2 \times 0.7$$

where:

1.10E+04 = AMTB Vent flow in cfm.

1.41E+07 = EMF58 Xe-133 Correlation Factor, cpm/ μ Ci/ml

0.02 = apportioned 2% to AMTB vent.

However, most gaseous releases at Catawba are batch releases, e.g., Containment Purge (VP), in which the radiation monitor setpoint is calculated based on actual activity expected in the release. For batch releases with a low activity release rate, the expected monitor response is essentially no greater than background and the trip setpoints are based on practical minimum detectable activity to prevent spurious alarms. For batch releases where the effluent can contain activity significantly above background the following setpoint methodology is used:

$$C_{Xe-133} = \sum_i (C_i \times Eq_i)$$

$$Expected\ Cpm = (C_{Xe-133} \times CF_{Xe-133}) + bkg \quad \text{Equation 3.7}$$

"Trip" setpoints are set based on a multiplier factor above the "expected" cpm calculated in Equation 3.7.

where:

C_{Xe-133} = Xe-133 equivalent concentration, in μ Ci/ml.

Eq_i = Xe-133 equivalence factor for each isotope, excluding tritium, to that of Xe-133 due to different beta energies and abundance. (See Table 3.0-3).

All other parameters were previously defined.

3.0.2.1 CONTAINMENT AIR RELEASE AND ADDITION (VQ) SETPOINTS (EMF 39, EMF 36)

As shown on Figure 2.0-3, EMF 39 (when operable) and EMF 36 (when EMF 39 is inoperable) are the controlling radiation monitors for VQ releases from Containment to the Unit Vent.

EMF 39 setpoints for VQ releases are the lower of the setpoint as calculated below:

Maximum EMF 39 Trip 2 Setpoint

$$Trip2 \leq \frac{(134,000 + 350) \times (8.362E + 03)}{350} \leq 3.20E + 06 \text{ cpm} + \text{bkg}$$

A Trip 2 setpoint of 3.00E+06 cpm is used for conservatism.

$$Trip1 = Trip2 \times 0.7 = 2.10E + 06 \text{ cpm}$$

where:

134,000 = Unit Vent dilution flow available (cfm).

350 = Flow from VQ (cfm).

8.362E+03 = Maximum Unit Vent radiation monitor setpoint (cpm).

bkg = EMF 39 background.

Both EMF 39 and Unit Vent radiation monitor (EMF 36) correlation factors are 2.66E+07 cpm/ μ Ci/cc.

EMF 39 Trip 2 Setpoint Based on Sample Concentration

For EMF 39 if the containment Xe-133 equivalent is $\leq 2.0E-05 \mu\text{Ci/ml}$, then 2.0E-05 $\mu\text{Ci/ml}$ may be used in the Trip 1 and 2 setpoint calculations. This is an indication of low activity in containment and normal EMF fluctuation may cause Trip 2 alarms and release termination.

When $Xe-133$ equivalent concentration $\leq 2.0E - 05 \mu\text{Ci/ml}$:

$$Trip2 \text{ setpoint} = (C_{Xe-133} \times CF_{Xe-133} \times 2.0) + \text{bkg} \text{ or } 3 \times \text{bkg}, \text{ whichever is higher.}$$

When $Xe-133$ equivalent concentration $> 2.0E-05 \mu\text{Ci/ml}$:

$$\text{Trip 2 setpoint} = (C_{Xe-133} \times CF_{Xe-133} \times 2.0) + \text{bkg}$$

$$\text{Trip 1} = \text{Trip 2} \times 0.7$$

where:

C_{Xe-133} = Xe-133 equivalent concentration (containment), in $\mu\text{Ci/ml}$.

CF_{Xe-133} = EMF 39 Xe-133 correlation factor, $2.66E+07 \text{ cpm}/\mu\text{Ci/ml}$.

2.0 = Multiplier to increase alarm value to 2 times process activity.

bkg = EMF 39 background.

$$\text{Expected EMF 39 cpm} = (C_{Xe-133} \times CF) + \text{bkg}$$

If EMF 39 is inoperable for a VQ release then the unit vent radiation monitor, EMF 36, is the controlling EMF for the release.

When EMF 36 must be used as the controlling monitor for VQ releases the EMF 36 setpoints are calculated as described below. If the EMF 36 reading significantly exceeds the expected cpm then the release is manually or automatically terminated.

The EMF 36 expected cpm from VQ activity is calculated as follows:

$$\text{Expected EMF 36 cpm} = \frac{350 \text{ cfm} \times C_{Xe-133} \times CF_{Xe-133}}{F_{UV}} + \text{bkg}$$

where:

C_{Xe-133} = Xe-133 equivalent concentration, in $\mu\text{Ci/ml}$.

CF_{Xe-133} = EMF 36 Xe-133 correlation factor, $2.66E+07 \text{ cpm}/\mu\text{Ci/ml}$.

bkg = EMF 36 background.

350 cfm = Maximum VQ flow rate.

F_{UV} = Current Unit Vent flow rate.

If the EMF 36 expected cpm is $< 7.50E+01 \text{ cpm}$, the normal (typical) EMF 36 Trip 2 setpoints of $1.50E+02 \text{ cpm} + \text{existing EMF 36 reading}$ are used. This is a conservative

setpoint to provide early indication of change in radiological conditions without inducing spurious alarms.

If the EMF 36 expected cpm is $\geq 7.50E+01$ cpm, the EMF 36 setpoints are the lower setpoint as calculated below.

Maximum EMF 36 Trip 2 Setpoint

8.362E+03 cpm based on Section 3.0.2 above. If the other unit's EMF 36 Trip 2 setpoint is reduced, the applicable unit's EMF 36 Trip 2 setpoint may be increased by the value the other unit's setpoint was reduced.

EMF 36 Trip 2 Setpoint Based on Sample Concentration

For EMF 36 if the containment Xe-133 equivalent is $\leq 1.07E-03$ $\mu\text{Ci/ml}$, then $1.07E-03$ $\mu\text{Ci/ml}$ may be used in the Trip 1 and 2 setpoint calculations. This is an indication of low activity in unit vent due to dilution and normal EMF fluctuation may cause Trip 2 alarms and release termination.

When Xe-133 equivalent concentration $\leq 1.07E-03$ $\mu\text{Ci/ml}$:

$$\text{EMF 36 Trip 2 cpm} = \frac{350 \text{ cfm} \times C_{\text{Xe-133}} \times CF_{\text{Xe-133}} \times 2.0}{F_{\text{UV}}} + \text{bkg or } 3 \times \text{bkg},$$

whichever is higher.

When Xe-133 equivalent concentration $> 1.07E-03$ $\mu\text{Ci/ml}$:

$$\text{EMF 36 Trip 2 cpm} = \frac{350 \text{ cfm} \times C_{\text{Xe-133}} \times CF_{\text{Xe-133}} \times 2.0}{F_{\text{UV}}} + \text{bkg}$$

$$\text{Trip 1} = \text{Trip 2} \times 0.7$$

where:

350 cfm = VQ flow rate.

$C_{\text{Xe-133}}$ = Xe-133 equivalent concentration, in $\mu\text{Ci/ml}$.

$CF_{\text{Xe-133}}$ = EMF 36 Xe-133 correlation factor, $2.66E+07$ cpm/ $\mu\text{Ci/ml}$.

2.0 = Multiplier to increase alarm value to 2 times process activity.

bkg = EMF 36 background.

3.0.2.2 CONTAINMENT PURGE (VP) AND INCORE PURGE (IP) SETPOINTS (EMF 39, EMF 36)

As shown on Figure 2.0-3 EMF 39 (when operable) and EMF 36 (when EMF 39 is inoperable) are the controlling radiation monitors for VP and IP releases from Containment to the Unit Vent.

EMF 39 setpoints for VP and IP releases are the lower of the setpoint as calculated below:

Maximum EMF 39 Trip 2 Setpoint

$$Trip2 \leq \frac{(134,000 + 26,000) \times (8.362E+03)}{26,000} \leq 5.14E+04 \text{ cpm} + \text{bkg}$$

A Trip 2 setpoint of 5.00E+04 cpm is used for conservatism.

$$Trip1 = Trip2 \times 0.7 = 3.50E+04 \text{ cpm}$$

where:

134,000 = Unit Vent dilution flow available (cfm).

26,000 = Flow from VP (cfm).

8.362E+03 = Maximum Unit Vent radiation monitor setpoint (cpm).

bkg = EMF 39 background.

Both EMF 39 and Unit Vent radiation monitor (EMF 36) correlation factors are 2.66E+07 cpm/ μ Ci/cc.

EMF 39 Trip 2 Setpoint Based on Sample Concentration

For EMF 39 if the containment Xe-133 equivalent is $\leq 2.0E-05 \mu\text{Ci/ml}$, then 2.0E-05 $\mu\text{Ci/ml}$ may be used in the Trip 1 and 2 setpoint calculations. This is an indication of low activity in containment and normal EMF fluctuation may cause Trip 2 alarms and release termination.

When $Xe-133$ equivalent concentration $\leq 2.0E-05 \mu\text{Ci/ml}$:

$$Trip2 \text{ setpoint} = (C_{Xe-133} \times CF_{Xe-133} \times 2.0) + \text{bkg} \text{ or } 3 \times \text{bkg}, \text{ whichever is higher.}$$

When $Xe-133$ equivalent concentration $> 2.0E-05 \mu\text{Ci/ml}$:

$$\text{Trip 2 setpoint} = (C_{\text{Xe-133}} \times CF_{\text{Xe-133}} \times 2.0) + \text{bkg}$$

$$\text{Trip 1} = \text{Trip 2} \times 0.7$$

where:

$C_{\text{Xe-133}}$ = Xe-133 equivalent concentration, in $\mu\text{Ci/ml}$.

$CF_{\text{Xe-133}}$ = EMF 39 Xe-133 correlation factor, $2.66\text{E}+07$ cpm/ $\mu\text{Ci/ml}$.

2.0 = Multiplier to increase alarm value to 2 times process activity.

bkg = EMF 39 background.

$$\text{Expected cpm} = (C_{\text{Xe-133}} \times CF) + \text{bkg}$$

If EMF 39 is inoperable for a VP release then the unit vent radiation monitor, EMF 36, is the controlling EMF for the release.

When EMF 36 must be used as the controlling monitor for VP releases the EMF 36 setpoints are calculated as described below. If the EMF 36 reading significantly exceeds the expected cpm then the release is manually or automatically terminated.

The EMF 36 expected cpm from VP activity is calculated as follows:

$$\text{Expected cpm} = \frac{26,000 \text{ cfm} \times C_{\text{Xe-133}} \times CF_{\text{Xe-133}}}{F_{\text{UV}}} + \text{bkg}$$

where:

$C_{\text{Xe-133}}$ = Xe-133 equivalent concentration, in $\mu\text{Ci/ml}$.

$CF_{\text{Xe-133}}$ = EMF 36 Xe-133 correlation factor, $2.66\text{E}+07$ cpm/ $\mu\text{Ci/ml}$.

bkg = EMF 36 background.

26,000 cfm = Maximum VP flow rate.

F_{UV} = Current Unit Vent flow rate.

If the EMF 36 expected cpm is $< 7.50\text{E}+01$ cpm, the normal (typical) EMF 36 Trip 2 setpoints of $1.50\text{E}+02$ cpm + existing EMF 36 reading are used. This is a conservative setpoint to provide early indication of change in radiological conditions without inducing spurious alarms.

If the EMF 36 expected cpm is $\geq 7.50E+01$ cpm, the EMF 36 setpoints are the lower setpoint as calculated below.

Maximum EMF 36 Trip 2 Setpoint

8.362E+03 cpm based on Section 3.0.2 above. If other unit's EMF 36 Trip 2 setpoint is reduced, applicable unit's EMF 36 Trip 2 setpoint may be increased by the value the other unit's setpoint was reduced.

EMF 36 Trip 2 Setpoint Based on Sample Concentration

For EMF 36 if the containment Xe-133 equivalent is $\leq 1.45E-05$ $\mu\text{Ci/ml}$, then 1.45E-05 $\mu\text{Ci/ml}$ may be used in the Trip 1 and 2 setpoint calculations. This is an indication of low activity in unit vent due to dilution and normal EMF fluctuation may cause Trip 2 alarms and release termination.

When $Xe-133$ equivalent concentration $\leq 1.45E-05$ $\mu\text{Ci/ml}$:

$$\text{EMF 36 Trip 2 } cpm = \frac{26,000 \text{ cfm} \times C_{Xe-133} \times CF_{Xe-133} \times 2.0}{F_{UV}} + \text{bkg or } 3 \times \text{bkg},$$

whichever is higher.

When $Xe-133$ equivalent concentration $> 1.45E-05$ $\mu\text{Ci/ml}$:

$$\text{EMF 36 Trip 2 } cpm = \frac{26,000 \text{ cfm} \times C_{Xe-133} \times CF_{Xe-133} \times 2.0}{F_{UV}} + \text{bkg}$$

$$\text{Trip 1} = \text{Trip 2} \times 0.7$$

where:

C_{Xe-133} = Xe-133 equivalent concentration, in $\mu\text{Ci/ml}$.

CF_{Xe-133} = EMF 36 Xe-133 correlation factor, 2.66E+07 cpm/ $\mu\text{Ci/ml}$.

2.0 = Multiplier to increase alarm value to 2 times process activity.

bkg = EMF 36 background .

3.0.2.3 WASTE GAS DECAY TANK (WGDT) SETPOINTS (EMF 50, EMF 36)

As shown on Figure 2.0-3, EMF 50 (when operable) and EMF 36 (when EMF 50 is not operable) are the controlling radiation monitors for WGDT releases to the Unit Vent. EMF 50 setpoints are based on actual tank activity, and are the lower of the setpoints as calculated below:

Maximum EMF 50 Trip 2 Setpoint

$$Trip2 \leq \frac{(134,000 + 50) \times (8.362E + 03) \times (1.39E + 06)}{50 \times (2.66E + 07)} \leq 1.17E + 06 \text{ cpm} + \text{bkg}$$

A Trip 2 setpoint of 1.10E+06 cpm is used for conservatism and as maximum EMF 50 setpoint based on EMF scale.

$$Trip1 = Trip2 \times 0.7 = 7.70E + 05 \text{ cpm}$$

where:

134,000 = Unit Vent dilution flow available (cfm).

50 = Flow from WG (cfm).

8.362E+03 = Maximum Unit Vent radiation monitor setpoint (cpm).

1.39E+06 = EMF 50 correlation factor (cpm/μCi/cc) corrected to 6 psig. EMF 50 Xe-133 correlation factor of 1.15E+06 cpm/μCi/cc (CNC-1346.05-00-0001 Rev. 0) times 121% pressure correction (CNM-1346.05-0115.001 Rev. 0).

2.66E+07 = Unit Vent radiation monitor (EMF 36) correlation factor (cpm/μCi/cc).

bkg = EMF 50 background.

EMF 50 Trip 2 Setpoint Based on Sample Concentration

When $Xe - 133$ equivalent concentration $\leq 1.00E - 04 \mu\text{Ci/ml}$:

Trip 2 setpoint = 10% of Maximum EMF 50 Trip 2 Setpoint = 1.10E +05 cpm

Trip 1 setpoint = 1% of Maximum EMF 50 Trip 2 Setpoint = 1.10E +04 cpm

When $Xe - 133$ equivalent concentration $> 1.00E - 04 \mu\text{Ci/ml}$:

$$Trip2 \text{ setpoint} = (C_{Xe-133} \times CF_{Xe-133} \times 2.0) + \text{bkg}$$

$$\text{Trip 1} = \text{Trip 2} \times 0.7$$

where:

Maximum EMF 50 Trip 2 Setpoint = $1.10\text{E} +06$ cpm

$C_{\text{Xe-133}}$ = Xe-133 equivalent concentration, in $\mu\text{Ci/ml}$.

$CF_{\text{Xe-133}}$ = EMF 50 Xe-133 pressure corrected correlation factor, $1.39\text{E}+06$ cpm/ $\mu\text{Ci/ml}$.

2.0 = Multiplier to increase alarm value to 2 times process activity.

bkg = EMF 50 background.

For EMF 50 if the WG Tank Xe-133 equivalent concentration is $\leq 1.00\text{E} -04$ $\mu\text{Ci/ml}$, this is an indication of a low activity tank. Normal EMF fluctuation may cause Trip 2 alarms and release termination. Setpoint determination may be made using 10% of the Maximum Trip 2 Setpoint for Trip 2 and 1% of the Maximum EMF 50 Trip 2 Setpoint for Trip 1.

The EMF 50 expected cpm is calculated as follows:

$$\text{Expected cpm} = (C_{\text{Xe-133}} \times CF_{\text{Xe-133}}) + \text{bkg}$$

where:

$C_{\text{Xe-133}}$ = Xe-133 equivalent concentration (WG tank), in $\mu\text{Ci/ml}$.

$CF_{\text{Xe-133}}$ = EMF 50 Xe-133 pressure corrected correlation factor, $1.39\text{E}+06$ cpm/ $\mu\text{Ci/ml}$.

bkg = EMF 50 background.

When EMF 36 must be used as the controlling monitor for WG releases the EMF 36 setpoints are calculated as described below. If the EMF 36 reading significantly exceeds the expected cpm then the release is manually or automatically terminated.

The EMF 36 expected cpm from WG activity is calculated as follows:

$$\text{Expected cpm} = \frac{50 \text{ cfm} \times C_{\text{Xe-133}} \times CF_{\text{Xe-133}}}{F_{\text{UV}}} + \text{bkg}$$

where:

$C_{\text{Xe-133}}$ = Xe-133 equivalent concentration, in $\mu\text{Ci/ml}$.

CF_{Xe-133} = EMF 36 Xe-133 correlation factor, $2.66E+07$ cpm/ μ Ci/ml.

bkg = EMF 36 background.

50 cfm = Maximum WG flow rate.

F_{UV} = Current Unit Vent flow rate (cfm).

If the EMF 36 expected cpm is $< 7.50E+01$ cpm, the normal (typical) EMF 36 Trip 2 setpoints of $1.50E+02$ cpm + existing EMF 36 reading are used. This is a conservative setpoint to provide early indication of change in radiological conditions without inducing spurious alarms.

If the EMF 36 expected cpm is $\geq 7.50E+01$ cpm, the EMF 36 setpoints are the lower setpoint as calculated below.

Maximum EMF 36 Trip 2 Setpoint

$8.362E+03$ cpm based on Section 3.0.2 above. If other unit's EMF 36 Trip 2 setpoint is reduced, applicable unit's EMF 36 Trip 2 setpoint may be increased by the value the other unit's setpoint was reduced.

EMF 36 Trip 2 Setpoint Based on Sample Concentration

For EMF 36 if the WG Tank Xe-133 equivalent is $\leq 7.50E-03$ μ Ci/ml, then $7.50E-03$ μ Ci/ml may be used in the Trip 1 and 2 setpoint calculations. This is an indication of low activity in unit vent due to dilution and normal EMF fluctuation may cause Trip 2 alarms and release termination.

When $Xe-133$ equivalent concentration $\leq 7.50E-03$ μ Ci/ml:

$$\text{EMF 36 Trip 2 } cpm = \frac{50 \text{ cfm} \times C_{Xe-133} \times CF_{Xe-133} \times 2.0}{F_{UV}} + \text{bkg} \text{ or } 3 \times \text{bkg},$$

whichever is higher.

When $Xe-133$ equivalent concentration $> 7.50E-03$ μ Ci/ml:

$$\text{EMF 36 Trip 2 } cpm = \frac{50 \text{ cfm} \times C_{Xe-133} \times CF_{Xe-133} \times 2.0}{F_{UV}} + \text{bkg}$$

$$\text{Trip 1} = \text{Trip 2} \times 0.7$$

where:

C_{Xe-133} = Xe-133 equivalent concentration, in μ Ci/ml.

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CF_{Xe-133} = EMF 36 Xe-133 correlation factor, 2.66E+07 cpm/ μ Ci/ml.

2.0 = Multiplier to increase alarm value to 2 times process activity.

bkg = EMF 36 background.

Table 3.0-3

Xe-133 Equivalents

Isotope	EMF 36/39 Equivalence Factor	EMF 50 Equivalence Factor
Kr-83m	0.00	0.00
Kr-85m	2.14	10.87
Kr-85	2.56	10.87
Kr-87	2.93	10.87
Kr-88	2.74	6.26
Kr-89	2.93	10.87
Kr-90	2.90	10.87
Xe-131m	1.65	0.00
Xe-133m	1.98	0.00
Xe-133	1.00	1.00
Xe-135m	0.56	6.38
Xe-135	2.63	10.87
Xe-137	2.93	10.87
Xe-138	2.93	10.87
Ar-41	2.93	10.87

4.0 EFFLUENT DOSE MODELS

The effluent dose models used to show compliance with 10CFR50, Appendix I ALARA design objectives, 40CFR190 fuel cycle dose limits, and the dose values given in station SLCs are based on the methodology given in NUREG-0133 and Regulatory Guide 1.109. Dose contributions to the maximum individual shall be calculated at least every 31 days, quarterly, and annually using software which implements the ODCM methodology. The software is designed to automate many of the tasks required in the administration of effluent releases at Catawba and performs normal operation effluent dose assessment using NUREG-0133 and Regulatory Guide 1.109 methodology.

Station long-term historical and dose projection calculations are performed periodically to determine the station's status with respect to meeting annual ALARA goals specified in the Catawba SLCs. Such calculations are used to verify that adequate margin remains during a report period to allow normal station and radwaste system operation, including anticipated operational occurrences, for the remainder of the report period without exceeding applicable goals. Station 31-day dose projections that are used to assess the need to reduce effluent releases with the Gaseous Waste (WG) or Liquid Waste (WL) systems as required in the Catawba SLCs are estimated by the previous month's calculated dose results.

Fuel cycle dose calculations shall be performed annually or as required by special reports. Dose contributions shall be calculated using the software implementing the ODCM methodology.

4.0.1 LIQUID EFFLUENT DOSE MODEL FOR THE MAXIMUM EXPOSED INDIVIDUAL

Of the possible exposure pathways in the aquatic environment, only three contribute significantly to the total dose; these pathways are ingestion of potable water and aquatic foods, and direct exposure from radioactivity deposited on the shoreline. The dose contribution from these pathways for measured quantities of radioactive materials identified in liquid effluents released to unrestricted areas shall be calculated for the maximum exposed individual in each age group using the methodology provided in this section.

There are two liquid discharge points to the environment at Catawba; (1) the RL/RN discharge point to Lake Wylie, and (2) the WC discharge point to Lake Wylie (See Figure 2.0-1). Liquid dose calculations for the maximum exposed individual are performed and documented in the Annual Radioactive Effluent Release Report for both locations using the applicable activity release and dilution data for each liquid effluent release point. The primary liquid effluent discharge point for Catawba is through RL/RN to Lake Wylie. In general, only low activity tritium releases (<1% station total) occur through the WC discharge point to Lake Wylie. Dose calculations are performed for each of the two liquid discharge points for dose reporting purposes. The highest calculated dose from the two dose calculations is used to define the maximum individual dose from liquid releases at Catawba.

Liquid Dose Calculations

The following equation is used for calculating liquid dose to the maximum exposed individual from each of the two liquid effluent release points:

$$Dose_{oa} = \sum_p \sum_i (A_{oapi} \times C_i) \times \Delta t \times F_n \times \frac{1}{D_w}$$

$$F_n = \frac{f}{f + F} \times \sigma$$

Formula: adapted from NUREG-0133, pages 15-17.	
Where:	
Dose _{oa}	The cumulative dose commitment for organ o and age group a, from the liquid effluent for the total time period, Δt. (mrem)
A _{oapi}	Dose commitment factor for organ o, age group a, pathway p, and nuclide i (mrem/hr per μCi/ml). (See Appendices C through F for age group and pathway specific dose commitment factors).
C _i	The average concentration of nuclide i, in undiluted liquid effluent during the time period, Δt. (μCi/ml)
Δt	The length of time over which C _i and F _n are averaged for all liquid releases. (hr)
F _n	The near field average dilution factor for C _i during the period of interest, Δt. Includes the recirculation factor. (dimensionless)
f	Average liquid radwaste flow during the period of interest, Δt. (gpm)
F	Average dilution flow during the period of interest, Δt. (gpm)
	RL/RN primary discharge location: RL/RN average dilution flow
	WC discharge location: 10% of RL/RN average dilution flow
σ	Recirculation factor.* (dimensionless)
D _w	Dilution factor from the near field area to the potable water intake; = 43.4 for Catawba. This factor applies to the potable water pathway only. The factor is calculated by (Average Wylie Dam Flow (4453 cfs) + Average Radwaste Flow (105 cfs)) divided by the (Average Radwaste Flow (105 cfs)). This value can be modified to account for deviations from average in a particular year, or for added conservatism such as accounting for minor radioactivity contributions from McGuire Nuclear Station. A D _w value of 10 is currently being used.

* The recirculation factor accounts for the fraction of discharged water reused by the station. Liquid effluent discharge cannot be recirculated back into the Catawba station. Therefore, the recirculation factor is 1.0 at Catawba.

Derivation of Liquid Dose Commitment Factors (A_{oapi})

Potable Water

$$A_{oapi} = 1.14 \times 10^5 \times U_{aw} \times D_{aoi} \times e^{-\lambda_i t_p}$$

**Formula: from NUREG-0133, page 16, and Regulatory Guide 1.109, page 1.109-12.
Where:**

A_{oapi}	Dose commitment factor for organ o, age group a, pathway p, and nuclide i, (mrem/hr per $\mu\text{Ci}/\text{ml}$). (See Appendices C through F for age group and pathway specific dose commitment factors).
1.14×10^5	Units conversion factor ($\text{pCi}\cdot\text{yr}\cdot\text{ml}$)/($\mu\text{Ci}\cdot\text{hr}\cdot\text{l}$).
U_{aw}	Water consumption rate in liters per year for age group a. From Table E-5, Regulatory Guide 1.109. Adult – 730 Teen – 510 Child – 510 Infant – 330
D_{aoi}	Dose factor for age group a, organ o, nuclide i, in mrem/pCi. From tables E-11 through E-14 of Regulatory Guide 1.109.
λ_i	Decay constant for nuclide i, in sec^{-1} .
t_p	Environmental transit time from release to receptor. Default = $4.32\text{E}+04$ sec (12 hours). From Regulatory Guide 1.109, Table E-15.

Aquatic Foods

$$A_{oapi} = 1.14 \times 10^5 \times U_{af} \times BF_i \times D_{aoi} \times e^{-\lambda_i t_p}$$

Formula: from NUREG-0133, page 16, and Regulatory Guide 1.109, page 1.109-12.	
Where:	
A_{oapi}	Dose commitment factor for organ o, age group a, pathway p, and nuclide i, (mrem/hr per $\mu\text{Ci}/\text{ml}$). (See Appendices C through F for age group and pathway specific dose commitment factors).
1.14×10^5	Units conversion factor ($\text{pCi}\cdot\text{yr}\cdot\text{ml}$)/($\mu\text{Ci}\cdot\text{hr}\cdot\text{l}$).
U_{af}	Fish consumption rate for age group a (kg/yr). From Table E-5, Regulatory Guide 1.109. Adult – 21 Teen – 16 Child – 6.9 Infant – 0
BF_i	Bioaccumulation factor for nuclide i, in fish, in units of pCi/kg per pCi/liter. From Table A-1 of Regulatory Guide 1.109.
D_{aoi}	Dose factor for age group a, organ o, nuclide i, in mrem/pCi. From tables E-11 through E-14 of Regulatory Guide 1.109.
λ_i	Decay constant for nuclide i, in sec^{-1} .
t_p	Environmental transit time from release to receptor. Default = $8.64\text{E}+04$ sec (1 day). From Regulatory Guide 1.109, Table E-15.

Shoreline Sediment

$$A_{oapi} = 1.14 \times 10^5 \times 100 \times DFG_{oi} \times w \times U_{as} \times T_i^{1/2} \times e^{-\lambda_i t_p} \times (1 - e^{-\lambda_i t_b})$$

Formula: adapted from Regulatory Guide 1.109, page 1.109-14.	
Where:	
A_{oapi}	Dose commitment factor for organ o, age group a, pathway p, and nuclide i, (mrem/hr per $\mu\text{Ci/ml}$). (See Appendices C through F for age group and pathway specific dose commitment factors).
1.14×10^5	Units conversion factor (pCi-yr-ml)/($\mu\text{Ci-hr-l}$).
100	Proportionality constant used in the sediment radioactivity model, ($\text{liters}/(\text{m}^2\text{-day})$).
DFG_{oi}	Ground plane dose conversion factor for organ o, nuclide i (mrem/hr per pCi/m^2), from Table E-6 of Regulatory Guide 1.109.
w	Shoreline width factor. For Catawba = 0.3, from Table A-2, Regulatory Guide 1.109.
U_{as}	Shoreline exposure rate for age group a (hr/yr), From Table E-5, Regulatory Guide 1.109. Adult – 12 Teen – 67 Child – 14 Infant – 0
$T_i^{1/2}$	Nuclide half life for nuclide i, in days.
λ_i	Nuclide decay constant for nuclide i.
t_p	Average transit time to point of exposure (0 hours).
t_b	Sediment exposure time (15 years). Page 1.109-14.

4.0.2 GASEOUS EFFLUENT DOSE MODEL FOR THE MAXIMUM EXPOSED INDIVIDUAL

The dose contributions from measured quantities of radioactive materials identified in gaseous effluent released to unrestricted areas shall be calculated for the maximum gamma and beta air dose from noble gases, and for the maximum exposed individual from radioiodines, particulates, and others using the following equations:

Gaseous Dose Calculations

Noble Gas Dose Calculations

Gamma Air Dose

$$Dose_{\gamma} = 3.17 \times 10^{-8} \times \chi / Q \times \sum_i (M_i \times Q_i)$$

Formula: adapted from NUREG-0133, page 28.	
Where:	
Dose _γ	Gamma air dose for the time period of interest (mrad).
3.17×10 ⁻⁸	Inverse number of seconds in year (year/seconds).
M _i	Gamma air dose factor due to gamma emissions for nuclide i (mrad/yr per μCi/m ³). (See Appendix A).
χ/Q	The highest calculated annual average relative concentration for any area at or beyond the site boundary (sec/m ³). (See Table 6.0-8).
Q _i	Activity for nuclide i released during the time period of interest (μCi).

Beta Air Dose

$$Dose_{\beta} = 3.17 \times 10^{-8} \times \chi / Q \times \sum_i (N_i \times Q_i)$$

Formula: adapted from NUREG-0133, page 28.	
Where:	
Dose _β	Beta air dose for the time period of interest (mrad).
3.17×10 ⁻⁸	Inverse number of seconds in year (year/seconds).
N _i	Beta air dose factor due to beta emissions for nuclide i (mrad/yr per μCi/m ³). (See Appendix A).
χ/Q	The highest calculated annual average relative concentration for any area at or beyond the site boundary (sec/m ³). (See Table 6.0-8).
Q _i	Activity for nuclide i released during the time period of interest (μCi).

Iodine, Particulates, and H-3 Dose Organ Dose Calculation

$$Dose_{oa} = 3.17 \times 10^{-8} \times W \times \sum_p \sum_i (R_{oapi} \times Q_i)$$

Formula: adapted from NUREG-0133, pages 29 & 30.																	
Where:																	
Dose _{oa}	The cumulative dose commitment to the total body or any organ o, for an individual of age group a (mrem).																
3.17×10 ⁻⁸	Inverse number of seconds in year (year/seconds).																
R _{oapi}	Dose commitment factor for organ o, age group a, pathway p, and nuclide i. The units are based on whether a dispersion or deposition factor is used. When a χ/Q is used the units are mrem/yr per $\mu\text{Ci}/\text{m}^3$. When a D/Q is used the units are (m ² · mrem/yr) per $\mu\text{Ci}/\text{sec}$. (See Appendices G through J for age group and pathway specific dose commitment factors).																
W*	Dispersion (χ/Q) or deposition factor (D/Q). The factor used is based upon the pathway. Note: χ/Q is always used for tritium and C-14.																
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">Pathway</th> <th style="width: 50%;">Factor Used</th> </tr> </thead> <tbody> <tr> <td>Ground Plane Deposition</td> <td>D/Q (m⁻²)</td> </tr> <tr> <td>Inhalation</td> <td>χ/Q (sec/m³)</td> </tr> <tr> <td>Vegetation</td> <td>D/Q (m⁻²)</td> </tr> <tr> <td>Grass/Cow/Milk</td> <td>D/Q (m⁻²)</td> </tr> <tr> <td>Grass/Goat/Milk</td> <td>D/Q (m⁻²)</td> </tr> <tr> <td>Grass/Cow/Meat</td> <td>D/Q (m⁻²)</td> </tr> <tr> <td>Grass/Goat/Meat</td> <td>D/Q (m⁻²)</td> </tr> </tbody> </table>	Pathway	Factor Used	Ground Plane Deposition	D/Q (m ⁻²)	Inhalation	χ/Q (sec/m ³)	Vegetation	D/Q (m ⁻²)	Grass/Cow/Milk	D/Q (m ⁻²)	Grass/Goat/Milk	D/Q (m ⁻²)	Grass/Cow/Meat	D/Q (m ⁻²)	Grass/Goat/Meat	D/Q (m ⁻²)
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Grass/Cow/Meat	D/Q (m ⁻²)																
Grass/Goat/Meat	D/Q (m ⁻²)																
Q _i **	Activity for nuclide i, released during the time period of interest (μCi).																

* Maximum individual organ dose is determined by calculating the organ dose at each of the χ/Q and D/Q locations shown in Table 6.0-8 and Table 6.0-9 (144 locations), and then choosing the maximum dose. Dose is calculated only for pathways (e.g., garden, milk animal, etc.) that actually exist at each location as determined by the land use census. As discussed in Catawba UFSAR Section 2.1.1.3, the boundary for establishing gaseous effluent release limits is the exclusion area boundary (EAB). The EAB is defined as a 2500-ft. (~0.5 mile) radius from the station center.

** C-14 airborne activity released to the environment is estimated based on actual power generation as discussed in Regulatory Guide 1.21, Revision 2. A value of 9.4 Ci/GWe-yr is used along with actual power generation to estimate C-14 activity released to the environment via gaseous effluents from Catawba. 9.4 Ci/GWe-yr is based on information from "Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents", EPRI, Palo Alto, CA: 2010. 1021106.

Derivations of Iodine, Particulate, and H-3 Dose Commitment Factors (R_{oapi})

Ground Plane Deposition Pathway

$$R_{oapi} = K'K''(SF)DFG_{oi} \left[\frac{(1 - e^{-\lambda_i t})}{\lambda_i} \right]$$

Formula: from NUREG-0133, page 32.

Where:

R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for ground plane deposition pathway ($m^2 \cdot mrem/yr$ per $\mu Ci/sec$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor $pCi/\mu Ci$ (10^6).
K''	Units conversion factor 8760 hr/year.
SF	Shielding factor (dimensionless) (0.7, from Regulatory Guide 1.109).
DFG_{oi}	Ground plane dose conversion factor for organ o, nuclide i ($mrem/hr$ per pCi/m^2), from Table E-6 of Regulatory Guide 1.109.
λ_i	Nuclide decay constant for nuclide i (sec^{-1}).
t	Exposure time, 4.73×10^8 seconds (15 years).

Inhalation Pathway

$$R_{oapi} = K'(BR_a)(DFA_{oi})_a$$

Formula: from NUREG-0133, page 31.

Where:

R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for inhalation pathway ($mrem/yr$ per $\mu Ci/m^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor $pCi/\mu Ci$ (10^6).
BR_a	Breathing rate for age group (m^3/yr), from Regulatory Guide 1.109: Adult – 8000 Teen – 8000 Child – 3700 Infant – 1400
$(DFA_{oi})_a$	Organ inhalation factor dose conversion factor for organ o, nuclide i, age group a ($mrem/pCi$), from Tables E-7 through E-10 of Regulatory Guide 1.109.

Vegetation

$$R_{oapi} = K' \left[\frac{(r)}{Y_v (\lambda_i + \lambda_w)} \right] \times (DFL_{oi})_a \times \left[U_a^L f_L e^{-\lambda_i t_L} + U_a^S f_g e^{-\lambda_i t_h} \right]$$

Formula: from NUREG-0133, page 35. Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for vegetation pathway ($m^2 \cdot mrem/yr$ per $\mu Ci/sec$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor $pCi/\mu Ci$ (10^6).
r	Fraction of deposited activity retained on vegetation, from Regulatory Guide 1.109. 1.0 for radioiodine. 0.2 for particulates.
Y_v	Vegetation areal density (kg/m^2) (2.0, from Regulatory Guide 1.109).
λ_i	Nuclide decay constant for nuclide i (sec^{-1}).
λ_w	Decay constant for removal of activity on leaf and plant surfaces by weathering ($5.73 \times 10^{-7} sec^{-1}$, from NUREG-0133).
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Reg. Guide 1.109 ($mrem/pCi$).
U_a^L	Consumption rate of fresh leafy vegetation for age group a (kg/yr) (from Regulatory Guide 1.109). Adult – 64 Teen – 42 Child – 26 Infant – 0
f_L	Fraction of annual intake of fresh leafy vegetation grown locally (1.0, from NUREG-0133).
t_L	Average time between harvest of leafy vegetation and consumption (8.6×10^4 seconds, (1 day), from Regulatory Guide 1.109).
U_a^S	Consumption rate of stored vegetation for age group a (kg/yr) (from Regulatory Guide 1.109). Adult – 520 Teen – 630 Child – 520 Infant – 0
f_g	Fraction of annual intake of stored vegetation (0.76, from Regulatory Guide 1.109).
t_h	Average time between harvest of stored vegetation and consumption (5.18×10^6 seconds, (60 days), from Regulatory Guide 1.109).

Vegetation – Tritium

$$R_{oapi} = K' K''' [U_a^L f_L + U_a^S f_g] (DFL_{oi})_a [0.75(0.5 / H)]$$

Formula: from NUREG-0133, page 36.	
Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, for vegetation pathway and tritium (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/ μCi (10^6).
K'''	Units conversion factor gm/kg (10^3).
U_a^L	Consumption rate of fresh leafy vegetation for age group a (kg/yr) (from Regulatory Guide 1.109). Adult – 64 Teen – 42 Child – 26 Infant – 0
f_L	Fraction of annual intake of fresh leafy vegetation grown locally (1.0, from NUREG-0133).
U_a^S	Consumption rate of stored vegetation for age group a (kg/yr) (from Regulatory Guide 1.109). Adult – 520 Teen – 630 Child – 520 Infant – 0
f_g	Fraction of annual intake of stored vegetation (0.76, from Regulatory Guide 1.109).
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
0.75	Fraction of total feed that is water. (From NUREG-0133).
0.5	Ratio of specific activity of feed grass water to atmospheric water. (From NUREG-0133).
H	Absolute humidity of the atmosphere ($8 \text{ gm}/\text{m}^3$, from Regulatory Guide 1.109).

Vegetation – Carbon-14

$$R_{oapi} = K'K''' \left[U_a^L f_L + U_a^S f_g \right] (DFL_{oi})_a [0.11/0.16](p)(f_i)$$

Formula: from NUREG-0133, page 36 and Regulatory Guide 1.109, page 26.	
Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, for vegetation pathway and carbon-14 (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/ μCi (10^6).
K'''	Units conversion factor gm/kg (10^3).
U_a^L	Consumption rate of fresh leafy vegetation for age group a (kg/yr) (from Regulatory Guide 1.109). Adult – 64 Teen – 42 Child – 26 Infant – 0
f_L	Fraction of annual intake of fresh leafy vegetation grown locally (1.0, from NUREG-0133).
U_a^S	Consumption rate of stored vegetation for age group a (kg/yr) (from Regulatory Guide 1.109). Adult – 520 Teen – 630 Child – 520 Infant – 0
f_g	Fraction of annual intake of stored vegetation (0.76, from Regulatory Guide 1.109).
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
0.11	Fraction of total plant mass that is natural carbon.
0.16	Concentration of natural carbon in the atmosphere (gm/m^3).
p	Ratio of the total annual C-14 release time to the total annual time during which photosynthesis occurs. This value is assumed to be 0.31, based on 70% of C-14 releases being from WGDTs, and 30% of C-14 releases being continuous from the unit vents (ref. IAEA Technical Reports Series no. 421, "Management of Waste Containing Tritium and Carbon-14", 2004; EPRI TR-1024827, "Carbon-14 Dose Calculation Methods at Nuclear Power Plants", 2012, Section 3.2.5).
f_i	The fraction of C-14 assumed to be in inorganic form (e.g., CO_2). Assumed to be 20%. Reference EPRI TR-105715, "Characterization of Carbon-14 Generated by the Nuclear Power Industry", Table 5-1.

Grass/Cow/Milk

$$R_{oapi} = K' \frac{Q_F (U_{ap})}{\lambda_i + \lambda_w} F_{mi}(r) (DFL_{oi})_a \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s) e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f}$$

Formula: from NUREG-0133, pages 32 & 33. Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/cow/milk pathway ($m^2 \cdot mrem/yr$ per $\mu Ci/sec$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor $pCi/\mu Ci$ (10^6).
Q_F	Cow consumption rate (50 kg/day, from Regulatory Guide 1.109)
U_{ap}	Consumption rate of cow milk for age group a (liters/yr, from Regulatory Guide 1.109). Adult – 310 Teen – 400 Child – 330 Infant – 330
r	Fraction of deposited activity retained on cow's feed grass, (from Regulatory Guide 1.109). 1.0 for radioiodine. 0.2 for particulates.
Y_p	Agricultural productivity by unit area of pasture feed grass (0.7 kg/m^2 , from Regulatory Guide 1.109).
Y_s	Agricultural productivity by unit area of stored feed (2.0 kg/m^2 , from Regulatory Guide 1.109).
λ_i	Nuclide decay constant for nuclide i (sec^{-1}).
λ_w	Decay constant for removal of activity on leaf and plant surfaces by weathering ($5.73 \times 10^{-7} \text{ sec}^{-1}$, from NUREG-0133).
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 ($mrem/pCi$).
F_{mi}	Stable element transfer coefficient for nuclide i, in days/liter, from Table E-1 of Regulatory Guide 1.109 for cow milk.
f_p	Fraction of year that the cow is on pasture (1.0, from RG 1.109).
f_s	Fraction of the cow feed that is pasture grass while the cow is on pasture (1.0, from Regulatory Guide 1.109).
t_f	Transport time for pasture to cow, to milk, to receptor ($1.73E+05$ seconds, from Regulatory Guide 1.109).
t_h	Transport time from pasture, to harvest, to cow, to milk, to receptor ($7.78E+06$ seconds, from Regulatory Guide 1.109).

Grass/Cow/Milk – Tritium

$$R_{oapi} = K' K''' F_{mi} Q_f U_{ap} (DFL_{io})_a [0.75(0.5 / H)]$$

Formula: from NUREG-0133, page 34.	
Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/cow/milk pathway (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/ μCi (10^6).
K'''	Units conversion factor gm/kg (10^3).
Q_F	Cow consumption rate (50 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of cow milk for age group a (liters/yr, from Regulatory Guide 1.109). Adult – 310 Teen – 400 Child – 330 Infant – 330
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
F_{mi}	Stable element transfer coefficient for nuclide i, in days/liter, from Table E-1 of Regulatory Guide 1.109 for cow milk.
0.75	Fraction of total feed that is water (from NUREG-0133).
0.5	Ratio of specific activity of feed grass water to atmospheric water (from NUREG-0133).
H	Absolute humidity of the atmosphere ($8 \text{ gm}/\text{m}^3$, from Regulatory Guide 1.109).

Grass/Cow/Milk – Carbon-14

$$R_{oapi} = K'K'' F_{mi} Q_F U_{ap} (DFL_{oi})_a [0.11/0.16](p)(f_I)$$

Formula: from NUREG-0133, page 34 and Regulatory Guide 1.109, page 26.	
Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/cow/meat pathway (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/ μCi (10^6).
K''	Units conversion factor gm/kg (10^3).
F_{mi}	Stable element transfer coefficient for nuclide i, in days/liter, from Table E-1 of Regulatory Guide 1.109 for cow milk.
Q_F	Cow consumption rate (50 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of cow milk for age group a (liters/yr) (from Regulatory Guide 1.109). Adult – 310 Teen – 400 Child – 330 Infant – 330
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
0.11	Fraction of total plant mass that is natural carbon.
0.16	Concentration of natural carbon in the atmosphere (gm/m^3).
p	Ratio of the total annual C-14 release time to the total annual time during which photosynthesis occurs. This value is assumed to be 0.31, based on 70% of C-14 releases being from WGDTs, and 30% of C-14 releases being continuous from the unit vents (ref. IAEA Technical Reports Series no. 421, "Management of Waste Containing Tritium and Carbon-14", 2004; EPRI TR-1024827, "Carbon-14 Dose Calculation Methods at Nuclear Power Plants", 2012, Section 3.2.5).
f_I	The fraction of C-14 assumed to be in inorganic form (e.g., CO_2). Assumed to be 20%. Reference EPRI TR-105715, "Characterization of Carbon-14 Generated by the Nuclear Power Industry", Table 5-1.

Grass/Goat/Milk

$$R_{oapi} = K' \frac{Q_F (U_{ap})}{\lambda_i + \lambda_w} F_{mi}(r)(DFL_{oi})_a \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s) e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f}$$

Formula: from NUREG-0133, pages 32 & 33. Where:

R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/goat/milk pathway ($m^2 \cdot mrem/yr$ per $\mu Ci/sec$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor $pCi/\mu Ci$ (10^6).
Q_F	Goat consumption rate (6 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of goat milk for age group a (liters/yr, from Regulatory Guide 1.109). Adult – 310 Teen – 400 Child – 330 Infant – 330
r	Fraction of deposited activity retained on goat's feed grass, from Regulatory Guide 1.109. 1.0 for radioiodine. 0.2 for particulates.
Y_p	Agricultural productivity by unit area of pasture feed grass ($0.7 kg/m^2$, from Regulatory Guide 1.109).
Y_s	Agricultural productivity by unit area of stored feed ($2.0 kg/m^2$, from Regulatory Guide 1.109).
λ_i	Nuclide decay constant for nuclide i (sec^{-1}).
λ_w	Decay constant for removal of activity on leaf and plant surfaces by weathering ($5.73 \times 10^{-7} sec^{-1}$, from NUREG-0133).
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 ($mrem/pCi$).
F_{mi}	Stable element transfer coefficient for nuclide i, in days/liter, from Table E-2 of Regulatory Guide 1.109 for goat milk.
f_p	Fraction of year that the goat is on pasture (1.0, from RG 1.109).
f_s	Fraction of the goat feed that is pasture grass while the goat is on pasture (1.0, from Regulatory Guide 1.109).
t_f	Transport time for pasture to goat, to milk, to receptor ($1.73E+05$ seconds, from Regulatory Guide 1.109).
t_h	Transport time from pasture, to harvest, to goat, to milk, to receptor ($7.78E+06$ seconds, from Regulatory Guide 1.109).

Grass/Goat/Milk – Tritium

$$R_{oapi} = K' K''' F_{mi} Q_f U_{ap} (DFL_{oi})_a [0.75(0.5 / H)]$$

Formula: from NUREG-0133, page 34.	
Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/goat/milk pathway (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/ μCi (10^6).
K'''	Units conversion factor gm/kg (10^3).
Q_F	Goat consumption rate (6 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of goat milk for age group a (liters/yr, from Regulatory Guide 1.109). Adult – 310 Teen – 400 Child – 330 Infant – 330
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
F_{mi}	Stable element transfer coefficient for nuclide i, in days/liter, from Table E-2 of Regulatory Guide 1.109 for goat milk.
0.75	Fraction of total feed that is water (from NUREG-0133).
0.5	Ratio of specific activity of feed grass water to atmospheric water (from NUREG-0133).
H	Absolute humidity of the atmosphere ($8 \text{ gm}/\text{m}^3$, from Regulatory Guide 1.109).

Grass/Goat/Milk – Carbon-14

$$R_{oapi} = K'K'' F_{mi} Q_F U_{ap} (DFL_{oi})_a [0.11/0.16](p)(f_I)$$

Formula: from NUREG-0133, page 34 and Regulatory Guide 1.109, page 26.	
Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/cow/meat pathway (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/ μCi (10^6).
K''	Units conversion factor gm/kg (10^3).
F_{mi}	Stable element transfer coefficient for nuclide i, in days/liter, from Table E-2 of Regulatory Guide 1.109 for goat milk (0.10).
Q_F	Goat consumption rate (6 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of goat milk for age group a (liters/yr) (from Regulatory Guide 1.109). Adult – 310 Teen – 400 Child – 330 Infant – 330
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
0.11	Fraction of total plant mass that is natural carbon.
0.16	Concentration of natural carbon in the atmosphere (gm/m^3).
p	Ratio of the total annual C-14 release time to the total annual time during which photosynthesis occurs. This value is assumed to be 0.31, based on 70% of C-14 releases being from WGDTs, and 30% of C-14 releases being continuous from the unit vents (ref. IAEA Technical Reports Series no. 421, "Management of Waste Containing Tritium and Carbon-14", 2004; EPRI TR-1024827, "Carbon-14 Dose Calculation Methods at Nuclear Power Plants", 2012, Section 3.2.5).
f_I	The fraction of C-14 assumed to be in inorganic form (e.g., CO_2). Assumed to be 20%. Reference EPRI TR-105715, "Characterization of Carbon-14 Generated by the Nuclear Power Industry", Table 5-1.

Grass/Cow/Meat

$$R_{oapi} = K' \frac{Q_F (U_{ap})}{\lambda_i + \lambda_w} F_{fi}(r) (DFL_{i,a}) \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s) e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f}$$

Formula: from NUREG-0133, pages 34 & 35. Where:

R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/cow/meat pathway ($m^2 \cdot mrem/yr$ per $\mu Ci/sec$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor $pCi/\mu Ci$ (10^6).
Q_F	Cow consumption rate (50 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of cow meat for age group a (kg/yr, from Regulatory Guide 1.109). Adult – 110 Teen – 65 Child – 41 Infant – 0
r	Fraction of deposited activity retained on cow's feed grass (from Regulatory Guide 1.109). 1.0 for radioiodine. 0.2 for particulates.
Y_p	Agricultural productivity by unit area of pasture feed grass ($0.7 kg/m^2$, from Regulatory Guide 1.109).
Y_s	Agricultural productivity by unit area of stored feed ($2.0 kg/m^2$, from Regulatory Guide 1.109).
λ_i	Nuclide decay constant for nuclide i (sec^{-1}).
λ_w	Decay constant for removal of activity on leaf and plant surfaces by weathering ($5.73 \times 10^{-7} sec^{-1}$, from NUREG-0133).
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
F_{fi}	Stable element transfer coefficient for nuclide i, in days/kg, from Table E-1 of Regulatory Guide 1.109 for cow meat.
f_p	Fraction of year that the cow is on pasture (1.0, from RG 1.109).
f_s	Fraction of the cow feed that is pasture grass while the cow is on pasture (1.0, from Regulatory Guide 1.109).
t_f	Transport time from pasture to receptor ($1.73E+06$ seconds, from Regulatory Guide 1.109).
t_h	Transport time from crop field to receptor ($7.78E+06$ seconds, from Regulatory Guide 1.109).

Grass/Cow/Meat – Tritium

$$R_{oapi} = K' K''' F_{fi} Q_F U_{ap} (DFL_{oi})_a [0.75(0.5 / H)]$$

Formula: from NUREG-0133, page 35.	
Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/cow/meat pathway (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/ μCi (10^6).
K'''	Units conversion factor gm/kg (10^3).
Q_F	Cow consumption rate (50 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of cow meat for age group a (kg/yr, from Regulatory Guide 1.109). Adult – 110 Teen – 65 Child – 41 Infant – 0
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
F_{fi}	Stable element transfer coefficient for nuclide i, in days/liter, from Table E-1 of Regulatory Guide 1.109 for cow meat.
0.75	Fraction of total feed that is water (from NUREG-0133).
0.5	Ratio of specific activity of feed grass water to atmospheric water (from NUREG-0133).
H	Absolute humidity of the atmosphere ($8 \text{ gm}/\text{m}^3$, from Regulatory Guide 1.109).

Grass/Cow/Meat – Carbon-14

$$R_{oapi} = K'K'' F_{fi} Q_F U_{ap} (DFL_{oi})_a [0.11/0.16](p)(f_I)$$

Formula: from NUREG-0133, page 35 and Regulatory Guide 1.109, page 26.	
Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/cow/meat pathway (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/ μCi (10^6).
K''	Units conversion factor gm/kg (10^3).
F_{fi}	Stable element transfer coefficient for nuclide i, in days/liter, from Table E-1 of Regulatory Guide 1.109 for cow meat.
Q_F	Cow consumption rate (50 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of cow meat for age group a (kg/yr) (from Regulatory Guide 1.109). Adult – 110 Teen – 65 Child – 41 Infant – 0
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
0.11	Fraction of total plant mass that is natural carbon.
0.16	Concentration of natural carbon in the atmosphere (gm/m^3).
p	Ratio of the total annual C-14 release time to the total annual time during which photosynthesis occurs. This value is assumed to be 0.31, based on 70% of C-14 releases being from WGDTs, and 30% of C-14 releases being continuous from the unit vents (ref. IAEA Technical Reports Series no. 421, "Management of Waste Containing Tritium and Carbon-14", 2004; EPRI TR-1024827, "Carbon-14 Dose Calculation Methods at Nuclear Power Plants", 2012, Section 3.2.5).
f_I	The fraction of C-14 assumed to be in inorganic form (e.g., CO_2). Assumed to be 20%. Reference EPRI TR-105715, "Characterization of Carbon-14 Generated by the Nuclear Power Industry", Table 5-1.

Grass/Goat/Meat

$$R_{oapi} = K' \frac{Q_F (U_{ap})}{\lambda_i + \lambda_w} F_{fi}(r) (DFL_i)_a \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s) e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f}$$

Formula: from NUREG-0133, pages 34 & 35. Where:

R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/goat/meat pathway ($m^2 \cdot mrem/yr$ per $\mu Ci/sec$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor $pCi/\mu Ci$ (10^6).
Q_F	Goat consumption rate (6 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of goat meat for age group a (kg/yr, from Regulatory Guide 1.109). Adult – 110 Teen – 65 Child – 41 Infant – 0
r	Fraction of deposited activity retained on goat's feed grass (from Regulatory Guide 1.109). 1.0 for radioiodine. 0.2 for particulates.
Y_p	Agricultural productivity by unit area of pasture feed grass ($0.7 kg/m^2$, from Regulatory Guide 1.109).
Y_s	Agricultural productivity by unit area of stored feed ($2.0 kg/m^2$, from Regulatory Guide 1.109).
λ_i	Nuclide decay constant for nuclide i (sec^{-1}).
λ_w	Decay constant for removal of activity on leaf and plant surfaces by weathering ($5.73 \times 10^{-7} sec^{-1}$, from NUREG-0133).
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 ($mrem/pCi$).
F_{fi}	Stable element transfer coefficient for nuclide i, in days/kg, from Table E-1 of Regulatory Guide 1.109 for cow meat.
f_p	Fraction of year that the goat is on pasture (1.0, from RG 1.109).
f_s	Fraction of the goat feed that is pasture grass while the goat is on pasture (1.0, from Regulatory Guide 1.109).
t_f	Transport time from pasture to receptor ($1.73E+06$ seconds, from Regulatory Guide 1.109).
t_h	Transport time from crop field to receptor ($7.78E+06$ seconds, from Regulatory Guide 1.109).

Grass/Goat/Meat – Tritium

$$R_{oapi} = K' K''' F_{fi} Q_F U_{ap} (DFL_{oi})_a [0.75(0.5 / H)]$$

Formula: from NUREG-0133, page 35.	
Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/goat/meat pathway (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/ μCi (10^6).
K'''	Units conversion factor gm/kg (10^3).
Q_F	Goat consumption rate (6 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of goat meat for age group a (kg/yr, from Regulatory Guide 1.109). Adult – 110 Teen – 65 Child – 41 Infant – 0
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
F_{fi}	Stable element transfer coefficient for nuclide i, in days/liter, from Table E-1 of Regulatory Guide 1.109 for cow meat.
0.75	Fraction of total feed that is water (from NUREG-0133).
0.5	Ratio of specific activity of feed grass water to atmospheric water (from NUREG-0133).
H	Absolute humidity of the atmosphere ($8 \text{ gm}/\text{m}^3$, from Regulatory Guide 1.109).

Grass/Goat/Meat – Carbon-14

$$R_{oapi} = K'K''' F_{fi} Q_F U_{ap} (DFL_{oi})_a [0.11/0.16](p)(f_I)$$

Formula: from NUREG-0133, page 35 and Regulatory Guide 1.109, page 26.	
Where:	
R_{oapi}	Dose commitment factor for organ o, age group a, nuclide i, for grass/goat/meat pathway (mrem/yr per $\mu\text{Ci}/\text{m}^3$). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/ μCi (10^6).
K'''	Units conversion factor gm/kg (10^3).
F_{fi}	Stable element transfer coefficient for nuclide i, in days/liter, from Table E-1 of Regulatory Guide 1.109 for cow meat.
Q_F	Goat consumption rate (6 kg/day, from Regulatory Guide 1.109).
U_{ap}	Consumption rate of goat meat for age group a (kg/yr) (from Regulatory Guide 1.109). Adult – 110 Teen – 65 Child – 41 Infant – 0
$(DFL_{oi})_a$	Ingestion dose conversion factor for nuclide i, organ o, and age group a, from Tables E-11 through E-14 of Regulatory Guide 1.109 (mrem/pCi).
0.11	Fraction of total plant mass that is natural carbon.
0.16	Concentration of natural carbon in the atmosphere (gm/m^3).
p	Ratio of the total annual C-14 release time to the total annual time during which photosynthesis occurs. This value is assumed to be 0.31, based on 70% of C-14 releases being from WGDTs, and 30% of C-14 releases being continuous from the unit vents (ref. IAEA Technical Reports Series no. 421, "Management of Waste Containing Tritium and Carbon-14", 2004; EPRI TR-1024827, "Carbon-14 Dose Calculation Methods at Nuclear Power Plants", 2012, Section 3.2.5).
f_I	The fraction of C-14 assumed to be in inorganic form (e.g., CO_2). Assumed to be 20%. Reference EPRI TR-105715, "Characterization of Carbon-14 Generated by the Nuclear Power Industry", Table 5-1.

4.0.3 DIRECT RADIATION

Direct radiation is that radiation from confined sources, and does not include any external component from radioactive effluents. The Point Kernel method has been used to calculate offsite dose rates from radioactive materials stored in the refueling water storage tanks, reactor makeup water storage tanks, and temporary onsite radwaste storage tanks. Dose calculations using this method performed for Catawba Nuclear Station indicate direct radiation doses are much less than 0.01 mrem/yr and, therefore, make a negligible contribution to individual dose. Likewise, direct and air-scatter radiation dose contributions from the onsite Independent Spent Fuel Storage Installation (ISFSI) at Catawba have been calculated and documented in the Catawba 10CFR72.212 evaluation report. The results of the calculation demonstrate that the annual dose to any "real individual" beyond the controlled area boundary is below the 10CFR72.104(a) and 40CFR190.10(a) limit of 25 mrem from direct and skyshine radiation, and all other fuel cycle sources (e.g., effluent). Direct radiation doses will not be calculated routinely.

4.0.4 EFFLUENT APPORTIONMENT

For the Catawba Nuclear Station the effluent releases are apportioned equally to each unit for each site as recommended by Section 3.1 of NUREG-0133, because the shared radwaste treatment systems at each site make it impractical to accurately ascribe releases to a specific reactor unit. For Annual Radiological Effluent Release Report purposes effluent releases are summed for each unit, and the maximum individual dose to the public is reported as a site total.

5.0 FUEL CYCLE CALCULATIONS

In accordance with the requirements of 40CFR190, the annual dose commitment to any member of the general public shall be calculated to assure that doses are limited to 25 millirems to the total body or any organ with the exception of the thyroid which is limited to 75 millirems. In accordance with the requirements of the Selected Licensee Commitments, the annual dose commitment shall also be calculated any time twice the specified quarterly dose limit of the Selected Licensee Commitments is exceeded; these annual dose commitments may not just be calculated for the calendar year.

The "Uranium fuel cycle" is defined in 40CFR Part 190.02(b) as:

"Uranium fuel cycle means the operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel, to the extent that these directly support the production of electrical power for public use utilizing nuclear energy, but excludes mining operations, operations at waste disposal sites, transportation of any radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and by-product materials from the cycle."

Based on this definition of the fuel cycle and the information in 10CFR51, Table S-3, and Wash-1248, the radiological impact of the following operations has been assessed for Catawba Nuclear Station:

5.0.1 MILLING

No milling operations occur within fifty miles of the Catawba Nuclear Station.

5.0.2 CONVERSION

No uranium hexafluoride production occurs within fifty miles of the Catawba Nuclear Station.

5.0.3 ENRICHMENT

No uranium enrichment operations occur within fifty miles of the Catawba Nuclear Station.

5.0.4 FUEL FABRICATION

No fuel fabrication operations occur within fifty miles of the Catawba Nuclear Station.

5.0.5 NUCLEAR POWER PRODUCTION

The production of electricity for public use using light-water-cooled nuclear power stations results in increments of dose to individuals within fifty miles of any station due to liquid and gaseous effluent releases and direct radiation or skyshine. The increments of dose resulting from liquid and gaseous effluent releases will be calculated using the software implementing the ODCM methodology. The dose from direct radiation, skyshine, and radiation from the station storage facilities has been estimated using conservative assumptions (see Section 4.0.3).

In certain situations more than one nuclear power station site may contribute to the doses to be considered in making fuel cycle dose assessments in accordance with 40CFR190. However, since the Catawba and McGuire nuclear stations are located approximately 30 miles apart the relative dose contribution from each site to the other is insignificant, and can be ignored in assessing compliance with 40CFR190.

5.0.6 FUEL REPROCESSING

No fuel reprocessing operations occur within fifty miles of the Catawba Nuclear Station.

5.0.7 40CFR190 TOTAL DOSE DETERMINATION

To summarize, only dose increments from nuclear power production operations (Section 5.0.5) need be considered in calculations to demonstrate compliance with the requirements of 40CFR190. The fuel cycle dose assessments for Catawba Nuclear Station only include liquid and gaseous dose contributions from Catawba and dose from Catawba's ISFSI since no other uranium fuel cycle facility contributes significantly to Catawba's maximum exposed individual. For this dose assessment, the total body and maximum organ dose contributions to the maximum exposed individual from Catawba's liquid and gaseous effluents are estimated using the following calculations:

$$D_{wb}(T) = D_{wb}(l) + D_{wb}(g)$$

$$D_{mo}(T) = D_{mo}(l) + D_{mo}(g)$$

where:

$D_{wb}(T)$ = Total estimated fuel cycle whole body dose commitment resulting from the combined liquid and gaseous effluents of Catawba during the calendar year of interest, in mrem.

$D_{mo}(T)$ = Total estimated fuel cycle maximum organ dose commitment resulting from the combined liquid and gaseous effluents of Catawba during the calendar year of interest, in mrem.

6.0 ENVIRONMENTAL LOCATIONS

6.0.1 SITE DESCRIPTION AND SAMPLE LOCATIONS

Catawba Nuclear Station is located geographically near the center of a highly industrialized region of the Carolinas. The land is predominantly rural non-farm with a small amount of land being used to support beef cattle and farming. Recreation in the area is confined mostly to the lake and shores of Lake Wylie. The site is located in the northeastern portion of York County, South Carolina, on a peninsula bounded by Beaver Dam Creek to the north, Big Allison Creek



Fish Sampling

to the south, the main body of Lake Wylie to the east, and private property to the west. The Duke Power Company Wylie Dam and Hydroelectric Station are located approximately 4.5 miles southeast of the site. Rock Hill, South Carolina and Charlotte, North Carolina are the nearest large cities. The city limit of Rock Hill is located approximately 5.8 miles south-southeast of the site and the Charlotte city limit is located approximately 10.5 miles east-northeast of the site. The CNS site exclusion radius is 2500 feet.

Table 6.0-1 and Table 6.0-2 define the sampling and TLD locations for the Catawba Radiological Monitoring Program. Figure 6.0-1 and Figure 6.0-2 illustrate these locations as compared to Catawba Nuclear Station.

6.0.2 LAND USE CENSUS DATA

The Annual Land Use Census, required by Selected Licensee Commitments, is performed to ensure that changes in the use of areas at or beyond the site boundary are identified, and that modifications to the Radiological Environmental Monitoring Program are made if required by changes in land use. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10CFR50. The land use census identifies nearest pathways to the exclusion area boundary (EAB, ~ 0.5 mile) for each of the 16 meteorological sectors. Global Positioning System field measurements are taken as close as possible to the item of interest and are accurate to within 2-5 meters. Locations beyond the nearest pathway for each sector are assumed to contain that pathway for dose calculation purposes. For the 4.5-5.0 mile sector all pathways, i.e., residence, garden, milk animal (goat), and meat animal (cow), are assumed to exist for dose calculation purposes. Results are maintained on file and data reviewed in accordance with procedure AD-CP-ALL-0014, Land Use Census Evaluation.

**TABLE 6.0-1
CATAWBA RADIOLOGICAL MONITORING PROGRAM
SAMPLING LOCATIONS**

Table 6.0-1 Codes			
W	Weekly	SM	Semimonthly
BW	BiWeekly	Q	Quarterly
M	Monthly	SA	Semiannually
C	Control		

Site #	Location Description*	Air Rad. & Part.	Surface Water	Drinking Water	Shoreline Sediment	Food Products (a)	Fish	Milk	Broad Leaf Veg. (b)	Ground Water **
200	Site Boundary (0.63 mi NNE)	W							M	
201	Site Boundary (0.53 mi NE)	W							M	
208	Discharge Canal (0.45 mi S)	W	M		SA		SA			
210	Ebenezer Access (2.31 mi SE)				SA					
211	Wylie Dam (4.06 mi ESE)		M							
212	Tega Cay (3.32 mi E)	W								
214	Rock Hill Water Supply (7.30 mi SSE)			M						
216 C	Hwy 49 Bridge (4.19 mi NNE)						SA			
218 C	Belmont Water Supply (13.5 mi NNE)			M						
221 C	Dairy (14.5 mi NW)							SM		
222	Site Boundary (0.70 mi N)								M	
226	Site Boundary (0.48 mi S)								M	
258 C	Fairhope Road (9.84 mi W)	W							M	
260	Irrigated Gardens (2.00 mi SSE)					M(a)				
261	Firing Range - Site Boundary (0.72 mi N)	W								
262 C	Lake Wylie Marina - Hwy 49 (4.19 mi NNE)				SA					
263 C	Liberty Hill Road (0.59 mi NNE)		M							

(a) During Harvest Season

(b) When Available

* GPS data reflect approximate accuracy to within 2-5 meters. GPS field measurements were taken as close as possible to the item of interest.

** Currently no off-site ground water monitoring locations available that are used for drinking or irrigation purposes where hydraulic gradient or recharge properties are suitable for contamination.

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Offsite Dose Calculation Manual (ODCM)

TABLE 6.0-2

**CATAWBA RADIOLOGICAL MONITORING PROGRAM
SAMPLING LOCATIONS**

(TLD SITES)

Site #	Location*	Distance	Sector	Site #	Location*	Distance	Sector
200	SITE BOUNDARY	0.63 miles	NNE	234	WELLS FARGO BANK	4.50 miles	E
201	SITE BOUNDARY	0.53 miles	NE	235	LAKE WYLIE DAM	4.07 miles	ESE
203	SITE BOUNDARY	0.38 miles	ESE	236	SC WILDLIFE FEDERATION OFFICE	4.25 miles	SE
204	SITE BOUNDARY	0.48 miles	SSW	237	TWIN LAKES ROAD AND HOMESTEAD ROAD	4.75 miles	SSE
205	SITE BOUNDARY	0.50 miles	SW	238	PENNINGTON ROAD AND WEST OAK ROAD	4.02 miles	S
206	SITE BOUNDARY	0.67 miles	WNW	239	CARTER LUMBER COMPANY	4.49 miles	SSW
207	SITE BOUNDARY	0.95 miles	NNW	240	PARAHAM ROAD	4.07 miles	SW
212 SI	TEGA CAY AIR SITE	3.32 miles	E	241	CAMPBELL ROAD	4.58 miles	WSW
217 C	BLACKMON ROAD	10.3 miles	SSE	242	TRANSMISSION TOWER ON PARAHAM ROAD	4.56 miles	W
222	SITE BOUNDARY	0.71 miles	N	243	KINGSBURRY ROAD	4.39 miles	WNW
223	SITE BOUNDARY	0.57 miles	E	244	BETHEL ELEMENTARY SCHOOL	4.02 miles	NW
225	SITE BOUNDARY	0.68 miles	SE	245	CROWDERS CREEK BOAT LANDING	4.01 miles	NNW
226	SITE BOUNDARY	0.48 miles	S	246 SI	CAROWINDS GUARD HOUSE	7.87 miles	ENE
227	SITE BOUNDARY	0.52 miles	WSW	247 C	FORT MILL	7.33 miles	ESE
228	SITE BOUNDARY	0.61 miles	W	248 SI	PIEDMONT MEDICAL CENTER	6.54 miles	S
229	SITE BOUNDARY	0.84 miles	NW	249 SI	YORK COUNTY OPERATIONS CENTER	7.17 miles	S
230	RIVER HILLS COMMUNITY CHURCH	4.37 miles	N	250 SI	YORK DUKE POWER OFFICE	10.4 miles	WSW
231	RIVER HILLS FRONT ENTRANCE	4.21 miles	NNE	251 C	CLOVER	9.72 miles	WNW
232	PLEASANT HILL ROAD	4.18 miles	NE	255	SITE BOUNDARY	0.61 miles	ENE
233	ZOAR ROAD AND THOMAS DRIVE	3.95 miles	ENE	256	SITE BOUNDARY	0.58 miles	SSE
				258	FAIRHOPE ROAD	9.84 miles	W

C = Control
SI = Special Interest

* GPS data reflect approximate accuracy to within 2-5 meters. GPS field measurements were taken as close as possible to the item of interest.

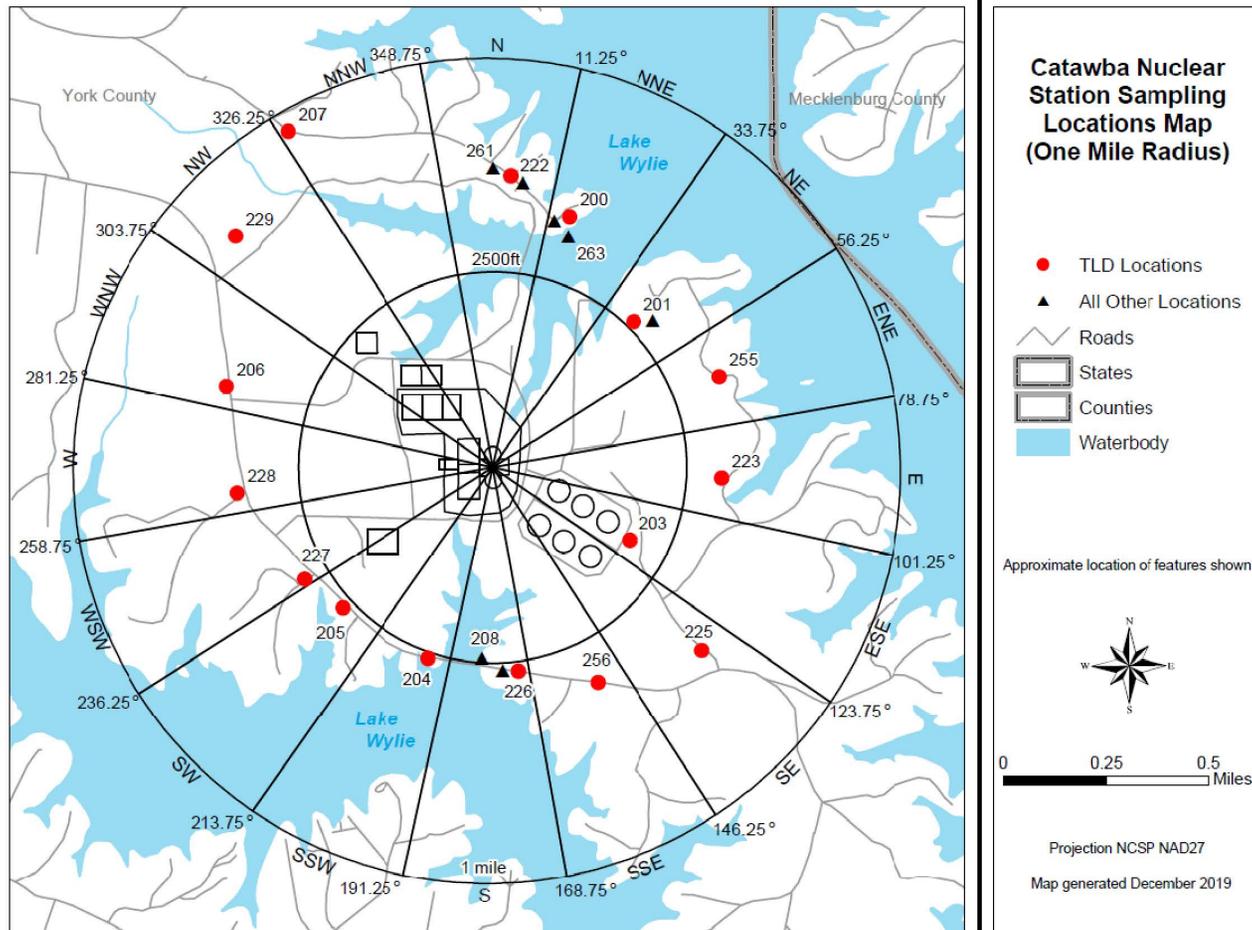
TABLE 6.0-3

Land Use Census Results

Deleted in ODCM Revision 60.

Catawba Nuclear Station
Offsite Dose Calculation Manual (ODCM)

Figure 6.0-1 Sampling Locations Map (Site Boundary)



Catawba Nuclear Station
 Offsite Dose Calculation Manual (ODCM)

Figure 6.0-2 Sampling Locations Map (Ten Mile Radius)

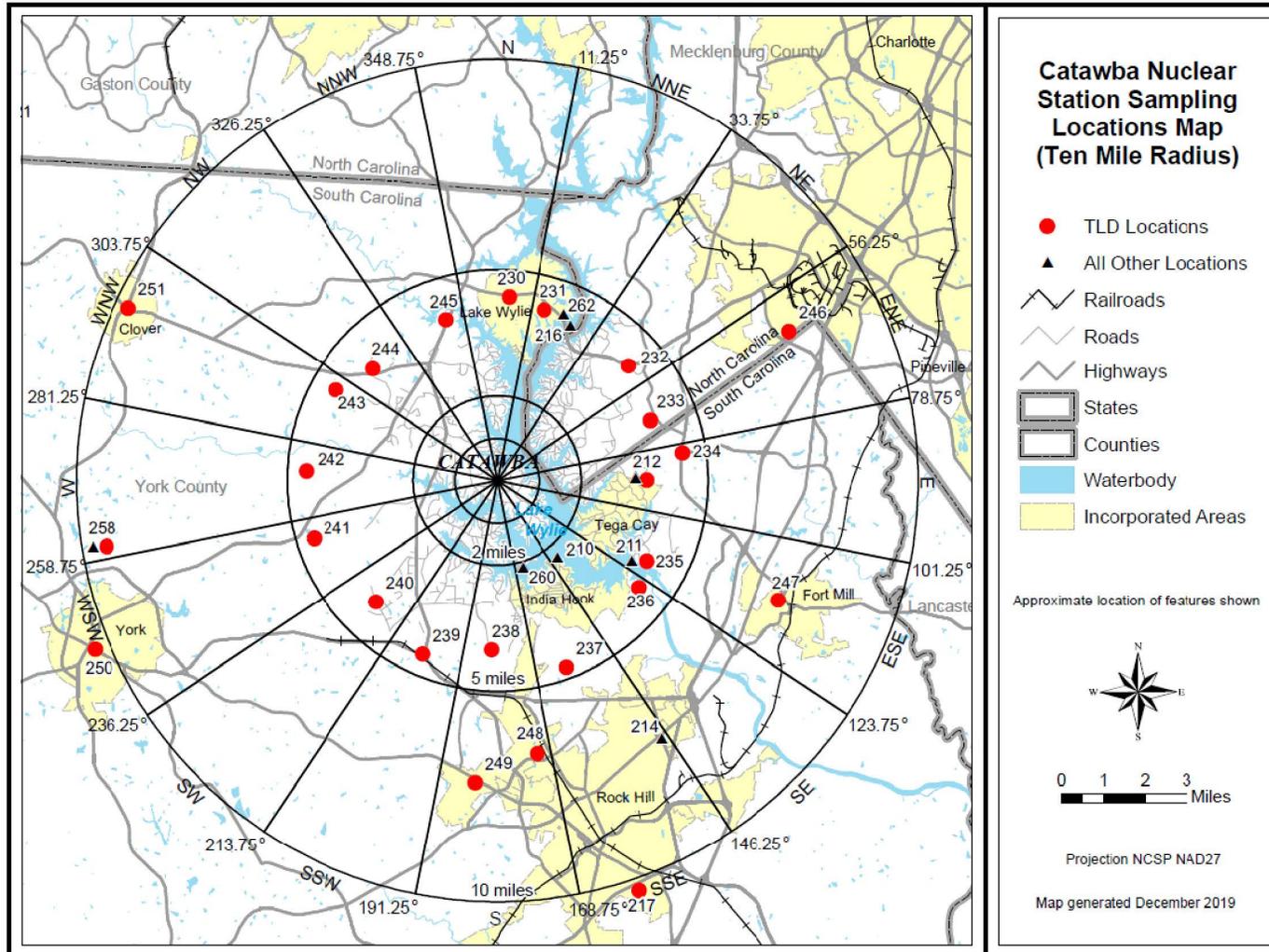


Figure 6.0-3 Land Use Census Map

Deleted in ODCM Revision 60.

6.0.3 CATAWBA METEOROLOGY: RELATIVE AIR CONCENTRATIONS AND DEPOSITION

Calculations of annually averaged air concentrations and deposition values from routine releases provide the air dispersion and deposition factors needed for dose assessment. The methodology is based upon Regulatory Guide 1.111, as implemented by the NRC's computer model "XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," NUREG/CR-2919, PNL-4380, September 1982. The calculation is documented in CNC-1108.01-00-0002 "Annual Air Dispersion and Deposition Factors for Routine Releases (ODCM)."

Five years of hourly meteorological data from the onsite instruments are processed into a representative joint frequency distribution of winds and atmospheric stability for input into the XOQDOQ model (Version 2.0). Thus, the air dispersion and deposition factors (X/Q and D/Q) output by the model are based on a five-year climatology for the site.

6.0.3.1 XOQDOQ METHODOLOGY AND ASSUMPTIONS

A continuous, routine release (non-purge) is simulated from each unit vent. The release type is treated as "ground-level" in the model, for which surrounding terrain elevations are not input. The locale does consist of gently rolling to flat terrain, so the default open terrain recirculation factor is applied in XOQDOQ [KOPT(8)=1]. This correction factor is recommended in RG 1.111 to adjust the straight-line airflow of the model for spatial and temporal variations that are produced by large-scale weather patterns, or other non-linear flow conditions at local and regional scales.

In order for XOQDOQ to treat the plume as a ground-level release, the exit velocity and the inside diameter of the unit vent must be input as zero. The heat emission rate of each vent is also assumed to be zero, as recommended by the model. The height of the vent (38 m) above plant grade elevation (594 ft msl) is then used to determine the plume centerline height. Using the building height (41 m) and minimum cross-sectional area of the containment building (1616 m²), XOQDOQ applies a building wake correction to the relative air concentrations from the ground level release.

Calculations of relative air concentrations and deposition are made for grid receptor distances per directional sector. The "no decay" assumption is used in the XOQDOQ model.

6.0.3.2 METEOROLOGICAL DATA

Five years (1988-1992) of hourly, onsite meteorological data are used to produce the joint frequency distributions of wind speed and direction per stability class. The 10 m level winds are used. It is these joint frequency distributions which are input to the XOQDOQ model. Hours of calm winds are distributed by direction with the same frequency as the lowest "noncalm" wind speed class [KOPT(1)=1]. Thus, wind speed classes are established so that the lowest wind speed class is the starting threshold of the anemometer

(i.e. the "calm" wind speed class). The largest wind speed class has the upper bound of (5 m/s + max hourly wind speed). Stability classes (A-G) are based on the vertical temperature gradient, measured by the hourly averaged delta-T variable.

6.0.3.3 ANNUAL XOQDOQ COMPARISON TO THE ODCM

Each year, the prevailing winds and stability class frequencies for CNS are compared to the 5-year period (1988-1992) upon which the χ/Q and D/Q calculations have been made. The 5-year climatology is summarized in Table 6.0-4 and Table 6.0-5 below. Since the comparison is being made to a 5-year climatology, significant differences should not occur in the meteorological variables of concern (i.e. winds and delta-T). The meteorological comparison serves to verify this assumption.

**Table 6.0-4
CNS Atmospheric Stability Frequency (1988-1992)**

	A	B	C	D	E	F	G
Frequency (%)	10.9	4.3	5.5	31.1	26.9	10.3	10.9

**Table 6.0-5
CNS Frequency of Wind Direction (From) and Speed (1988-1992)**

Sector	Wind Direction Frequency (%)	Wind Speed Class (m/s)	Wind Speed Frequency (%)
N	10.1	CALM	0.9
NNE	8.7	0.45 - 0.74 m/s	2.8
NE	5.0	0.75 - 0.99 m/s	4.8
ENE	1.9	1.00 - 1.24 m/s	6.4
E	1.0	1.25 - 1.49 m/s	9.9
ESE	1.4	1.50 - 1.99 m/s	17.8
SE	2.9	2.00 - 2.99 m/s	25.5
SSE	6.2	3.00 - 3.99 m/s	16.8
S	11.2	4.00 - 4.99 m/s	9.6
SSW	13.8	5.00 - 5.99 m/s	3.6
SW	9.8	6.00 - 7.99 m/s	1.6
WSW	5.3	8.00 - 9.99 m/s	0.1
W	4.1	> 9.99 m/s	0.2
WNW	4.9		
NW	4.9		
NNW	9.0		

The joint frequency distributions of wind speed and direction versus atmospheric stability class are also determined from the annual data to provide input to the XOQDOQ model.

Modeled χ/Q and D/Q values for the 0.5 mile Exclusion Area Boundary at CNS are compared to the maximum of the (1988-1992) χ/Q and D/Q values from all sectors. If the newly calculated annual dispersion and deposition values do not result in a significant increase in the calculated offsite dose relative to the 10CFR50, Appendix I dose objectives then the 5-year χ/Q and D/Q values used in the Annual Radiological Effluent Release Report (ARERR) are not revised. An increase in calculated offsite dose that is greater than five percent of the 10CFR50, Appendix I dose objectives would be considered significant enough to warrant a change in the χ/Q and D/Q values used in the ARERR. If an increasing trend in the annual χ/Q and D/Q values compared to the 5-year values is noted then a revised set of 5-year χ/Q and D/Q values will be generated. These limiting values are listed in Table 6.0-6. The entire χ/Q and D/Q list based on directional sector and distance is given in Table 6.0-8 and 6.0-9.

Table 6.0-6
CNS Limiting χ/Q and D/Q Values (1988-1992)

	$(\chi/Q, s/m^3)$ $(D/Q, 1/m^2)$	Distance	Sector
Maximum X/Q	3.510E-5	0.5 mile EAB	NNE
Maximum D/Q	1.078E-7	0.5 mile EAB	NNE

Note:

The Catawba meteorological instruments were moved from the 40 m microwave tower to a new 60 m meteorological tower in June 1996. The taller tower became operational at 1900 hours on June 11, 1996. Therefore, determination of atmospheric stability prior to this time uses the 30 m separation criteria shown in Table 6.0-7, while data after this time uses the 50.9 m separation criteria.

Table 6.0-7
CNS Delta-T Ranges per Vertical Separation Distances

Stability Class	30 m separation Delta-T (between 40m-10m levels)	50.9 m separation Delta-T (between 60.2m-9.3m levels) Starting at 1900 hours on June 11, 1996.
A	$dT \leq -0.57$	$dT \leq -0.97$
B	$-0.57 < dT \leq -0.51$	$-0.97 < dT \leq -0.87$
C	$-0.51 < dT \leq -0.45$	$-0.87 < dT \leq -0.76$
D	$-0.45 < dT \leq -0.15$	$-0.76 < dT \leq -0.25$
E	$-0.15 < dT \leq 0.45$	$-0.25 < dT \leq 0.76$
F	$0.45 < dT \leq 1.2$	$0.76 < dT \leq 2.04$
G	$1.2 < dT$	$2.04 < dT$

Table 6.0-8

**Catawba χ/Q Average Values (1988-1992)
(sec/m³)**

Sector	0.5-1.0*	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0
N	2.959E-05	7.879E-06	3.222E-06	1.768E-06	1.133E-06	7.978E-07	5.987E-07	4.701E-07	3.818E-07
NNE	3.510E-05	9.342E-06	3.814E-06	2.091E-06	1.338E-06	9.420E-07	7.066E-07	5.546E-07	4.503E-07
NE	2.927E-05	7.738E-06	3.166E-06	1.738E-06	1.114E-06	7.848E-07	5.891E-07	4.627E-07	3.759E-07
ENE	2.208E-05	5.813E-06	2.406E-06	1.330E-06	8.573E-07	6.065E-07	4.568E-07	3.598E-07	2.931E-07
E	1.858E-05	4.895E-06	2.032E-06	1.126E-06	7.266E-07	5.147E-07	3.880E-07	3.059E-07	2.493E-07
ESE	1.962E-05	5.223E-06	2.163E-06	1.197E-06	7.712E-07	5.457E-07	4.110E-07	3.238E-07	2.637E-07
SE	1.965E-05	5.167E-06	2.151E-06	1.194E-06	7.717E-07	5.471E-07	4.128E-07	3.257E-07	2.656E-07
SSE	2.561E-05	6.751E-06	2.798E-06	1.548E-06	9.982E-07	7.064E-07	5.323E-07	4.194E-07	3.416E-07
S	1.552E-05	4.101E-06	1.642E-06	8.878E-07	5.624E-07	3.926E-07	2.924E-07	2.282E-07	1.843E-07
SSW	8.747E-06	2.267E-06	8.761E-07	4.621E-07	2.872E-07	1.973E-07	1.450E-07	1.118E-07	8.939E-08
SW	5.071E-06	1.328E-06	5.087E-07	2.666E-07	1.648E-07	1.127E-07	8.249E-08	6.340E-08	5.052E-08
WSW	3.265E-06	8.730E-07	3.413E-07	1.815E-07	1.135E-07	7.839E-08	5.786E-08	4.479E-08	3.592E-08
W	2.024E-06	5.307E-07	2.058E-07	1.088E-07	6.771E-08	4.657E-08	3.426E-08	2.644E-08	2.115E-08
WNW	3.468E-06	9.193E-07	3.595E-07	1.913E-07	1.197E-07	8.267E-08	6.104E-08	4.727E-08	3.793E-08
NW	6.249E-06	1.680E-06	6.638E-07	3.558E-07	2.239E-07	1.555E-07	1.153E-07	8.959E-08	7.212E-08
NNW	1.406E-05	3.723E-06	1.508E-06	8.221E-07	5.242E-07	3.678E-07	2.752E-07	2.155E-07	1.747E-07

* Units are in miles from the station. Each χ/Q value is calculated at the closest location for the sector, e.g., 2.959E-05 sec/m³ is the χ/Q value at 0.5 miles (N) from the station. As discussed in Catawba UFSAR Section 2.1.1.3, the boundary for establishing gaseous effluent release limits is the exclusion area boundary (EAB). The EAB is defined as a 2500-ft. (~0.5 mile) radius from the station center.

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Table 6.0-9

**Catawba D/Q Average Values (1988-1992)
(m⁻²)**

Sector	0.5-1.0*	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0
N	8.799E-08	2.148E-08	7.715E-09	3.826E-09	2.253E-09	1.475E-09	1.038E-09	7.693E-10	5.928E-10
NNE	1.078E-07	2.630E-08	9.448E-09	4.686E-09	2.759E-09	1.807E-09	1.271E-09	9.421E-10	7.260E-10
NE	7.653E-08	1.868E-08	6.710E-09	3.328E-09	1.960E-09	1.283E-09	9.028E-10	6.691E-10	5.156E-10
ENE	4.135E-08	1.009E-08	3.626E-09	1.798E-09	1.059E-09	6.933E-10	4.878E-10	3.615E-10	2.786E-10
E	3.246E-08	7.924E-09	2.846E-09	1.411E-09	8.311E-10	5.442E-10	3.829E-10	2.838E-10	2.187E-10
ESE	3.810E-08	9.301E-09	3.341E-09	1.657E-09	9.755E-10	6.388E-10	4.495E-10	3.331E-10	2.567E-10
SE	3.799E-08	9.274E-09	3.331E-09	1.652E-09	9.727E-10	6.369E-10	4.482E-10	3.321E-10	2.560E-10
SSE	7.019E-08	1.713E-08	6.154E-09	3.052E-09	1.797E-09	1.177E-09	8.280E-10	6.136E-10	4.729E-10
S	7.881E-08	1.924E-08	6.910E-09	3.427E-09	2.018E-09	1.321E-09	9.297E-10	6.890E-10	5.310E-10
SSW	6.787E-08	1.657E-08	5.951E-09	2.951E-09	1.738E-09	1.138E-09	8.007E-10	5.934E-10	4.573E-10
SW	3.877E-08	9.464E-09	3.399E-09	1.686E-09	9.926E-10	6.500E-10	4.573E-10	3.389E-10	2.612E-10
WSW	1.476E-08	3.604E-09	1.295E-09	6.420E-10	3.780E-10	2.475E-10	1.742E-10	1.291E-10	9.947E-11
W	7.895E-09	1.927E-09	6.922E-10	3.433E-10	2.021E-10	1.324E-10	9.313E-11	6.902E-11	5.319E-11
WNW	1.087E-08	2.654E-09	9.534E-10	4.728E-10	2.784E-10	1.823E-10	1.283E-10	9.507E-11	7.326E-11
NW	2.319E-08	5.661E-09	2.033E-09	1.008E-09	5.938E-10	3.888E-10	2.736E-10	2.027E-10	1.562E-10
NNW	4.863E-08	1.187E-08	4.264E-09	2.114E-09	1.245E-09	8.152E-10	5.736E-10	4.251E-10	3.276E-10

* Units are in miles from the station. Each D/Q value is calculated at the closest location for the sector, e.g., 8.799E-08 m⁻² is the D/Q value at 0.5 miles (N) from the station. As discussed in Catawba UFSAR Section 2.1.1.3, the boundary for establishing gaseous effluent release limits is the exclusion area boundary (EAB). The EAB is defined as a 2500-ft. (~0.5 mile) radius from the station center.

7.0 LICENSEE INITIATED CHANGES

All ODCM changes are reviewed by knowledgeable individual(s), and approved by either the Station Manager or Radiation Protection Manager. The below changes do not adversely impact the accuracy or reliability of effluent, dose, or setpoint calculations.

ODCM Revision 63

ODCM Revision 63 was approved by the Radiation Protection Manager on 12/12/2019. Some changes reflected were implemented prior to the above date under a different change and approval process (e.g., land use census), and in those cases the implementation date is noted below. Changes driven by Document Revision Requests (DRR) are noted with DRR number.

Table of Contents

Updated page numbers as necessary.

Section 6 - Page 3

Table 6.0-1:

- Removed point surface water control point 215C (River Pointe -Hwy 49 (4.21 mi NNE)) and added new surface water control point 263C (Liberty Hill Road (0.59 mi NNE)). The previous control point was located on private property. The new control point is located in the York County Sheriff's Office (YCSO) Lake Enforcement boat house on Duke Energy property. A Memorandum of Understanding has been established with the YCSO for monthly surface water sampling to be performed at this location. Changes took effect on 01/03/2019 as documented in DRR 02247815.
- Changed Location Description for point 262C from "T-Bones Restaurant / Lake Wylie Marina - Hwy 49 (4.19 mi NNE)" to "Lake Wylie Marina - Hwy 49 (4.19 mi NNE)." The T-Bones restaurant was sold to new owners who changed the name of the establishment to Papa Doc's Shore Club; removed name of restaurant from sample location.

Section 6 - Page 6

Updated Figure 6.0-1 Sampling Locations Map (Site Boundary), to add sample location 263. Change to sampling location took effect on 01/03/2019 as documented in DRR 02247815. Updated Map generated December, 2019.

Section 6 - Page 7

- Updated Figure 6.0-2 Sampling Locations Map (Ten Mile Radius), to remove sample location 215. Change to sampling location took effect on 01/03/2019 as documented in DRR 02247815. Updated Map generated December, 2019.

APPENDIX A

Dose Factors for Exposure to a Semi-Infinite Cloud of Noble Gases*

Nuclide	K_i Total Body mrem/yr/ $\mu\text{Ci}/\text{m}^3$	L_i Skin mrem/yr/ $\mu\text{Ci}/\text{m}^3$	M_i Gamma Air mrad/yr/ $\mu\text{Ci}/\text{m}^3$	N_i Beta Air mrad/yr/ $\mu\text{Ci}/\text{m}^3$
AR-41	8.840E+03	2.690E+03	9.300E+03	3.280E+03
KR-83M	7.560E-02	0.000E+00	1.930E+01	2.880E+02
KR-85M	1.170E+03	1.460E+03	1.230E+03	1.970E+03
KR-85	1.610E+01	1.340E+03	1.720E+01	1.950E+03
KR-87	5.920E+03	9.730E+03	6.170E+03	1.030E+04
KR-88	1.470E+04	2.370E+03	1.520E+04	2.930E+03
KR-89	1.660E+04	1.010E+04	1.730E+04	1.060E+04
KR-90	1.560E+04	7.290E+03	1.630E+04	7.830E+03
XE-131M	9.150E+01	4.760E+02	1.560E+02	1.110E+03
XE-133M	2.510E+02	9.940E+02	3.270E+02	1.480E+03
XE-133	2.940E+02	3.060E+02	3.530E+02	1.050E+03
XE-135M	3.120E+03	7.110E+02	3.360E+03	7.390E+02
XE-135	1.810E+03	1.860E+03	1.920E+03	2.460E+03
XE-137	1.420E+03	1.220E+04	1.510E+03	1.270E+04
XE-138	8.830E+03	4.130E+03	9.210E+03	4.750E+03

* Reference Regulatory Guide 1.109, Table B-1

APPENDIX B

P_i Dose Factors for use in the Gaseous Release Rate Limit Calculations

Agegroup:	CHILD	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.120E+03	1.120E+03	1.120E+03	1.120E+03	1.120E+03	0.000E+00	1.120E+03
C-14	3.590E+04	6.730E+03	6.730E+03	6.730E+03	6.730E+03	6.730E+03	0.000E+00	6.730E+03
NA-24	1.610E+04	1.610E+04	1.610E+04	1.610E+04	1.610E+04	1.610E+04	0.000E+00	1.610E+04
P-32	2.600E+06	1.140E+05	0.000E+00	0.000E+00	0.000E+00	4.220E+04	0.000E+00	9.880E+04
CR-51	0.000E+00	0.000E+00	8.550E+01	2.430E+01	1.700E+04	1.080E+03	0.000E+00	1.540E+02
MN-54	0.000E+00	4.290E+04	0.000E+00	1.000E+04	1.580E+06	2.290E+04	0.000E+00	9.510E+03
MN-56	0.000E+00	1.660E+00	0.000E+00	1.670E+00	1.310E+04	1.230E+05	0.000E+00	3.120E-01
FE-55	4.740E+04	2.520E+04	0.000E+00	0.000E+00	1.110E+05	2.870E+03	0.000E+00	7.770E+03
FE-59	2.070E+04	3.340E+04	0.000E+00	0.000E+00	1.270E+06	7.070E+04	0.000E+00	1.670E+04
CO-58	0.000E+00	1.770E+03	0.000E+00	0.000E+00	1.110E+06	3.440E+04	0.000E+00	3.160E+03
CO-60	0.000E+00	1.310E+04	0.000E+00	0.000E+00	7.070E+06	9.620E+04	0.000E+00	2.260E+04
NI-63	8.210E+05	4.620E+04	0.000E+00	0.000E+00	2.750E+05	6.330E+03	0.000E+00	2.800E+04
NI-65	2.990E+00	2.960E-01	0.000E+00	0.000E+00	8.180E+03	8.400E+04	0.000E+00	1.640E-01
CU-64	0.000E+00	1.990E+00	0.000E+00	6.030E+00	9.580E+03	3.670E+04	0.000E+00	1.070E+00
ZN-65	4.260E+04	1.130E+05	0.000E+00	7.140E+04	9.950E+05	1.630E+04	0.000E+00	7.030E+04
ZN-69	6.700E-02	9.660E-02	0.000E+00	5.850E-02	1.420E+03	1.020E+04	0.000E+00	8.920E-03
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.740E+02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.480E+02
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.530E+01
RB-86	0.000E+00	1.980E+05	0.000E+00	0.000E+00	0.000E+00	7.990E+03	0.000E+00	1.140E+05
RB-88	0.000E+00	5.620E+02	0.000E+00	0.000E+00	0.000E+00	1.720E+01	0.000E+00	3.660E+02
RB-89	0.000E+00	3.450E+02	0.000E+00	0.000E+00	0.000E+00	1.890E+00	0.000E+00	2.900E+02
SR-89	5.990E+05	0.000E+00	0.000E+00	0.000E+00	2.160E+06	1.670E+05	0.000E+00	1.720E+04
SR-90	1.010E+08	0.000E+00	0.000E+00	0.000E+00	1.480E+07	3.430E+05	0.000E+00	6.440E+06
SR-91	1.210E+02	0.000E+00	0.000E+00	0.000E+00	5.330E+04	1.740E+05	0.000E+00	4.590E+00

APPENDIX B

P_i Dose Factors for use in the Gaseous Release Rate Limit Calculations

Agegroup:	CHILD	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	1.310E+01	0.000E+00	0.000E+00	0.000E+00	2.400E+04	2.420E+05	0.000E+00	5.250E-01
Y-90	4.110E+03	0.000E+00	0.000E+00	0.000E+00	2.620E+05	2.680E+05	0.000E+00	1.110E+02
Y-91	9.140E+05	0.000E+00	0.000E+00	0.000E+00	2.630E+06	1.840E+05	0.000E+00	2.440E+04
Y-91M	5.070E-01	0.000E+00	0.000E+00	0.000E+00	2.810E+03	1.720E+03	0.000E+00	1.840E-02
Y-92	2.030E+01	0.000E+00	0.000E+00	0.000E+00	2.390E+04	2.390E+05	0.000E+00	5.810E-01
Y-93	1.860E+02	0.000E+00	0.000E+00	0.000E+00	7.440E+04	3.880E+05	0.000E+00	5.110E+00
ZR-95	1.900E+05	4.180E+04	0.000E+00	5.960E+04	2.230E+06	6.110E+04	0.000E+00	3.700E+04
ZR-97	1.880E+02	2.720E+01	0.000E+00	3.880E+01	1.130E+05	3.510E+05	0.000E+00	1.600E+01
NB-95	2.350E+04	9.180E+03	0.000E+00	8.620E+03	6.140E+05	3.700E+04	0.000E+00	6.550E+03
MO-99	0.000E+00	1.720E+02	0.000E+00	3.920E+02	1.350E+05	1.270E+05	0.000E+00	4.260E+01
TC-99M	1.780E-03	3.480E-03	0.000E+00	5.070E-02	9.510E+02	4.810E+03	0.000E+00	5.770E-02
TC-101	8.100E-05	8.510E-05	0.000E+00	1.450E-03	5.850E+02	1.630E+01	0.000E+00	1.080E-03
RU-103	2.790E+03	0.000E+00	0.000E+00	7.030E+03	6.620E+05	4.480E+04	0.000E+00	1.070E+03
RU-105	1.530E+00	0.000E+00	0.000E+00	1.340E+00	1.590E+04	9.950E+04	0.000E+00	5.550E-01
RU-106	1.360E+05	0.000E+00	0.000E+00	1.840E+05	1.430E+07	4.290E+05	0.000E+00	1.690E+04
AG-110M	1.690E+04	1.140E+04	0.000E+00	2.120E+04	5.480E+06	1.000E+05	0.000E+00	9.140E+03
TE-125M	6.730E+03	2.330E+03	1.920E+03	0.000E+00	4.770E+05	3.380E+04	0.000E+00	9.140E+02
TE-127	2.770E+00	9.510E-01	1.960E+00	7.070E+00	1.000E+04	5.620E+04	0.000E+00	6.100E-01
TE-127M	2.490E+04	8.550E+03	6.070E+03	6.360E+04	1.480E+06	7.140E+04	0.000E+00	3.020E+03
TE-129	9.770E-02	3.500E-02	7.140E-02	2.570E-01	2.930E+03	2.550E+04	0.000E+00	2.380E-02
TE-129M	1.920E+04	6.840E+03	6.330E+03	5.030E+04	1.760E+06	1.820E+05	0.000E+00	3.040E+03
TE-131	2.170E-02	8.440E-03	1.700E-02	5.880E-02	2.050E+03	1.330E+03	0.000E+00	6.590E-03
TE-131M	1.340E+02	5.920E+01	9.770E+01	4.000E+02	2.060E+05	3.080E+05	0.000E+00	5.070E+01
TE-132	4.810E+02	2.720E+02	3.170E+02	1.770E+03	3.770E+05	1.380E+05	0.000E+00	2.630E+02
I-130	8.180E+03	1.640E+04	1.850E+06	2.450E+04	0.000E+00	5.110E+03	0.000E+00	8.440E+03

APPENDIX B

P_i Dose Factors for use in the Gaseous Release Rate Limit Calculations

Agegroup:	CHILD	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	4.810E+04	4.810E+04	1.620E+07	7.880E+04	0.000E+00	2.840E+03	0.000E+00	2.730E+04
I-132	2.120E+03	4.070E+03	1.940E+05	6.250E+03	0.000E+00	3.200E+03	0.000E+00	1.880E+03
I-133	1.660E+04	2.030E+04	3.850E+06	3.380E+04	0.000E+00	5.480E+03	0.000E+00	7.700E+03
I-134	1.170E+03	2.160E+03	5.070E+04	3.300E+03	0.000E+00	9.550E+02	0.000E+00	9.950E+02
I-135	4.920E+03	8.730E+03	7.920E+05	1.340E+04	0.000E+00	4.440E+03	0.000E+00	4.140E+03
CS-134	6.510E+05	1.010E+06	0.000E+00	3.300E+05	1.210E+05	3.850E+03	0.000E+00	2.250E+05
CS-136	6.510E+04	1.710E+05	0.000E+00	9.550E+04	1.450E+04	4.180E+03	0.000E+00	1.160E+05
CS-137	9.060E+05	8.250E+05	0.000E+00	2.820E+05	1.040E+05	3.620E+03	0.000E+00	1.280E+05
CS-138	6.330E+02	8.400E+02	0.000E+00	6.220E+02	6.810E+01	2.700E+02	0.000E+00	5.550E+02
BA-139	1.840E+00	9.840E-04	0.000E+00	8.620E-04	5.770E+03	5.770E+04	0.000E+00	5.360E-02
BA-140	7.400E+04	6.480E+01	0.000E+00	2.110E+01	1.740E+06	1.020E+05	0.000E+00	4.330E+03
BA-141	1.960E-01	1.090E-04	0.000E+00	9.470E-05	2.920E+03	2.750E+02	0.000E+00	6.360E-03
BA-142	5.000E-02	3.600E-05	0.000E+00	2.910E-05	1.640E+03	2.740E+00	0.000E+00	2.790E-03
LA-140	6.440E+02	2.250E+02	0.000E+00	0.000E+00	1.830E+05	2.260E+05	0.000E+00	7.550E+01
LA-142	1.300E+00	4.110E-01	0.000E+00	0.000E+00	8.700E+03	7.580E+04	0.000E+00	1.290E-01
CE-141	3.920E+04	1.950E+04	0.000E+00	8.550E+03	5.440E+05	5.660E+04	0.000E+00	2.900E+03
CE-143	3.660E+02	1.990E+02	0.000E+00	8.360E+01	1.150E+05	1.270E+05	0.000E+00	2.870E+01
CE-144	6.770E+06	2.120E+06	0.000E+00	1.170E+06	1.200E+07	3.880E+05	0.000E+00	3.610E+05
PR-143	1.850E+04	5.550E+03	0.000E+00	3.000E+03	4.330E+05	9.730E+04	0.000E+00	9.140E+02
PR-144	5.960E-02	1.850E-02	0.000E+00	9.770E-03	1.570E+03	1.970E+02	0.000E+00	3.000E-03
ND-147	1.080E+04	8.730E+03	0.000E+00	4.810E+03	3.280E+05	8.210E+04	0.000E+00	6.810E+02
W-187	1.630E+01	9.660E+00	0.000E+00	0.000E+00	4.110E+04	9.100E+04	0.000E+00	4.330E+00
NP-239	4.660E+02	3.340E+01	0.000E+00	9.730E+01	5.810E+04	6.400E+04	0.000E+00	2.350E+01

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	8.740E+00	8.740E+00	8.740E+00	8.740E+00	8.740E+00	0.000E+00	8.740E+00
C-14	2.360E+02	4.730E+01	4.730E+01	4.730E+01	4.730E+01	4.730E+01	0.000E+00	4.730E+01
NA-24	8.140E+01	8.140E+01	8.140E+01	8.140E+01	8.140E+01	8.140E+01	0.000E+00	8.140E+01
P-32	1.570E+04	9.750E+02	0.000E+00	0.000E+00	0.000E+00	1.760E+03	0.000E+00	6.060E+02
CR-51	0.000E+00	0.000E+00	1.310E-01	4.820E-02	2.900E-01	5.500E+01	0.000E+00	2.190E-01
MN-54	0.000E+00	3.800E+02	0.000E+00	1.130E+02	0.000E+00	1.160E+03	0.000E+00	7.250E+01
MN-56	0.000E+00	3.800E-01	0.000E+00	4.820E-01	0.000E+00	1.210E+01	0.000E+00	6.740E-02
FE-55	2.290E+02	1.580E+02	0.000E+00	0.000E+00	8.820E+01	9.070E+01	0.000E+00	3.690E+01
FE-59	3.580E+02	8.420E+02	0.000E+00	0.000E+00	2.350E+02	2.810E+03	0.000E+00	3.230E+02
CO-58	0.000E+00	6.170E+01	0.000E+00	0.000E+00	0.000E+00	1.250E+03	0.000E+00	1.380E+02
CO-60	0.000E+00	1.780E+02	0.000E+00	0.000E+00	0.000E+00	3.340E+03	0.000E+00	3.930E+02
NI-63	1.080E+04	7.500E+02	0.000E+00	0.000E+00	0.000E+00	1.560E+02	0.000E+00	3.630E+02
NI-65	1.620E+00	2.100E-01	0.000E+00	0.000E+00	0.000E+00	5.340E+00	0.000E+00	9.600E-02
CU-64	0.000E+00	3.590E+00	0.000E+00	9.060E+00	0.000E+00	3.060E+02	0.000E+00	1.690E+00
ZN-65	4.020E+02	1.280E+03	0.000E+00	8.560E+02	0.000E+00	8.060E+02	0.000E+00	5.780E+02
ZN-69	1.070E-04	2.050E-04	0.000E+00	1.330E-04	0.000E+00	3.080E-05	0.000E+00	1.430E-05
SE-75	1.038E+02	3.991E+01	3.991E+01	7.983E+00	9.579E+01	1.118E+02	0.000E+00	7.983E+02
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.480E-01	0.000E+00	1.030E-01
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.270E-12	0.000E+00	6.710E-07
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.380E-77
RB-86	0.000E+00	1.720E+03	0.000E+00	0.000E+00	0.000E+00	3.400E+02	0.000E+00	8.030E+02
RB-88	0.000E+00	3.360E-12	0.000E+00	0.000E+00	0.000E+00	4.640E-23	0.000E+00	1.780E-12
RB-89	0.000E+00	3.090E-14	0.000E+00	0.000E+00	0.000E+00	1.790E-27	0.000E+00	2.170E-14
SR-89	2.550E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.080E+03	0.000E+00	7.310E+02
SR-90	6.310E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.820E+04	0.000E+00	1.550E+05

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-91	1.960E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.350E+02	0.000E+00	7.930E+00
SR-92	8.290E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.640E+02	0.000E+00	3.590E-01
Y-90	7.030E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.460E+03	0.000E+00	1.890E-02
Y-91	1.170E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.420E+03	0.000E+00	3.120E-01
Y-91M	3.360E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.860E-07	0.000E+00	1.300E-08
Y-92	6.710E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.170E+02	0.000E+00	1.960E-04
Y-93	9.770E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.100E+03	0.000E+00	2.700E-03
ZR-95	2.520E+00	8.070E-01	0.000E+00	1.270E+00	0.000E+00	2.560E+03	0.000E+00	5.460E-01
ZR-97	8.540E-02	1.720E-02	0.000E+00	2.600E-02	0.000E+00	5.340E+03	0.000E+00	7.880E-03
NB-95	5.130E-01	2.850E-01	0.000E+00	2.820E-01	0.000E+00	1.730E+03	0.000E+00	1.530E-01
MO-99	0.000E+00	3.160E+02	0.000E+00	7.160E+02	0.000E+00	7.330E+02	0.000E+00	6.020E+01
TC-99M	5.160E-03	1.460E-02	0.000E+00	2.210E-01	7.140E-03	8.630E+00	0.000E+00	1.860E-01
TC-101	1.130E-17	1.630E-17	0.000E+00	2.930E-16	8.320E-18	4.890E-29	0.000E+00	1.600E-16
RU-103	1.530E+01	0.000E+00	0.000E+00	5.820E+01	0.000E+00	1.780E+03	0.000E+00	6.570E+00
RU-105	1.970E-01	0.000E+00	0.000E+00	2.540E+00	0.000E+00	1.200E+02	0.000E+00	7.760E-02
RU-106	2.290E+02	0.000E+00	0.000E+00	4.410E+02	0.000E+00	1.480E+04	0.000E+00	2.890E+01
AG-108M	9.207E+01	3.541E+01	3.541E+01	7.082E+00	8.498E+01	9.915E+01	0.000E+00	7.082E+02
AG-110M	1.330E+01	1.230E+01	0.000E+00	2.420E+01	0.000E+00	5.020E+03	0.000E+00	7.300E+00
SN-113	2.913E+01	1.121E+01	1.121E+01	2.241E+00	2.689E+01	3.137E+01	0.000E+00	2.241E+02
SN-117M	2.771E+01	1.066E+01	1.066E+01	2.131E+00	2.557E+01	2.984E+01	0.000E+00	2.131E+02
SB-124	2.317E+02	4.377E+00	5.618E-01	0.000E+00	1.804E+02	6.578E+03	0.000E+00	9.184E+01
SB-125	1.489E+02	1.664E+00	1.514E-01	0.000E+00	1.148E+02	1.639E+03	0.000E+00	3.544E+01
SB-126	9.307E+01	1.894E+00	5.697E-01	0.000E+00	5.705E+01	7.607E+03	0.000E+00	3.358E+01
TE-123M	5.588E+01	2.149E+01	2.149E+01	4.298E+00	5.158E+01	6.018E+01	0.000E+00	4.298E+02
TE-125M	2.220E+02	8.030E+01	6.670E+01	9.020E+02	0.000E+00	8.850E+02	0.000E+00	2.970E+01

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
TE-127	3.780E+00	1.360E+00	2.800E+00	1.540E+01	0.000E+00	2.980E+02	0.000E+00	8.170E-01
TE-127M	5.620E+02	2.010E+02	1.440E+02	2.280E+03	0.000E+00	1.880E+03	0.000E+00	6.840E+01
TE-129	1.920E-03	7.230E-04	1.480E-03	8.080E-03	0.000E+00	1.450E-03	0.000E+00	4.690E-04
TE-129M	9.470E+02	3.530E+02	3.250E+02	3.950E+03	0.000E+00	4.770E+03	0.000E+00	1.500E+02
TE-131	3.520E-09	1.470E-09	2.900E-09	1.540E-08	0.000E+00	4.990E-10	0.000E+00	1.110E-09
TE-131M	1.090E+02	5.340E+01	8.450E+01	5.400E+02	0.000E+00	5.300E+03	0.000E+00	4.450E+01
TE-132	1.880E+02	1.220E+02	1.350E+02	1.170E+03	0.000E+00	5.770E+03	0.000E+00	1.140E+02
I-130	3.210E+01	9.460E+01	8.020E+03	1.480E+02	0.000E+00	8.140E+01	0.000E+00	3.730E+01
I-131	3.320E+02	4.740E+02	1.550E+05	8.130E+02	0.000E+00	1.250E+02	0.000E+00	2.720E+02
I-132	4.540E-01	1.220E+00	4.250E+01	1.940E+00	0.000E+00	2.280E-01	0.000E+00	4.250E-01
I-133	7.920E+01	1.380E+02	2.020E+04	2.400E+02	0.000E+00	1.240E+02	0.000E+00	4.200E+01
I-134	6.580E-04	1.790E-03	3.100E-02	2.840E-03	0.000E+00	1.560E-06	0.000E+00	6.390E-04
I-135	1.050E+01	2.750E+01	1.810E+03	4.400E+01	0.000E+00	3.100E+01	0.000E+00	1.010E+01
CS-134	5.170E+03	1.230E+04	0.000E+00	3.980E+03	1.320E+03	2.150E+02	0.000E+00	1.010E+04
CS-136	5.280E+02	2.080E+03	0.000E+00	1.160E+03	1.590E+02	2.370E+02	0.000E+00	1.500E+03
CS-137	6.630E+03	9.070E+03	0.000E+00	3.080E+03	1.020E+03	1.760E+02	0.000E+00	5.940E+03
CS-138	8.450E-07	1.670E-06	0.000E+00	1.230E-06	1.210E-07	7.120E-12	0.000E+00	8.260E-07
BA-133	6.004E+01	2.309E+01	2.309E+01	4.618E+00	5.542E+01	6.466E+01	0.000E+00	4.618E+02
BA-139	1.990E-02	1.420E-05	0.000E+00	1.330E-05	8.050E-06	3.530E-02	0.000E+00	5.830E-04
BA-140	1.640E+03	2.070E+00	0.000E+00	7.020E-01	1.180E+00	3.390E+03	0.000E+00	1.080E+02
BA-141	5.440E-12	4.120E-15	0.000E+00	3.830E-15	2.340E-15	2.570E-21	0.000E+00	1.840E-13
BA-142	6.290E-21	6.470E-24	0.000E+00	5.460E-24	3.660E-24	8.860E-39	0.000E+00	3.960E-22
LA-140	1.690E-01	8.530E-02	0.000E+00	0.000E+00	0.000E+00	6.260E+03	0.000E+00	2.250E-02
LA-142	5.720E-05	2.600E-05	0.000E+00	0.000E+00	0.000E+00	1.900E-01	0.000E+00	6.480E-06
CE-141	7.710E-01	5.210E-01	0.000E+00	2.420E-01	0.000E+00	1.990E+03	0.000E+00	5.910E-02

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
CE-143	1.070E-01	7.890E+01	0.000E+00	3.470E-02	0.000E+00	2.950E+03	0.000E+00	8.730E-03
CE-144	4.060E+01	1.700E+01	0.000E+00	1.010E+01	0.000E+00	1.370E+04	0.000E+00	2.180E+00
PR-143	7.460E-01	2.990E-01	0.000E+00	1.730E-01	0.000E+00	3.270E+03	0.000E+00	3.700E-02
PR-144	7.350E-16	3.050E-16	0.000E+00	1.720E-16	0.000E+00	1.060E-22	0.000E+00	3.730E-17
ND-147	5.070E-01	5.860E-01	0.000E+00	3.430E-01	0.000E+00	2.810E+03	0.000E+00	3.510E-02
EU-152	1.623E+01	3.695E+00	0.000E+00	2.288E+01	0.000E+00	2.130E+03	0.000E+00	3.245E+00
W-187	6.050E+00	5.050E+00	0.000E+00	0.000E+00	0.000E+00	1.660E+03	0.000E+00	1.770E+00
NP-239	8.550E-02	8.400E-03	0.000E+00	2.620E-02	0.000E+00	1.720E+03	0.000E+00	4.630E-03

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	2.260E-01	2.260E-01	2.260E-01	2.260E-01	2.260E-01	0.000E+00	2.260E-01
C-14	3.130E+04	6.260E+03	6.260E+03	6.260E+03	6.260E+03	6.260E+03	0.000E+00	6.260E+03
NA-24	1.350E+02	1.350E+02	1.350E+02	1.350E+02	1.350E+02	1.350E+02	0.000E+00	1.350E+02
P-32	1.320E+06	8.210E+04	0.000E+00	0.000E+00	0.000E+00	1.480E+05	0.000E+00	5.100E+04
CR-51	0.000E+00	0.000E+00	7.420E-01	2.740E-01	1.650E+00	3.120E+02	0.000E+00	1.240E+00
MN-54	0.000E+00	4.370E+03	0.000E+00	1.300E+03	0.000E+00	1.340E+04	0.000E+00	8.330E+02
MN-56	0.000E+00	1.730E-01	0.000E+00	2.200E-01	0.000E+00	5.530E+00	0.000E+00	3.070E-02
FE-55	6.580E+02	4.550E+02	0.000E+00	0.000E+00	2.540E+02	2.610E+02	0.000E+00	1.060E+02
FE-59	1.020E+03	2.400E+03	0.000E+00	0.000E+00	6.720E+02	8.010E+03	0.000E+00	9.220E+02
CO-58	0.000E+00	8.830E+01	0.000E+00	0.000E+00	0.000E+00	1.790E+03	0.000E+00	1.980E+02
CO-60	0.000E+00	2.560E+02	0.000E+00	0.000E+00	0.000E+00	4.810E+03	0.000E+00	5.650E+02
NI-63	3.110E+04	2.160E+03	0.000E+00	0.000E+00	0.000E+00	4.500E+02	0.000E+00	1.040E+03
NI-65	1.720E-01	2.230E-02	0.000E+00	0.000E+00	0.000E+00	5.660E-01	0.000E+00	1.020E-02
CU-64	0.000E+00	2.680E+00	0.000E+00	6.760E+00	0.000E+00	2.290E+02	0.000E+00	1.260E+00
ZN-65	2.310E+04	7.350E+04	0.000E+00	4.920E+04	0.000E+00	4.630E+04	0.000E+00	3.320E+04
ZN-69	7.730E-07	1.480E-06	0.000E+00	9.610E-07	0.000E+00	2.220E-07	0.000E+00	1.030E-07
SE-75	5.953E+02	2.290E+02	2.290E+02	4.579E+01	5.495E+02	6.411E+02	0.000E+00	4.579E+03
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.500E-02	0.000E+00	3.820E-02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.850E-18	0.000E+00	1.250E-12
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	9.730E+04	0.000E+00	0.000E+00	0.000E+00	1.920E+04	0.000E+00	4.530E+04
RB-88	0.000E+00	1.290E-22	0.000E+00	0.000E+00	0.000E+00	1.780E-33	0.000E+00	6.830E-23
RB-89	0.000E+00	1.640E-26	0.000E+00	0.000E+00	0.000E+00	9.560E-40	0.000E+00	1.160E-26
SR-89	2.180E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.500E+03	0.000E+00	6.260E+02
SR-90	5.440E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.570E+04	0.000E+00	1.340E+05

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-91	7.050E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.360E+02	0.000E+00	2.850E+00
SR-92	3.320E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.570E+00	0.000E+00	1.430E-02
Y-90	4.440E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.710E+03	0.000E+00	1.190E-02
Y-91	8.340E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.590E+03	0.000E+00	2.230E-01
Y-91M	1.070E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.150E-11	0.000E+00	4.150E-13
Y-92	4.600E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.060E+00	0.000E+00	1.340E-05
Y-93	3.080E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.770E+02	0.000E+00	8.500E-04
ZR-95	2.380E-01	7.620E-02	0.000E+00	1.200E-01	0.000E+00	2.410E+02	0.000E+00	5.160E-02
ZR-97	4.960E-03	1.000E-03	0.000E+00	1.510E-03	0.000E+00	3.100E+02	0.000E+00	4.570E-04
NB-95	4.380E+02	2.440E+02	0.000E+00	2.410E+02	0.000E+00	1.480E+06	0.000E+00	1.310E+02
MO-99	0.000E+00	8.020E+01	0.000E+00	1.820E+02	0.000E+00	1.860E+02	0.000E+00	1.530E+01
TC-99M	5.590E-04	1.580E-03	0.000E+00	2.400E-02	7.740E-04	9.340E-01	0.000E+00	2.010E-02
TC-101	2.610E-33	3.760E-33	0.000E+00	6.770E-32	1.920E-33	1.130E-44	0.000E+00	3.690E-32
RU-103	4.350E+00	0.000E+00	0.000E+00	1.660E+01	0.000E+00	5.080E+02	0.000E+00	1.870E+00
RU-105	8.670E-03	0.000E+00	0.000E+00	1.120E-01	0.000E+00	5.300E+00	0.000E+00	3.420E-03
RU-106	6.570E+01	0.000E+00	0.000E+00	1.270E+02	0.000E+00	4.250E+03	0.000E+00	8.320E+00
AG-108M	2.648E+01	1.019E+01	1.019E+01	2.037E+00	2.445E+01	2.852E+01	0.000E+00	2.037E+02
AG-110M	8.790E-01	8.130E-01	0.000E+00	1.600E+00	0.000E+00	3.320E+02	0.000E+00	4.830E-01
SN-113	2.507E+03	9.641E+02	9.641E+02	1.928E+02	2.314E+03	2.699E+03	0.000E+00	1.928E+04
SN-117M	2.331E+03	8.965E+02	8.965E+02	1.793E+02	2.152E+03	2.510E+03	0.000E+00	1.793E+04
SB-124	6.626E+02	1.252E+01	1.607E+00	0.000E+00	5.159E+02	1.881E+04	0.000E+00	2.627E+02
SB-125	4.282E+02	4.785E+00	4.354E-01	0.000E+00	3.301E+02	4.713E+03	0.000E+00	1.019E+02
SB-126	2.603E+02	5.297E+00	1.594E+00	0.000E+00	1.596E+02	2.128E+04	0.000E+00	9.395E+01
TE-123M	6.411E+02	2.466E+02	2.466E+02	4.932E+01	5.918E+02	6.904E+02	0.000E+00	4.932E+03
TE-125M	2.540E+03	9.190E+02	7.630E+02	1.030E+04	0.000E+00	1.010E+04	0.000E+00	3.400E+02

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
TE-127	1.790E+01	6.440E+00	1.330E+01	7.300E+01	0.000E+00	1.410E+03	0.000E+00	3.880E+00
TE-127M	6.440E+03	2.300E+03	1.650E+03	2.620E+04	0.000E+00	2.160E+04	0.000E+00	7.850E+02
TE-129	1.630E-05	6.120E-06	1.250E-05	6.850E-05	0.000E+00	1.230E-05	0.000E+00	3.970E-06
TE-129M	1.080E+04	4.020E+03	3.710E+03	4.500E+04	0.000E+00	5.430E+04	0.000E+00	1.710E+03
TE-131	8.710E-17	3.640E-17	7.160E-17	3.820E-16	0.000E+00	1.230E-17	0.000E+00	2.750E-17
TE-131M	9.510E+02	4.650E+02	7.370E+02	4.710E+03	0.000E+00	4.620E+04	0.000E+00	3.880E+02
TE-132	1.950E+03	1.260E+03	1.390E+03	1.210E+04	0.000E+00	5.960E+04	0.000E+00	1.180E+03
I-130	7.050E+00	2.080E+01	1.760E+03	3.250E+01	0.000E+00	1.790E+01	0.000E+00	8.210E+00
I-131	1.370E+02	1.960E+02	6.420E+04	3.360E+02	0.000E+00	5.170E+01	0.000E+00	1.120E+02
I-132	5.270E-03	1.410E-02	4.940E-01	2.250E-02	0.000E+00	2.650E-03	0.000E+00	4.940E-03
I-133	2.290E+01	3.990E+01	5.860E+03	6.950E+01	0.000E+00	3.580E+01	0.000E+00	1.210E+01
I-134	2.120E-08	5.750E-08	9.960E-07	9.140E-08	0.000E+00	5.010E-11	0.000E+00	2.060E-08
I-135	1.290E+00	3.370E+00	2.220E+02	5.410E+00	0.000E+00	3.810E+00	0.000E+00	1.240E+00
CS-134	2.980E+05	7.080E+05	0.000E+00	2.290E+05	7.610E+04	1.240E+04	0.000E+00	5.790E+05
CS-136	2.960E+04	1.170E+05	0.000E+00	6.500E+04	8.900E+03	1.330E+04	0.000E+00	8.400E+04
CS-137	3.820E+05	5.220E+05	0.000E+00	1.770E+05	5.890E+04	1.010E+04	0.000E+00	3.420E+05
CS-138	8.940E-12	1.770E-11	0.000E+00	1.300E-11	1.280E-12	7.530E-17	0.000E+00	8.750E-12
BA-133	6.908E+00	2.657E+00	2.657E+00	5.314E-01	6.376E+00	7.439E+00	0.000E+00	5.314E+01
BA-139	5.650E-06	4.030E-09	0.000E+00	3.760E-09	2.280E-09	1.000E-05	0.000E+00	1.660E-07
BA-140	1.840E+02	2.310E-01	0.000E+00	7.860E-02	1.320E-01	3.790E+02	0.000E+00	1.210E+01
BA-141	8.700E-25	6.580E-28	0.000E+00	6.120E-28	3.730E-28	4.100E-34	0.000E+00	2.940E-26
BA-142	2.570E-42	2.640E-45	0.000E+00	2.230E-45	1.490E-45	3.620E-60	0.000E+00	1.610E-43
LA-140	9.900E-02	4.990E-02	0.000E+00	0.000E+00	0.000E+00	3.660E+03	0.000E+00	1.320E-02
LA-142	2.210E-07	1.000E-07	0.000E+00	0.000E+00	0.000E+00	7.330E-04	0.000E+00	2.500E-08
CE-141	2.190E-02	1.480E-02	0.000E+00	6.890E-03	0.000E+00	5.670E+01	0.000E+00	1.680E-03

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
CE-143	2.380E-03	1.760E+00	0.000E+00	7.760E-04	0.000E+00	6.590E+01	0.000E+00	1.950E-04
CE-144	1.170E+00	4.870E-01	0.000E+00	2.890E-01	0.000E+00	3.940E+02	0.000E+00	6.260E-02
PR-143	5.230E-01	2.100E-01	0.000E+00	1.210E-01	0.000E+00	2.290E+03	0.000E+00	2.590E-02
PR-144	1.550E-28	6.440E-29	0.000E+00	3.630E-29	0.000E+00	2.230E-35	0.000E+00	7.880E-30
ND-147	3.530E-01	4.080E-01	0.000E+00	2.390E-01	0.000E+00	1.960E+03	0.000E+00	2.440E-02
EU-152	2.334E+01	5.314E+00	0.000E+00	3.291E+01	0.000E+00	3.064E+03	0.000E+00	4.668E+00
W-187	1.470E+02	1.230E+02	0.000E+00	0.000E+00	0.000E+00	4.030E+04	0.000E+00	4.300E+01
NP-239	2.120E-02	2.090E-03	0.000E+00	6.510E-03	0.000E+00	4.280E+02	0.000E+00	1.150E-03

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NA-24	6.410E-01	6.410E-01	6.410E-01	6.410E-01	6.410E-01	6.410E-01	7.440E-01	6.410E-01
P-32	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CR-51	2.500E-01	2.500E-01	2.500E-01	2.500E-01	2.500E-01	2.500E-01	2.960E-01	2.500E-01
MN-54	7.440E+01	7.440E+01	7.440E+01	7.440E+01	7.440E+01	7.440E+01	8.720E+01	7.440E+01
MN-56	4.840E-02	4.840E-02	4.840E-02	4.840E-02	4.840E-02	4.840E-02	5.720E-02	4.840E-02
FE-55	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
FE-59	1.460E+01	1.460E+01	1.460E+01	1.460E+01	1.460E+01	1.460E+01	1.720E+01	1.460E+01
CO-58	2.030E+01	2.030E+01	2.030E+01	2.030E+01	2.030E+01	2.030E+01	2.380E+01	2.030E+01
CO-60	1.150E+03	1.150E+03	1.150E+03	1.150E+03	1.150E+03	1.150E+03	1.360E+03	1.150E+03
NI-63	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NI-65	1.590E-02	1.590E-02	1.590E-02	1.590E-02	1.590E-02	1.590E-02	1.850E-02	1.590E-02
CU-64	3.260E-02	3.260E-02	3.260E-02	3.260E-02	3.260E-02	3.260E-02	3.690E-02	3.260E-02
ZN-65	4.010E+01	4.010E+01	4.010E+01	4.010E+01	4.010E+01	4.010E+01	4.610E+01	4.010E+01
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE-75	2.425E+02	2.425E+02	2.425E+02	2.425E+02	2.425E+02	2.425E+02	2.838E+02	2.425E+02
BR-83	2.620E-04	2.620E-04	2.620E-04	2.620E-04	2.620E-04	2.620E-04	3.800E-04	2.620E-04
BR-84	1.090E-02	1.090E-02	1.090E-02	1.090E-02	1.090E-02	1.090E-02	1.270E-02	1.090E-02
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	4.820E-01	4.820E-01	4.820E-01	4.820E-01	4.820E-01	4.820E-01	5.510E-01	4.820E-01
RB-88	1.780E-03	1.780E-03	1.780E-03	1.780E-03	1.780E-03	1.780E-03	2.030E-03	1.780E-03
RB-89	6.600E-03	6.600E-03	6.600E-03	6.600E-03	6.600E-03	6.600E-03	7.920E-03	6.600E-03
SR-89	1.160E-03	1.160E-03	1.160E-03	1.160E-03	1.160E-03	1.160E-03	1.350E-03	1.160E-03
SR-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-91	1.150E-01	1.150E-01	1.150E-01	1.150E-01	1.150E-01	1.150E-01	1.350E-01	1.150E-01
SR-92	4.170E-02	4.170E-02	4.170E-02	4.170E-02	4.170E-02	4.170E-02	4.630E-02	4.170E-02
Y-90	2.410E-04	2.410E-04	2.410E-04	2.410E-04	2.410E-04	2.410E-04	2.850E-04	2.410E-04
Y-91	5.760E-02	5.760E-02	5.760E-02	5.760E-02	5.760E-02	5.760E-02	6.480E-02	5.760E-02
Y-91M	5.380E-03	5.380E-03	5.380E-03	5.380E-03	5.380E-03	5.380E-03	6.230E-03	5.380E-03
Y-92	9.680E-03	9.680E-03	9.680E-03	9.680E-03	9.680E-03	9.680E-03	1.150E-02	9.680E-03
Y-93	9.840E-03	9.840E-03	9.840E-03	9.840E-03	9.840E-03	9.840E-03	1.350E-02	9.840E-03
ZR-95	1.310E+01	1.310E+01	1.310E+01	1.310E+01	1.310E+01	1.310E+01	1.520E+01	1.310E+01
ZR-97	1.590E-01	1.590E-01	1.590E-01	1.590E-01	1.590E-01	1.590E-01	1.850E-01	1.590E-01
NB-95	7.340E+00	7.340E+00	7.340E+00	7.340E+00	7.340E+00	7.340E+00	8.630E+00	7.340E+00
MO-99	2.140E-01	2.140E-01	2.140E-01	2.140E-01	2.140E-01	2.140E-01	2.480E-01	2.140E-01
TC-99M	9.880E-03	9.880E-03	9.880E-03	9.880E-03	9.880E-03	9.880E-03	1.130E-02	9.880E-03
TC-101	1.090E-03	1.090E-03	1.090E-03	1.090E-03	1.090E-03	1.090E-03	1.210E-03	1.090E-03
RU-103	5.810E+00	5.810E+00	5.810E+00	5.810E+00	5.810E+00	5.810E+00	6.780E+00	5.810E+00
RU-105	3.420E-02	3.420E-02	3.420E-02	3.420E-02	3.420E-02	3.420E-02	3.870E-02	3.420E-02
RU-106	2.270E+01	2.270E+01	2.270E+01	2.270E+01	2.270E+01	2.270E+01	2.720E+01	2.270E+01
AG-108M	2.768E+04	2.768E+04	2.768E+04	2.768E+04	2.768E+04	2.768E+04	3.239E+04	2.768E+04
AG-110M	1.850E+02	1.850E+02	1.850E+02	1.850E+02	1.850E+02	1.850E+02	2.150E+02	1.850E+02
SN-113	8.011E+00	8.011E+00	8.011E+00	8.011E+00	8.011E+00	8.011E+00	9.372E+00	8.011E+00
SN-117M	1.119E+01	1.119E+01	1.119E+01	1.119E+01	1.119E+01	1.119E+01	1.310E+01	1.119E+01
SB-124	3.211E+01	3.211E+01	3.211E+01	3.211E+01	3.211E+01	3.211E+01	3.705E+01	3.211E+01
SB-125	1.252E+02	1.252E+02	1.252E+02	1.252E+02	1.252E+02	1.252E+02	1.414E+02	1.252E+02
SB-126	4.529E+00	4.529E+00	4.529E+00	4.529E+00	4.529E+00	4.529E+00	5.089E+00	4.529E+00
TE-123M	9.088E+01	9.088E+01	9.088E+01	9.088E+01	9.088E+01	9.088E+01	1.063E+02	9.088E+01
TE-125M	8.330E-02	8.330E-02	8.330E-02	8.330E-02	8.330E-02	8.330E-02	1.140E-01	8.330E-02

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
TE-127	1.600E-04	1.600E-04	1.600E-04	1.600E-04	1.600E-04	1.600E-04	1.760E-04	1.600E-04
TE-127M	4.920E-03	4.920E-03	4.920E-03	4.920E-03	4.920E-03	4.920E-03	5.810E-03	4.920E-03
TE-129	1.410E-03	1.410E-03	1.410E-03	1.410E-03	1.410E-03	1.410E-03	1.670E-03	1.410E-03
TE-129M	1.060E+00	1.060E+00	1.060E+00	1.060E+00	1.060E+00	1.060E+00	1.240E+00	1.060E+00
TE-131	1.570E-03	1.570E-03	1.570E-03	1.570E-03	1.570E-03	1.570E-03	1.850E+00	1.570E-03
TE-131M	4.310E-01	4.310E-01	4.310E-01	4.310E-01	4.310E-01	4.310E-01	5.080E-01	4.310E-01
TE-132	2.270E-01	2.270E-01	2.270E-01	2.270E-01	2.270E-01	2.270E-01	2.670E-01	2.270E-01
I-130	2.960E-01	2.960E-01	2.960E-01	2.960E-01	2.960E-01	2.960E-01	3.590E-01	2.960E-01
I-131	9.240E-01	9.240E-01	9.240E-01	9.240E-01	9.240E-01	9.240E-01	1.120E+00	9.240E-01
I-132	6.680E-02	6.680E-02	6.680E-02	6.680E-02	6.680E-02	6.680E-02	7.860E-02	6.680E-02
I-133	1.320E-01	1.320E-01	1.320E-01	1.320E-01	1.320E-01	1.320E-01	1.600E-01	1.320E-01
I-134	2.400E-02	2.400E-02	2.400E-02	2.400E-02	2.400E-02	2.400E-02	2.850E-02	2.400E-02
I-135	1.360E-01	1.360E-01	1.360E-01	1.360E-01	1.360E-01	1.360E-01	1.580E-01	1.360E-01
CS-134	3.680E+02	3.680E+02	3.680E+02	3.680E+02	3.680E+02	3.680E+02	4.300E+02	3.680E+02
CS-136	8.100E+00	8.100E+00	8.100E+00	8.100E+00	8.100E+00	8.100E+00	9.180E+00	8.100E+00
CS-137	5.520E+02	5.520E+02	5.520E+02	5.520E+02	5.520E+02	5.520E+02	6.440E+02	5.520E+02
CS-138	1.930E-02	1.930E-02	1.930E-02	1.930E-02	1.930E-02	1.930E-02	2.200E-02	1.930E-02
BA-133	4.732E+03	4.732E+03	4.732E+03	4.732E+03	4.732E+03	4.732E+03	5.536E+03	4.732E+03
BA-139	5.680E-03	5.680E-03	5.680E-03	5.680E-03	5.680E-03	5.680E-03	6.390E-03	5.680E-03
BA-140	1.100E+00	1.100E+00	1.100E+00	1.100E+00	1.100E+00	1.100E+00	1.260E+00	1.100E+00
BA-141	2.240E-03	2.240E-03	2.240E-03	2.240E-03	2.240E-03	2.240E-03	2.550E-03	2.240E-03
BA-142	2.410E-03	2.410E-03	2.410E-03	2.410E-03	2.410E-03	2.410E-03	2.740E-03	2.410E-03
LA-140	1.030E+00	1.030E+00	1.030E+00	1.030E+00	1.030E+00	1.030E+00	1.170E+00	1.030E+00
LA-142	4.080E-02	4.080E-02	4.080E-02	4.080E-02	4.080E-02	4.080E-02	4.890E-02	4.080E-02
CE-141	7.330E-01	7.330E-01	7.330E-01	7.330E-01	7.330E-01	7.330E-01	8.270E-01	7.330E-01

APPENDIX C

A_i Adult Dose Factors for use in the Liquid Dose Calculations

Age group:	ADULT	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μCi/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
CE-143	1.240E-01	1.240E-01	1.240E-01	1.240E-01	1.240E-01	1.240E-01	1.410E-01	1.240E-01
CE-144	3.730E+00	3.730E+00	3.730E+00	3.730E+00	3.730E+00	3.730E+00	4.320E+00	3.730E+00
PR-143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR-144	9.850E-05	9.850E-05	9.850E-05	9.850E-05	9.850E-05	9.850E-05	1.130E-04	9.850E-05
ND-147	4.510E-01	4.510E-01	4.510E-01	4.510E-01	4.510E-01	4.510E-01	5.410E-01	4.510E-01
EU-152	7.976E+02	7.976E+02	7.976E+02	7.976E+02	7.976E+02	7.976E+02	9.231E+02	7.976E+02
W-187	1.260E-01	1.260E-01	1.260E-01	1.260E-01	1.260E-01	1.260E-01	1.470E-01	1.260E-01
NP-239	9.180E-02	9.180E-02	9.180E-02	9.180E-02	9.180E-02	9.180E-02	1.060E-01	9.180E-02

APPENDIX D

A_i Teen Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	6.160E+00	6.160E+00	6.160E+00	6.160E+00	6.160E+00	0.000E+00	6.160E+00
C-14	2.360E+02	4.720E+01	4.720E+01	4.720E+01	4.720E+01	4.720E+01	0.000E+00	4.720E+01
NA-24	7.690E+01	7.690E+01	7.690E+01	7.690E+01	7.690E+01	7.690E+01	0.000E+00	7.690E+01
P-32	1.570E+04	9.700E+02	0.000E+00	0.000E+00	0.000E+00	1.320E+03	0.000E+00	6.070E+02
CR-51	0.000E+00	0.000E+00	1.150E-01	4.530E-02	2.950E-01	3.470E+01	0.000E+00	2.070E-01
MN-54	0.000E+00	3.430E+02	0.000E+00	1.020E+02	0.000E+00	7.030E+02	0.000E+00	6.790E+01
MN-56	0.000E+00	3.640E-01	0.000E+00	4.610E-01	0.000E+00	2.400E+01	0.000E+00	6.480E-02
FE-55	2.200E+02	1.560E+02	0.000E+00	0.000E+00	9.880E+01	6.740E+01	0.000E+00	3.630E+01
FE-59	3.390E+02	7.900E+02	0.000E+00	0.000E+00	2.490E+02	1.870E+03	0.000E+00	3.050E+02
CO-58	0.000E+00	5.620E+01	0.000E+00	0.000E+00	0.000E+00	7.750E+02	0.000E+00	1.300E+02
CO-60	0.000E+00	1.630E+02	0.000E+00	0.000E+00	0.000E+00	2.130E+03	0.000E+00	3.680E+02
NI-63	1.030E+04	7.270E+02	0.000E+00	0.000E+00	0.000E+00	1.160E+02	0.000E+00	3.490E+02
NI-65	1.610E+00	2.050E-01	0.000E+00	0.000E+00	0.000E+00	1.110E+01	0.000E+00	9.350E-02
CU-64	0.000E+00	3.470E+00	0.000E+00	8.770E+00	0.000E+00	2.690E+02	0.000E+00	1.630E+00
ZN-65	3.340E+02	1.160E+03	0.000E+00	7.430E+02	0.000E+00	4.920E+02	0.000E+00	5.420E+02
ZN-69	1.070E-04	2.040E-04	0.000E+00	1.330E-04	0.000E+00	3.760E-04	0.000E+00	1.430E-05
SE-75	8.644E+01	3.325E+01	3.325E+01	6.649E+00	7.979E+01	9.309E+01	0.000E+00	6.649E+02
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.030E-01
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.500E-07
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.360E-77
RB-86	0.000E+00	1.700E+03	0.000E+00	0.000E+00	0.000E+00	2.520E+02	0.000E+00	7.990E+02
RB-88	0.000E+00	3.300E-12	0.000E+00	0.000E+00	0.000E+00	2.830E-19	0.000E+00	1.760E-12
RB-89	0.000E+00	2.960E-14	0.000E+00	0.000E+00	0.000E+00	4.540E-23	0.000E+00	2.090E-14
SR-89	2.540E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.030E+03	0.000E+00	7.280E+02
SR-90	4.830E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.350E+04	0.000E+00	1.190E+05

APPENDIX D

A_i Teen Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-91	1.950E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.850E+02	0.000E+00	7.760E+00
SR-92	8.220E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.090E+02	0.000E+00	3.500E-01
Y-90	7.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.770E+03	0.000E+00	1.880E-02
Y-91	1.160E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.760E+03	0.000E+00	3.120E-01
Y-91M	3.330E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.570E-05	0.000E+00	1.270E-08
Y-92	6.710E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.840E+02	0.000E+00	1.940E-04
Y-93	9.760E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.980E+03	0.000E+00	2.670E-03
ZR-95	2.380E+00	7.520E-01	0.000E+00	1.100E+00	0.000E+00	1.730E+03	0.000E+00	5.170E-01
ZR-97	8.420E-02	1.670E-02	0.000E+00	2.530E-02	0.000E+00	4.510E+03	0.000E+00	7.670E-03
NB-95	4.730E-01	2.630E-01	0.000E+00	2.540E-01	0.000E+00	1.120E+03	0.000E+00	1.440E-01
MO-99	0.000E+00	3.090E+02	0.000E+00	7.070E+02	0.000E+00	5.530E+02	0.000E+00	5.890E+01
TC-99M	4.840E-03	1.350E-02	0.000E+00	2.010E-01	7.500E-03	8.870E+00	0.000E+00	1.750E-01
TC-101	1.120E-17	1.590E-17	0.000E+00	2.880E-16	9.700E-18	2.720E-24	0.000E+00	1.560E-16
RU-103	1.470E+01	0.000E+00	0.000E+00	5.180E+01	0.000E+00	1.230E+03	0.000E+00	6.280E+00
RU-105	1.940E-01	0.000E+00	0.000E+00	2.450E+00	0.000E+00	1.570E+02	0.000E+00	7.540E-02
RU-106	2.280E+02	0.000E+00	0.000E+00	4.390E+02	0.000E+00	1.090E+04	0.000E+00	2.870E+01
AG-108M	7.830E+01	3.012E+01	3.012E+01	6.023E+00	7.228E+01	8.433E+01	0.000E+00	6.023E+02
AG-110M	1.190E+01	1.130E+01	0.000E+00	2.150E+01	0.000E+00	3.160E+03	0.000E+00	6.850E+00
SN-113	2.565E+01	9.866E+00	9.866E+00	1.973E+00	2.368E+01	2.762E+01	0.000E+00	1.973E+02
SN-117M	2.399E+01	9.227E+00	9.227E+00	1.845E+00	2.215E+01	2.584E+01	0.000E+00	1.845E+02
SB-124	2.237E+02	4.122E+00	5.075E-01	0.000E+00	1.954E+02	4.509E+03	0.000E+00	8.729E+01
SB-125	1.441E+02	1.575E+00	1.377E-01	0.000E+00	1.267E+02	1.122E+03	0.000E+00	3.371E+01
SB-126	8.989E+01	1.837E+00	5.083E-01	0.000E+00	6.445E+01	5.320E+03	0.000E+00	3.228E+01
TE-123M	4.740E+01	1.823E+01	1.823E+01	3.646E+00	4.376E+01	5.105E+01	0.000E+00	3.646E+02
TE-125M	2.210E+02	7.980E+01	6.180E+01	0.000E+00	0.000E+00	6.530E+02	0.000E+00	2.960E+01

APPENDIX D

A_i Teen Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
TE-127	3.790E+00	1.340E+00	2.610E+00	1.530E+01	0.000E+00	2.930E+02	0.000E+00	8.150E-01
TE-127M	5.600E+02	1.990E+02	1.330E+02	2.270E+03	0.000E+00	1.400E+03	0.000E+00	6.660E+01
TE-129	1.920E-03	7.150E-04	1.370E-03	8.040E-03	0.000E+00	1.050E-02	0.000E+00	4.660E-04
TE-129M	9.380E+02	3.480E+02	3.030E+02	3.920E+03	0.000E+00	3.520E+03	0.000E+00	1.480E+02
TE-131	3.490E-09	1.440E-09	2.690E-09	1.520E-08	0.000E+00	2.860E-10	0.000E+00	1.090E-09
TE-131M	1.080E+02	5.150E+01	7.750E+01	5.380E+02	0.000E+00	4.140E+03	0.000E+00	4.300E+01
TE-132	1.820E+02	1.150E+02	1.220E+02	1.110E+03	0.000E+00	3.660E+03	0.000E+00	1.090E+02
I-130	3.050E+01	8.830E+01	7.200E+03	1.360E+02	0.000E+00	6.790E+01	0.000E+00	3.530E+01
I-131	3.260E+02	4.560E+02	1.330E+05	7.850E+02	0.000E+00	9.020E+01	0.000E+00	2.450E+02
I-132	4.360E-01	1.140E+00	3.850E+01	1.800E+00	0.000E+00	4.970E-01	0.000E+00	4.100E-01
I-133	7.830E+01	1.330E+02	1.860E+04	2.330E+02	0.000E+00	1.010E+02	0.000E+00	4.050E+01
I-134	6.330E-04	1.680E-03	2.800E-02	2.640E-03	0.000E+00	2.210E-05	0.000E+00	6.020E-04
I-135	1.010E+01	2.600E+01	1.670E+03	4.100E+01	0.000E+00	2.880E+01	0.000E+00	9.630E+00
CS-134	4.860E+03	1.140E+04	0.000E+00	3.640E+03	1.390E+03	1.420E+02	0.000E+00	5.310E+03
CS-136	4.860E+02	1.910E+03	0.000E+00	1.040E+03	1.640E+02	1.540E+02	0.000E+00	1.290E+03
CS-137	6.510E+03	8.660E+03	0.000E+00	2.950E+03	1.150E+03	1.230E+02	0.000E+00	3.020E+03
CS-138	8.300E-07	1.590E-06	0.000E+00	1.180E-06	1.370E-07	7.230E-10	0.000E+00	7.970E-07
BA-133	2.041E+02	7.851E+01	7.851E+01	1.570E+01	1.884E+02	2.198E+02	0.000E+00	1.570E+03
BA-139	1.990E-02	1.400E-05	0.000E+00	1.320E-05	9.670E-06	1.780E-01	0.000E+00	5.810E-04
BA-140	1.610E+03	1.970E+00	0.000E+00	6.680E-01	1.320E+00	2.480E+03	0.000E+00	1.040E+02
BA-141	5.420E-12	4.050E-15	0.000E+00	3.760E-15	2.770E-15	1.150E-17	0.000E+00	1.810E-13
BA-142	6.170E-21	6.170E-24	0.000E+00	5.220E-24	4.100E-24	1.890E-32	0.000E+00	3.800E-22
LA-140	1.650E-01	8.090E-02	0.000E+00	0.000E+00	0.000E+00	4.640E+03	0.000E+00	2.150E-02
LA-142	5.590E-05	2.480E-05	0.000E+00	0.000E+00	0.000E+00	7.550E-01	0.000E+00	6.180E-06
CE-141	7.650E-01	5.110E-01	0.000E+00	2.400E-01	0.000E+00	1.460E+03	0.000E+00	5.870E-02

APPENDIX D

A_i Teen Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
CE-143	1.060E-01	7.730E+01	0.000E+00	3.460E-02	0.000E+00	2.320E+03	0.000E+00	8.630E-03
CE-144	4.040E+01	1.670E+01	0.000E+00	9.990E+00	0.000E+00	1.020E+04	0.000E+00	2.170E+00
PR-143	7.420E-01	2.960E-01	0.000E+00	1.720E-01	0.000E+00	2.440E+03	0.000E+00	3.700E-02
PR-144	7.330E-16	3.000E-16	0.000E+00	1.720E-16	0.000E+00	8.080E-19	0.000E+00	3.720E-17
ND-147	5.280E-01	5.750E-01	0.000E+00	3.370E-01	0.000E+00	2.070E+03	0.000E+00	3.440E-02
EU-152	1.424E+01	3.430E+00	0.000E+00	1.593E+01	0.000E+00	1.262E+03	0.000E+00	3.023E+00
W-187	5.990E+00	4.880E+00	0.000E+00	0.000E+00	0.000E+00	1.320E+03	0.000E+00	1.710E+00
NP-239	8.830E-02	8.330E-03	0.000E+00	2.610E-02	0.000E+00	1.340E+03	0.000E+00	4.630E-03

APPENDIX D

A_i Teen Dose Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.740E-01	1.740E-01	1.740E-01	1.740E-01	1.740E-01	0.000E+00	1.740E-01
C-14	3.410E+04	6.810E+03	6.810E+03	6.810E+03	6.810E+03	6.810E+03	0.000E+00	6.810E+03
NA-24	1.390E+02	1.390E+02	1.390E+02	1.390E+02	1.390E+02	1.390E+02	0.000E+00	1.390E+02
P-32	1.440E+06	8.910E+04	0.000E+00	0.000E+00	0.000E+00	1.210E+05	0.000E+00	5.580E+04
CR-51	0.000E+00	0.000E+00	7.120E-01	2.810E-01	1.830E+00	2.150E+02	0.000E+00	1.280E+00
MN-54	0.000E+00	4.300E+03	0.000E+00	1.280E+03	0.000E+00	8.810E+03	0.000E+00	8.520E+02
MN-56	0.000E+00	1.810E-01	0.000E+00	2.300E-01	0.000E+00	1.190E+01	0.000E+00	3.230E-02
FE-55	6.890E+02	4.880E+02	0.000E+00	0.000E+00	3.100E+02	2.110E+02	0.000E+00	1.140E+02
FE-59	1.050E+03	2.460E+03	0.000E+00	0.000E+00	7.760E+02	5.820E+03	0.000E+00	9.500E+02
CO-58	0.000E+00	8.780E+01	0.000E+00	0.000E+00	0.000E+00	1.210E+03	0.000E+00	2.020E+02
CO-60	0.000E+00	2.560E+02	0.000E+00	0.000E+00	0.000E+00	3.340E+03	0.000E+00	5.770E+02
NI-63	3.230E+04	2.280E+03	0.000E+00	0.000E+00	0.000E+00	3.630E+02	0.000E+00	1.090E+03
NI-65	1.860E-01	2.370E-02	0.000E+00	0.000E+00	0.000E+00	1.290E+00	0.000E+00	1.080E-02
CU-64	0.000E+00	2.820E+00	0.000E+00	7.140E+00	0.000E+00	2.190E+02	0.000E+00	1.330E+00
ZN-65	2.100E+04	7.280E+04	0.000E+00	4.660E+04	0.000E+00	3.080E+04	0.000E+00	3.390E+04
ZN-69	8.410E-07	1.600E-06	0.000E+00	1.050E-06	0.000E+00	2.950E-06	0.000E+00	1.120E-07
SE-75	5.408E+02	2.080E+02	2.080E+02	4.160E+01	4.992E+02	5.824E+02	0.000E+00	4.160E+03
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.160E-02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.320E-12
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	1.050E+05	0.000E+00	0.000E+00	0.000E+00	1.550E+04	0.000E+00	4.920E+04
RB-88	0.000E+00	1.380E-22	0.000E+00	0.000E+00	0.000E+00	1.180E-29	0.000E+00	7.360E-23
RB-89	0.000E+00	1.720E-26	0.000E+00	0.000E+00	0.000E+00	2.630E-35	0.000E+00	1.220E-26
SR-89	2.370E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.830E+03	0.000E+00	6.800E+02
SR-90	4.540E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.270E+04	0.000E+00	1.120E+05

APPENDIX D

A_i Teen Dose Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-91	7.640E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.470E+02	0.000E+00	3.040E+00
SR-92	3.590E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.130E+00	0.000E+00	1.530E-02
Y-90	4.820E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.980E+03	0.000E+00	1.300E-02
Y-91	9.060E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.710E+03	0.000E+00	2.430E-01
Y-91M	1.160E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.470E-10	0.000E+00	4.430E-13
Y-92	5.020E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.380E+01	0.000E+00	1.450E-05
Y-93	3.350E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.020E+03	0.000E+00	9.190E-04
ZR-95	2.450E-01	7.740E-02	0.000E+00	1.140E-01	0.000E+00	1.790E+02	0.000E+00	5.320E-02
ZR-97	5.330E-03	1.050E-03	0.000E+00	1.600E-03	0.000E+00	2.850E+02	0.000E+00	4.860E-04
NB-95	4.410E+02	2.450E+02	0.000E+00	2.370E+02	0.000E+00	1.050E+06	0.000E+00	1.350E+02
MO-99	0.000E+00	8.550E+01	0.000E+00	1.960E+02	0.000E+00	1.530E+02	0.000E+00	1.630E+01
TC-99M	5.720E-04	1.600E-03	0.000E+00	2.380E-02	8.860E-04	1.050E+00	0.000E+00	2.070E-02
TC-101	2.820E-33	4.010E-33	0.000E+00	7.240E-32	2.440E-33	6.840E-40	0.000E+00	3.930E-32
RU-103	4.570E+00	0.000E+00	0.000E+00	1.610E+01	0.000E+00	3.820E+02	0.000E+00	1.950E+00
RU-105	9.350E-03	0.000E+00	0.000E+00	1.180E-01	0.000E+00	7.550E+00	0.000E+00	3.630E-03
RU-106	7.140E+01	0.000E+00	0.000E+00	1.380E+02	0.000E+00	3.420E+03	0.000E+00	8.990E+00
AG-108M	2.457E+01	9.448E+00	9.448E+00	1.890E+00	2.268E+01	2.645E+01	0.000E+00	1.890E+02
AG-110M	8.580E-01	8.120E-01	0.000E+00	1.550E+00	0.000E+00	2.280E+02	0.000E+00	4.940E-01
SN-113	2.407E+03	9.257E+02	9.257E+02	1.851E+02	2.222E+03	2.592E+03	0.000E+00	1.851E+04
SN-117M	2.201E+03	8.466E+02	8.466E+02	1.693E+02	2.032E+03	2.371E+03	0.000E+00	1.693E+04
SB-124	6.978E+02	1.286E+01	1.583E+00	0.000E+00	6.095E+02	1.406E+04	0.000E+00	2.723E+02
SB-125	4.520E+02	4.940E+00	4.320E-01	0.000E+00	3.974E+02	3.518E+03	0.000E+00	1.057E+02
SB-126	2.742E+02	5.606E+00	1.551E+00	0.000E+00	1.966E+02	1.623E+04	0.000E+00	9.849E+01
TE-123M	5.931E+02	2.281E+02	2.281E+02	4.563E+01	5.475E+02	6.388E+02	0.000E+00	4.563E+03
TE-125M	2.760E+03	9.950E+02	7.710E+02	0.000E+00	0.000E+00	8.150E+03	0.000E+00	3.690E+02

APPENDIX D

A_i Teen Dose Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
TE-127	1.960E+01	6.950E+00	1.350E+01	7.940E+01	0.000E+00	1.510E+03	0.000E+00	4.220E+00
TE-127M	7.010E+03	2.490E+03	1.670E+03	2.840E+04	0.000E+00	1.750E+04	0.000E+00	8.340E+02
TE-129	1.770E-05	6.600E-06	1.260E-05	7.430E-05	0.000E+00	9.680E-05	0.000E+00	4.310E-06
TE-129M	1.160E+04	4.320E+03	3.760E+03	4.870E+04	0.000E+00	4.370E+04	0.000E+00	1.840E+03
TE-131	9.400E-17	3.870E-17	7.240E-17	4.110E-16	0.000E+00	7.710E-18	0.000E+00	2.940E-17
TE-131M	1.020E+03	4.900E+02	7.370E+02	5.110E+03	0.000E+00	3.930E+04	0.000E+00	4.090E+02
TE-132	2.060E+03	1.300E+03	1.370E+03	1.250E+04	0.000E+00	4.130E+04	0.000E+00	1.230E+03
I-130	7.320E+00	2.120E+01	1.730E+03	3.260E+01	0.000E+00	1.630E+01	0.000E+00	8.460E+00
I-131	1.470E+02	2.060E+02	6.000E+04	3.540E+02	0.000E+00	4.070E+01	0.000E+00	1.100E+02
I-132	5.520E-03	1.440E-02	4.870E-01	2.280E-02	0.000E+00	6.290E-03	0.000E+00	5.180E-03
I-133	2.470E+01	4.190E+01	5.850E+03	7.350E+01	0.000E+00	3.170E+01	0.000E+00	1.280E+01
I-134	2.220E-08	5.890E-08	9.810E-07	9.280E-08	0.000E+00	7.760E-10	0.000E+00	2.110E-08
I-135	1.350E+00	3.480E+00	2.240E+02	5.490E+00	0.000E+00	3.850E+00	0.000E+00	1.290E+00
CS-134	3.050E+05	7.180E+05	0.000E+00	2.280E+05	8.710E+04	8.930E+03	0.000E+00	3.330E+05
CS-136	2.970E+04	1.170E+05	0.000E+00	6.370E+04	1.000E+04	9.410E+03	0.000E+00	7.860E+04
CS-137	4.090E+05	5.440E+05	0.000E+00	1.850E+05	7.190E+04	7.730E+03	0.000E+00	1.890E+05
CS-138	9.580E-12	1.840E-11	0.000E+00	1.360E-11	1.580E-12	8.340E-15	0.000E+00	9.190E-12
BA-133	2.561E+01	9.851E+00	9.851E+00	1.970E+00	2.364E+01	2.758E+01	0.000E+00	1.970E+02
BA-139	6.170E-06	4.340E-09	0.000E+00	4.090E-09	2.990E-09	5.510E-05	0.000E+00	1.800E-07
BA-140	1.960E+02	2.410E-01	0.000E+00	8.160E-02	1.620E-01	3.030E+02	0.000E+00	1.260E+01
BA-141	9.450E-25	7.050E-28	0.000E+00	6.550E-28	4.830E-28	2.010E-30	0.000E+00	3.150E-26
BA-142	2.750E-42	2.750E-45	0.000E+00	2.320E-45	1.830E-45	8.430E-54	0.000E+00	1.690E-43
LA-140	1.050E-01	5.160E-02	0.000E+00	0.000E+00	0.000E+00	2.960E+03	0.000E+00	1.370E-02
LA-142	2.350E-07	1.040E-07	0.000E+00	0.000E+00	0.000E+00	3.180E-03	0.000E+00	2.600E-08
CE-141	2.370E-02	1.590E-02	0.000E+00	7.460E-03	0.000E+00	4.540E+01	0.000E+00	1.820E-03

APPENDIX D

A_i Teen Dose Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
CE-143	2.590E-03	1.880E+00	0.000E+00	8.450E-04	0.000E+00	5.660E+01	0.000E+00	2.100E-04
CE-144	1.270E+00	5.240E-01	0.000E+00	3.130E-01	0.000E+00	3.180E+02	0.000E+00	6.810E-02
PR-143	5.680E-01	2.270E-01	0.000E+00	1.320E-01	0.000E+00	1.870E+03	0.000E+00	2.830E-02
PR-144	1.690E-28	6.900E-29	0.000E+00	3.960E-29	0.000E+00	1.860E-31	0.000E+00	8.550E-30
ND-147	4.020E-01	4.370E-01	0.000E+00	2.560E-01	0.000E+00	1.580E+03	0.000E+00	2.620E-02
EU-152	2.234E+01	5.380E+00	0.000E+00	2.499E+01	0.000E+00	1.979E+03	0.000E+00	4.742E+00
W-187	1.590E+02	1.300E+02	0.000E+00	0.000E+00	0.000E+00	3.510E+04	0.000E+00	4.540E+01
NP-239	2.390E-02	2.260E-03	0.000E+00	7.080E-03	0.000E+00	3.630E+02	0.000E+00	1.250E-03

APPENDIX D

A_i Teen Dose Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NA-24	3.580E+00	3.580E+00	3.580E+00	3.580E+00	3.580E+00	3.580E+00	4.150E+00	3.580E+00
P-32	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CR-51	1.400E+00	1.400E+00	1.400E+00	1.400E+00	1.400E+00	1.400E+00	1.650E+00	1.400E+00
MN-54	4.150E+02	4.150E+02	4.150E+02	4.150E+02	4.150E+02	4.150E+02	4.870E+02	4.150E+02
MN-56	2.700E-01	2.700E-01	2.700E-01	2.700E-01	2.700E-01	2.700E-01	3.200E-01	2.700E-01
FE-55	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
FE-59	8.180E+01	8.180E+01	8.180E+01	8.180E+01	8.180E+01	8.180E+01	9.610E+01	8.180E+01
CO-58	1.140E+02	1.140E+02	1.140E+02	1.140E+02	1.140E+02	1.140E+02	1.330E+02	1.140E+02
CO-60	6.440E+03	6.440E+03	6.440E+03	6.440E+03	6.440E+03	6.440E+03	7.580E+03	6.440E+03
NI-63	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NI-65	8.900E-02	8.900E-02	8.900E-02	8.900E-02	8.900E-02	8.900E-02	1.030E-01	8.900E-02
CU-64	1.820E-01	1.820E-01	1.820E-01	1.820E-01	1.820E-01	1.820E-01	2.060E-01	1.820E-01
ZN-65	2.240E+02	2.240E+02	2.240E+02	2.240E+02	2.240E+02	2.240E+02	2.580E+02	2.240E+02
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE-75	1.354E+03	1.354E+03	1.354E+03	1.354E+03	1.354E+03	1.354E+03	1.584E+03	1.354E+03
BR-83	1.460E-03	1.460E-03	1.460E-03	1.460E-03	1.460E-03	1.460E-03	2.120E-03	1.460E-03
BR-84	6.070E-02	6.070E-02	6.070E-02	6.070E-02	6.070E-02	6.070E-02	7.080E-02	6.070E-02
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	2.690E+00	2.690E+00	2.690E+00	2.690E+00	2.690E+00	2.690E+00	3.080E+00	2.690E+00
RB-88	9.910E-03	9.910E-03	9.910E-03	9.910E-03	9.910E-03	9.910E-03	1.130E-02	9.910E-03
RB-89	3.680E-02	3.680E-02	3.680E-02	3.680E-02	3.680E-02	3.680E-02	4.420E-02	3.680E-02
SR-89	6.490E-03	6.490E-03	6.490E-03	6.490E-03	6.490E-03	6.490E-03	7.530E-03	6.490E-03
SR-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

APPENDIX D

A_i Teen Dose Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μCi/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-91	6.440E-01	6.440E-01	6.440E-01	6.440E-01	6.440E-01	6.440E-01	7.530E-01	6.440E-01
SR-92	2.330E-01	2.330E-01	2.330E-01	2.330E-01	2.330E-01	2.330E-01	2.590E-01	2.330E-01
Y-90	1.350E-03	1.350E-03	1.350E-03	1.350E-03	1.350E-03	1.350E-03	1.590E-03	1.350E-03
Y-91	3.220E-01	3.220E-01	3.220E-01	3.220E-01	3.220E-01	3.220E-01	3.620E-01	3.220E-01
Y-91M	3.010E-02	3.010E-02	3.010E-02	3.010E-02	3.010E-02	3.010E-02	3.480E-02	3.010E-02
Y-92	5.410E-02	5.410E-02	5.410E-02	5.410E-02	5.410E-02	5.410E-02	6.420E-02	5.410E-02
Y-93	5.500E-02	5.500E-02	5.500E-02	5.500E-02	5.500E-02	5.500E-02	7.520E-02	5.500E-02
ZR-95	7.330E+01	7.330E+01	7.330E+01	7.330E+01	7.330E+01	7.330E+01	8.510E+01	7.330E+01
ZR-97	8.870E-01	8.870E-01	8.870E-01	8.870E-01	8.870E-01	8.870E-01	1.030E+00	8.870E-01
NB-95	4.100E+01	4.100E+01	4.100E+01	4.100E+01	4.100E+01	4.100E+01	4.820E+01	4.100E+01
MO-99	1.200E+00	1.200E+00	1.200E+00	1.200E+00	1.200E+00	1.200E+00	1.390E+00	1.200E+00
TC-99M	5.520E-02	5.520E-02	5.520E-02	5.520E-02	5.520E-02	5.520E-02	6.320E-02	5.520E-02
TC-101	6.100E-03	6.100E-03	6.100E-03	6.100E-03	6.100E-03	6.100E-03	6.780E-03	6.100E-03
RU-103	3.250E+01	3.250E+01	3.250E+01	3.250E+01	3.250E+01	3.250E+01	3.790E+01	3.250E+01
RU-105	1.910E-01	1.910E-01	1.910E-01	1.910E-01	1.910E-01	1.910E-01	2.160E-01	1.910E-01
RU-106	1.270E+02	1.270E+02	1.270E+02	1.270E+02	1.270E+02	1.270E+02	1.520E+02	1.270E+02
AG-108M	1.546E+05	1.546E+05	1.546E+05	1.546E+05	1.546E+05	1.546E+05	1.808E+05	1.546E+05
AG-110M	1.030E+03	1.030E+03	1.030E+03	1.030E+03	1.030E+03	1.030E+03	1.200E+03	1.030E+03
SN-113	4.473E+01	4.473E+01	4.473E+01	4.473E+01	4.473E+01	4.473E+01	5.233E+01	4.473E+01
SN-117M	6.250E+01	6.250E+01	6.250E+01	6.250E+01	6.250E+01	6.250E+01	7.313E+01	6.250E+01
SB-124	1.793E+02	1.793E+02	1.793E+02	1.793E+02	1.793E+02	1.793E+02	2.069E+02	1.793E+02
SB-125	6.992E+02	6.992E+02	6.992E+02	6.992E+02	6.992E+02	6.992E+02	7.894E+02	6.992E+02
SB-126	2.529E+01	2.529E+01	2.529E+01	2.529E+01	2.529E+01	2.529E+01	2.841E+01	2.529E+01
TE-123M	5.074E+02	5.074E+02	5.074E+02	5.074E+02	5.074E+02	5.074E+02	5.937E+02	5.074E+02
TE-125M	4.650E-01	4.650E-01	4.650E-01	4.650E-01	4.650E-01	4.650E-01	6.380E-01	4.650E-01

APPENDIX D

A_i Teen Dose Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
TE-127	8.920E-04	8.920E-04	8.920E-04	8.920E-04	8.920E-04	8.920E-04	9.820E-04	8.920E-04
TE-127M	2.750E-02	2.750E-02	2.750E-02	2.750E-02	2.750E-02	2.750E-02	3.250E-02	2.750E-02
TE-129	7.860E-03	7.860E-03	7.860E-03	7.860E-03	7.860E-03	7.860E-03	9.300E-03	7.860E-03
TE-129M	5.930E+00	5.930E+00	5.930E+00	5.930E+00	5.930E+00	5.930E+00	6.930E+00	5.930E+00
TE-131	8.750E-03	8.750E-03	8.750E-03	8.750E-03	8.750E-03	8.750E-03	1.030E+01	8.750E-03
TE-131M	2.410E+00	2.410E+00	2.410E+00	2.410E+00	2.410E+00	2.410E+00	2.840E+00	2.410E+00
TE-132	1.270E+00	1.270E+00	1.270E+00	1.270E+00	1.270E+00	1.270E+00	1.490E+00	1.270E+00
I-130	1.650E+00	1.650E+00	1.650E+00	1.650E+00	1.650E+00	1.650E+00	2.010E+00	1.650E+00
I-131	5.160E+00	5.160E+00	5.160E+00	5.160E+00	5.160E+00	5.160E+00	6.260E+00	5.160E+00
I-132	3.730E-01	3.730E-01	3.730E-01	3.730E-01	3.730E-01	3.730E-01	4.390E-01	3.730E-01
I-133	7.350E-01	7.350E-01	7.350E-01	7.350E-01	7.350E-01	7.350E-01	8.930E-01	7.350E-01
I-134	1.340E-01	1.340E-01	1.340E-01	1.340E-01	1.340E-01	1.340E-01	1.590E-01	1.340E-01
I-135	7.570E-01	7.570E-01	7.570E-01	7.570E-01	7.570E-01	7.570E-01	8.830E-01	7.570E-01
CS-134	2.060E+03	2.060E+03	2.060E+03	2.060E+03	2.060E+03	2.060E+03	2.400E+03	2.060E+03
CS-136	4.520E+01	4.520E+01	4.520E+01	4.520E+01	4.520E+01	4.520E+01	5.130E+01	4.520E+01
CS-137	3.080E+03	3.080E+03	3.080E+03	3.080E+03	3.080E+03	3.080E+03	3.590E+03	3.080E+03
CS-138	1.080E-01	1.080E-01	1.080E-01	1.080E-01	1.080E-01	1.080E-01	1.230E-01	1.080E-01
BA-133	2.642E+04	2.642E+04	2.642E+04	2.642E+04	2.642E+04	2.642E+04	3.091E+04	2.642E+04
BA-139	3.170E-02	3.170E-02	3.170E-02	3.170E-02	3.170E-02	3.170E-02	3.570E-02	3.170E-02
BA-140	6.150E+00	6.150E+00	6.150E+00	6.150E+00	6.150E+00	6.150E+00	7.030E+00	6.150E+00
BA-141	1.250E-02	1.250E-02	1.250E-02	1.250E-02	1.250E-02	1.250E-02	1.420E-02	1.250E-02
BA-142	1.340E-02	1.340E-02	1.340E-02	1.340E-02	1.340E-02	1.340E-02	1.530E-02	1.340E-02
LA-140	5.760E+00	5.760E+00	5.760E+00	5.760E+00	5.760E+00	5.760E+00	6.530E+00	5.760E+00
LA-142	2.280E-01	2.280E-01	2.280E-01	2.280E-01	2.280E-01	2.280E-01	2.730E-01	2.280E-01
CE-141	4.090E+00	4.090E+00	4.090E+00	4.090E+00	4.090E+00	4.090E+00	4.620E+00	4.090E+00

APPENDIX D

A_i Teen Dose Factors for use in the Liquid Dose Calculations

Age group:	TEEN	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
CE-143	6.930E-01	6.930E-01	6.930E-01	6.930E-01	6.930E-01	6.930E-01	7.870E-01	6.930E-01
CE-144	2.080E+01	2.080E+01	2.080E+01	2.080E+01	2.080E+01	2.080E+01	2.410E+01	2.080E+01
PR-143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR-144	5.500E-04	5.500E-04	5.500E-04	5.500E-04	5.500E-04	5.500E-04	6.320E-04	5.500E-04
ND-147	2.520E+00	2.520E+00	2.520E+00	2.520E+00	2.520E+00	2.520E+00	3.020E+00	2.520E+00
EU-152	4.453E+03	4.453E+03	4.453E+03	4.453E+03	4.453E+03	4.453E+03	5.154E+03	4.453E+03
W-187	7.050E-01	7.050E-01	7.050E-01	7.050E-01	7.050E-01	7.050E-01	8.190E-01	7.050E-01
NP-239	5.130E-01	5.130E-01	5.130E-01	5.130E-01	5.130E-01	5.130E-01	5.930E-01	5.130E-01

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.180E+01	1.180E+01	1.180E+01	1.180E+01	1.180E+01	0.000E+00	1.180E+01
C-14	7.030E+02	1.410E+02	1.410E+02	1.410E+02	1.410E+02	1.410E+02	0.000E+00	1.410E+02
NA-24	1.940E+02	1.940E+02	1.940E+02	1.940E+02	1.940E+02	1.940E+02	0.000E+00	1.940E+02
P-32	4.680E+04	2.190E+03	0.000E+00	0.000E+00	0.000E+00	1.290E+03	0.000E+00	1.800E+03
CR-51	0.000E+00	0.000E+00	2.840E-01	7.750E-02	5.180E-01	2.710E+01	0.000E+00	5.110E-01
MN-54	0.000E+00	6.210E+02	0.000E+00	1.740E+02	0.000E+00	5.220E+02	0.000E+00	1.660E+02
MN-56	0.000E+00	7.700E-01	0.000E+00	9.320E-01	0.000E+00	1.120E+02	0.000E+00	1.740E-01
FE-55	6.680E+02	3.550E+02	0.000E+00	0.000E+00	2.010E+02	6.570E+01	0.000E+00	1.100E+02
FE-59	9.520E+02	1.540E+03	0.000E+00	0.000E+00	4.470E+02	1.600E+03	0.000E+00	7.670E+02
CO-58	0.000E+00	1.040E+02	0.000E+00	0.000E+00	0.000E+00	6.070E+02	0.000E+00	3.190E+02
CO-60	0.000E+00	3.080E+02	0.000E+00	0.000E+00	0.000E+00	1.700E+03	0.000E+00	9.070E+02
NI-63	3.130E+04	1.670E+03	0.000E+00	0.000E+00	0.000E+00	1.130E+02	0.000E+00	1.060E+03
NI-65	4.760E+00	4.480E-01	0.000E+00	0.000E+00	0.000E+00	5.490E+01	0.000E+00	2.610E-01
CU-64	0.000E+00	7.390E+00	0.000E+00	1.780E+01	0.000E+00	3.470E+02	0.000E+00	4.460E+00
ZN-65	7.950E+02	2.120E+03	0.000E+00	1.340E+03	0.000E+00	3.720E+02	0.000E+00	1.320E+03
ZN-69	3.190E-04	4.610E-04	0.000E+00	2.800E-04	0.000E+00	2.900E-02	0.000E+00	4.260E-05
SE-75	2.314E+02	8.902E+01	8.902E+01	1.780E+01	2.136E+02	2.492E+02	0.000E+00	1.780E+03
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.060E-01
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.780E-06
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.300E-76
RB-86	0.000E+00	3.820E+03	0.000E+00	0.000E+00	0.000E+00	2.460E+02	0.000E+00	2.350E+03
RB-88	0.000E+00	7.360E-12	0.000E+00	0.000E+00	0.000E+00	3.610E-13	0.000E+00	5.110E-12
RB-89	0.000E+00	6.300E-14	0.000E+00	0.000E+00	0.000E+00	5.490E-16	0.000E+00	5.600E-14
SR-89	7.620E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.950E+03	0.000E+00	2.180E+03
SR-90	9.880E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.330E+04	0.000E+00	2.510E+05

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-91	5.810E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.280E+03	0.000E+00	2.190E+01
SR-92	2.430E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.610E+02	0.000E+00	9.760E-01
Y-90	2.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.980E+03	0.000E+00	5.620E-02
Y-91	3.480E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.640E+03	0.000E+00	9.310E-01
Y-91M	9.860E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.930E-03	0.000E+00	3.590E-08
Y-92	2.000E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.770E+02	0.000E+00	5.710E-04
Y-93	2.900E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.330E+03	0.000E+00	7.970E-03
ZR-95	6.710E+00	1.470E+00	0.000E+00	2.110E+00	0.000E+00	1.540E+03	0.000E+00	1.310E+00
ZR-97	2.480E-01	3.590E-02	0.000E+00	5.150E-02	0.000E+00	5.440E+03	0.000E+00	2.120E-02
NB-95	1.300E+00	5.040E-01	0.000E+00	4.740E-01	0.000E+00	9.330E+02	0.000E+00	3.600E-01
MO-99	0.000E+00	6.820E+02	0.000E+00	1.460E+03	0.000E+00	5.640E+02	0.000E+00	1.690E+02
TC-99M	1.350E-02	2.640E-02	0.000E+00	3.840E-01	1.340E-02	1.500E+01	0.000E+00	4.380E-01
TC-101	3.330E-17	3.480E-17	0.000E+00	5.940E-16	1.840E-17	1.110E-16	0.000E+00	4.410E-16
RU-103	4.210E+01	0.000E+00	0.000E+00	1.060E+02	0.000E+00	1.090E+03	0.000E+00	1.620E+01
RU-105	5.750E-01	0.000E+00	0.000E+00	5.060E+00	0.000E+00	3.750E+02	0.000E+00	2.090E-01
RU-106	6.800E+02	0.000E+00	0.000E+00	9.180E+02	0.000E+00	1.060E+04	0.000E+00	8.480E+01
AG-108M	1.818E+02	6.991E+01	6.991E+01	1.398E+01	1.678E+02	1.958E+02	0.000E+00	1.398E+03
AG-110M	3.130E+01	2.110E+01	0.000E+00	3.940E+01	0.000E+00	2.510E+03	0.000E+00	1.690E+01
SN-113	7.249E+01	2.788E+01	2.788E+01	5.576E+00	6.692E+01	7.807E+01	0.000E+00	5.576E+02
SN-117M	6.816E+01	2.621E+01	2.621E+01	5.243E+00	6.291E+01	7.340E+01	0.000E+00	5.243E+02
SB-124	6.416E+02	8.324E+00	1.416E+00	0.000E+00	3.561E+02	4.012E+03	0.000E+00	2.249E+02
SB-125	4.161E+02	3.208E+00	3.853E-01	0.000E+00	2.319E+02	9.939E+02	0.000E+00	8.718E+01
SB-126	2.488E+02	3.805E+00	1.459E+00	0.000E+00	1.187E+02	5.015E+03	0.000E+00	8.933E+01
TE-123M	1.366E+02	5.255E+01	5.255E+01	1.051E+01	1.261E+02	1.471E+02	0.000E+00	1.051E+03
TE-125M	6.590E+02	1.790E+02	1.850E+02	0.000E+00	0.000E+00	6.360E+02	0.000E+00	8.780E+01

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
TE-127	1.130E+01	3.050E+00	7.820E+00	3.210E+01	0.000E+00	4.410E+02	0.000E+00	2.420E+00
TE-127M	1.670E+03	4.510E+02	4.000E+02	4.780E+03	0.000E+00	1.360E+03	0.000E+00	1.990E+02
TE-129	5.730E-03	1.600E-03	4.090E-03	1.680E-02	0.000E+00	3.570E-01	0.000E+00	1.360E-03
TE-129M	2.800E+03	7.830E+02	9.030E+02	8.230E+03	0.000E+00	3.420E+03	0.000E+00	4.350E+02
TE-131	1.040E-08	3.160E-09	7.930E-09	3.140E-08	0.000E+00	5.450E-08	0.000E+00	3.090E-09
TE-131M	3.170E+02	1.100E+02	2.260E+02	1.060E+03	0.000E+00	4.450E+03	0.000E+00	1.170E+02
TE-132	5.280E+02	2.340E+02	3.400E+02	2.170E+03	0.000E+00	2.350E+03	0.000E+00	2.820E+02
I-130	8.650E+01	1.750E+02	1.930E+04	2.610E+02	0.000E+00	8.180E+01	0.000E+00	9.010E+01
I-131	9.580E+02	9.630E+02	3.190E+05	1.580E+03	0.000E+00	8.580E+01	0.000E+00	5.470E+02
I-132	1.250E+00	2.300E+00	1.070E+02	3.520E+00	0.000E+00	2.710E+00	0.000E+00	1.060E+00
I-133	2.310E+02	2.850E+02	5.300E+04	4.750E+02	0.000E+00	1.150E+02	0.000E+00	1.080E+02
I-134	1.820E-03	3.370E-03	7.760E-02	5.160E-03	0.000E+00	2.240E-03	0.000E+00	1.550E-03
I-135	2.890E+01	5.210E+01	4.610E+03	7.990E+01	0.000E+00	3.970E+01	0.000E+00	2.460E+01
CS-134	1.360E+04	2.230E+04	0.000E+00	6.920E+03	2.480E+03	1.200E+02	0.000E+00	4.710E+03
CS-136	1.330E+03	3.660E+03	0.000E+00	1.950E+03	2.910E+02	1.290E+02	0.000E+00	2.370E+03
CS-137	1.900E+04	1.820E+04	0.000E+00	5.930E+03	2.130E+03	1.140E+02	0.000E+00	2.690E+03
CS-138	2.440E-06	3.390E-06	0.000E+00	2.380E-06	2.570E-07	1.560E-06	0.000E+00	2.150E-06
BA-133	1.091E+02	4.194E+01	4.194E+01	8.389E+00	1.007E+02	1.174E+02	0.000E+00	8.389E+02
BA-139	5.940E-02	3.170E-05	0.000E+00	2.770E-05	1.860E-05	3.430E+00	0.000E+00	1.720E-03
BA-140	4.700E+03	4.120E+00	0.000E+00	1.340E+00	2.460E+00	2.380E+03	0.000E+00	2.740E+02
BA-141	1.620E-11	9.050E-15	0.000E+00	7.830E-15	5.310E-14	9.210E-12	0.000E+00	5.260E-13
BA-142	1.800E-20	1.300E-23	0.000E+00	1.050E-23	7.630E-24	2.350E-22	0.000E+00	1.010E-21
LA-140	4.780E-01	1.670E-01	0.000E+00	0.000E+00	0.000E+00	4.650E+03	0.000E+00	5.630E-02
LA-142	1.640E-04	5.210E-05	0.000E+00	0.000E+00	0.000E+00	1.030E+01	0.000E+00	1.630E-05
CE-141	2.280E+00	1.140E+00	0.000E+00	4.990E-01	0.000E+00	1.420E+03	0.000E+00	1.690E-01

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
CE-143	3.160E-01	1.710E+02	0.000E+00	7.180E-02	0.000E+00	2.510E+03	0.000E+00	2.480E-02
CE-144	1.210E+02	3.790E+01	0.000E+00	2.100E+01	0.000E+00	9.870E+03	0.000E+00	6.450E+00
PR-143	2.230E+00	6.690E-01	0.000E+00	3.620E-01	0.000E+00	2.400E+03	0.000E+00	1.110E-01
PR-144	2.200E-15	6.800E-16	0.000E+00	3.600E-16	0.000E+00	1.460E-12	0.000E+00	1.110E-16
ND-147	1.570E+00	1.270E+00	0.000E+00	6.990E-01	0.000E+00	2.020E+03	0.000E+00	9.860E-02
EU-152	3.575E+01	6.511E+00	0.000E+00	2.750E+01	0.000E+00	1.070E+03	0.000E+00	7.732E+00
W-187	1.760E+01	1.040E+01	0.000E+00	0.000E+00	0.000E+00	1.460E+03	0.000E+00	4.680E+00
NP-239	2.630E-01	1.890E-02	0.000E+00	5.470E-02	0.000E+00	1.400E+03	0.000E+00	1.330E-02

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.440E-01	1.440E-01	1.440E-01	1.440E-01	1.440E-01	0.000E+00	1.440E-01
C-14	4.380E+04	8.760E+03	8.760E+03	8.760E+03	8.760E+03	8.760E+03	0.000E+00	8.760E+03
NA-24	1.510E+02	1.510E+02	1.510E+02	1.510E+02	1.510E+02	1.510E+02	0.000E+00	1.510E+02
P-32	1.850E+06	8.680E+04	0.000E+00	0.000E+00	0.000E+00	5.130E+04	0.000E+00	7.150E+04
CR-51	0.000E+00	0.000E+00	7.580E-01	2.070E-01	1.380E+00	7.240E+01	0.000E+00	1.370E+00
MN-54	0.000E+00	3.360E+03	0.000E+00	9.420E+02	0.000E+00	2.820E+03	0.000E+00	8.950E+02
MN-56	0.000E+00	1.650E-01	0.000E+00	2.000E-01	0.000E+00	2.400E+01	0.000E+00	3.730E-02
FE-55	9.040E+02	4.790E+02	0.000E+00	0.000E+00	2.710E+02	8.880E+01	0.000E+00	1.490E+02
FE-59	1.280E+03	2.070E+03	0.000E+00	0.000E+00	5.990E+02	2.150E+03	0.000E+00	1.030E+03
CO-58	0.000E+00	7.010E+01	0.000E+00	0.000E+00	0.000E+00	4.090E+02	0.000E+00	2.150E+02
CO-60	0.000E+00	2.080E+02	0.000E+00	0.000E+00	0.000E+00	1.150E+03	0.000E+00	6.130E+02
NI-63	4.230E+04	2.270E+03	0.000E+00	0.000E+00	0.000E+00	1.530E+02	0.000E+00	1.440E+03
NI-65	2.370E-01	2.230E-02	0.000E+00	0.000E+00	0.000E+00	2.740E+00	0.000E+00	1.300E-02
CU-64	0.000E+00	2.590E+00	0.000E+00	6.260E+00	0.000E+00	1.220E+02	0.000E+00	1.570E+00
ZN-65	2.150E+04	5.730E+04	0.000E+00	3.610E+04	0.000E+00	1.010E+04	0.000E+00	3.560E+04
ZN-69	1.080E-06	1.560E-06	0.000E+00	9.470E-07	0.000E+00	9.840E-05	0.000E+00	1.440E-07
SE-75	6.244E+02	2.402E+02	2.402E+02	4.803E+01	5.764E+02	6.725E+02	0.000E+00	4.803E+03
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.340E-02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.570E-12
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	1.020E+05	0.000E+00	0.000E+00	0.000E+00	6.530E+03	0.000E+00	6.250E+04
RB-88	0.000E+00	1.330E-22	0.000E+00	0.000E+00	0.000E+00	6.510E-24	0.000E+00	9.220E-23
RB-89	0.000E+00	1.580E-26	0.000E+00	0.000E+00	0.000E+00	1.370E-28	0.000E+00	1.400E-26
SR-89	3.070E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.190E+03	0.000E+00	8.780E+02
SR-90	4.010E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.400E+03	0.000E+00	1.020E+05

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-91	9.800E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.160E+02	0.000E+00	3.700E+00
SR-92	4.580E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.670E+00	0.000E+00	1.840E-02
Y-90	6.240E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.780E+03	0.000E+00	1.670E-02
Y-91	1.170E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.560E+03	0.000E+00	3.130E-01
Y-91M	1.480E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.900E-08	0.000E+00	5.390E-13
Y-92	6.440E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.860E+01	0.000E+00	1.840E-05
Y-93	4.300E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.420E+02	0.000E+00	1.180E-03
ZR-95	2.980E-01	6.550E-02	0.000E+00	9.370E-02	0.000E+00	6.830E+01	0.000E+00	5.830E-02
ZR-97	6.780E-03	9.790E-04	0.000E+00	1.410E-03	0.000E+00	1.480E+02	0.000E+00	5.780E-04
NB-95	5.210E+02	2.030E+02	0.000E+00	1.900E+02	0.000E+00	3.750E+05	0.000E+00	1.450E+02
MO-99	0.000E+00	8.130E+01	0.000E+00	1.740E+02	0.000E+00	6.720E+01	0.000E+00	2.010E+01
TC-99M	6.860E-04	1.350E-03	0.000E+00	1.950E-02	6.830E-04	7.650E-01	0.000E+00	2.230E-02
TC-101	3.610E-33	3.780E-33	0.000E+00	6.440E-32	2.000E-33	1.200E-32	0.000E+00	4.790E-32
RU-103	5.650E+00	0.000E+00	0.000E+00	1.420E+01	0.000E+00	1.460E+02	0.000E+00	2.170E+00
RU-105	1.190E-02	0.000E+00	0.000E+00	1.050E-01	0.000E+00	7.790E+00	0.000E+00	4.330E-03
RU-106	9.190E+01	0.000E+00	0.000E+00	1.240E+02	0.000E+00	1.430E+03	0.000E+00	1.150E+01
AG-108M	2.459E+01	9.459E+00	9.459E+00	1.892E+00	2.270E+01	2.648E+01	0.000E+00	1.892E+02
AG-110M	9.720E-01	6.570E-01	0.000E+00	1.220E+00	0.000E+00	7.810E+01	0.000E+00	5.250E-01
SN-113	2.933E+03	1.128E+03	1.128E+03	2.256E+02	2.708E+03	3.159E+03	0.000E+00	2.256E+04
SN-117M	2.697E+03	1.037E+03	1.037E+03	2.074E+02	2.489E+03	2.904E+03	0.000E+00	2.074E+04
SB-124	8.631E+02	1.120E+01	1.905E+00	0.000E+00	4.790E+02	5.396E+03	0.000E+00	3.025E+02
SB-125	5.628E+02	4.339E+00	5.212E-01	0.000E+00	3.136E+02	1.344E+03	0.000E+00	1.179E+02
SB-126	3.273E+02	5.006E+00	1.919E+00	0.000E+00	1.562E+02	6.598E+03	0.000E+00	1.175E+02
TE-123M	7.373E+02	2.836E+02	2.836E+02	5.671E+01	6.806E+02	7.940E+02	0.000E+00	5.671E+03
TE-125M	3.540E+03	9.610E+02	9.950E+02	0.000E+00	0.000E+00	3.420E+03	0.000E+00	4.730E+02

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
TE-127	2.520E+01	6.800E+00	1.750E+01	7.170E+01	0.000E+00	9.850E+02	0.000E+00	5.410E+00
TE-127M	9.040E+03	2.430E+03	2.160E+03	2.580E+04	0.000E+00	7.320E+03	0.000E+00	1.070E+03
TE-129	2.280E-05	6.370E-06	1.630E-05	6.680E-05	0.000E+00	1.420E-03	0.000E+00	5.420E-06
TE-129M	1.500E+04	4.190E+03	4.840E+03	4.410E+04	0.000E+00	1.830E+04	0.000E+00	2.330E+03
TE-131	1.210E-16	3.680E-17	9.220E-17	3.650E-16	0.000E+00	6.330E-16	0.000E+00	3.590E-17
TE-131M	1.300E+03	4.500E+02	9.250E+02	4.350E+03	0.000E+00	1.820E+04	0.000E+00	4.790E+02
TE-132	2.570E+03	1.140E+03	1.650E+03	1.050E+04	0.000E+00	1.140E+04	0.000E+00	1.370E+03
I-130	8.950E+00	1.810E+01	1.990E+03	2.700E+01	0.000E+00	8.460E+00	0.000E+00	9.320E+00
I-131	1.860E+02	1.870E+02	6.190E+04	3.070E+02	0.000E+00	1.670E+01	0.000E+00	1.060E+02
I-132	6.830E-03	1.250E-02	5.820E-01	1.920E-02	0.000E+00	1.480E-02	0.000E+00	5.770E-03
I-133	3.140E+01	3.880E+01	7.210E+03	6.470E+01	0.000E+00	1.560E+01	0.000E+00	1.470E+01
I-134	2.750E-08	5.100E-08	1.170E-06	7.800E-08	0.000E+00	3.380E-08	0.000E+00	2.350E-08
I-135	1.670E+00	3.010E+00	2.660E+02	4.610E+00	0.000E+00	2.290E+00	0.000E+00	1.420E+00
CS-134	3.680E+05	6.040E+05	0.000E+00	1.870E+05	6.710E+04	3.250E+03	0.000E+00	1.270E+05
CS-136	3.510E+04	9.640E+04	0.000E+00	5.130E+04	7.660E+03	3.390E+03	0.000E+00	6.240E+04
CS-137	5.140E+05	4.920E+05	0.000E+00	1.600E+05	5.770E+04	3.080E+03	0.000E+00	7.270E+04
CS-138	1.210E-11	1.690E-11	0.000E+00	1.190E-11	1.280E-12	7.770E-12	0.000E+00	1.070E-11
BA-133	5.901E+00	2.270E+00	2.270E+00	4.539E-01	5.447E+00	6.355E+00	0.000E+00	4.539E+01
BA-139	7.930E-06	4.230E-09	0.000E+00	3.700E-09	2.490E-09	4.580E-04	0.000E+00	2.300E-07
BA-140	2.480E+02	2.170E-01	0.000E+00	7.060E-02	1.290E-01	1.250E+02	0.000E+00	1.450E+01
BA-141	1.210E-24	6.800E-28	0.000E+00	5.880E-28	3.990E-27	6.920E-25	0.000E+00	3.950E-26
BA-142	3.460E-42	2.490E-45	0.000E+00	2.020E-45	1.470E-45	4.510E-44	0.000E+00	1.930E-43
LA-140	1.310E-01	4.590E-02	0.000E+00	0.000E+00	0.000E+00	1.280E+03	0.000E+00	1.550E-02
LA-142	2.970E-07	9.470E-08	0.000E+00	0.000E+00	0.000E+00	1.880E-02	0.000E+00	2.960E-08
CE-141	3.060E-02	1.520E-02	0.000E+00	6.680E-03	0.000E+00	1.900E+01	0.000E+00	2.260E-03

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Fresh Water Fish - Sport (FFSP)			Units:	mrem/hr / μCi/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
CE-143	3.320E-03	1.800E+00	0.000E+00	7.550E-04	0.000E+00	2.640E+01	0.000E+00	2.610E-04
CE-144	1.630E+00	5.120E-01	0.000E+00	2.830E-01	0.000E+00	1.330E+02	0.000E+00	8.710E-02
PR-143	7.340E-01	2.200E-01	0.000E+00	1.190E-01	0.000E+00	7.920E+02	0.000E+00	3.640E-02
PR-144	2.180E-28	6.750E-29	0.000E+00	3.570E-29	0.000E+00	1.450E-25	0.000E+00	1.100E-29
ND-147	5.150E-01	4.170E-01	0.000E+00	2.290E-01	0.000E+00	6.610E+02	0.000E+00	3.230E-02
EU-152	2.418E+01	4.404E+00	0.000E+00	1.860E+01	0.000E+00	7.236E+02	0.000E+00	5.230E+00
W-187	2.010E+02	1.190E+02	0.000E+00	0.000E+00	0.000E+00	1.680E+04	0.000E+00	5.350E+01
NP-239	3.080E-02	2.210E-03	0.000E+00	6.390E-03	0.000E+00	1.630E+02	0.000E+00	1.550E-03

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NA-24	7.480E-01	7.480E-01	7.480E-01	7.480E-01	7.480E-01	7.480E-01	8.680E-01	7.480E-01
P-32	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CR-51	2.920E-01	2.920E-01	2.920E-01	2.920E-01	2.920E-01	2.920E-01	3.450E-01	2.920E-01
MN-54	8.680E+01	8.680E+01	8.680E+01	8.680E+01	8.680E+01	8.680E+01	1.020E+02	8.680E+01
MN-56	5.650E-02	5.650E-02	5.650E-02	5.650E-02	5.650E-02	5.650E-02	6.680E-02	5.650E-02
FE-55	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
FE-59	1.710E+01	1.710E+01	1.710E+01	1.710E+01	1.710E+01	1.710E+01	2.010E+01	1.710E+01
CO-58	2.370E+01	2.370E+01	2.370E+01	2.370E+01	2.370E+01	2.370E+01	2.780E+01	2.370E+01
CO-60	1.350E+03	1.350E+03	1.350E+03	1.350E+03	1.350E+03	1.350E+03	1.580E+03	1.350E+03
NI-63	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NI-65	1.860E-02	1.860E-02	1.860E-02	1.860E-02	1.860E-02	1.860E-02	2.160E-02	1.860E-02
CU-64	3.800E-02	3.800E-02	3.800E-02	3.800E-02	3.800E-02	3.800E-02	4.310E-02	3.800E-02
ZN-65	4.680E+01	4.680E+01	4.680E+01	4.680E+01	4.680E+01	4.680E+01	5.380E+01	4.680E+01
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE-75	2.830E+02	2.830E+02	2.830E+02	2.830E+02	2.830E+02	2.830E+02	3.311E+02	2.830E+02
BR-83	3.050E-04	3.050E-04	3.050E-04	3.050E-04	3.050E-04	3.050E-04	4.430E-04	3.050E-04
BR-84	1.270E-02	1.270E-02	1.270E-02	1.270E-02	1.270E-02	1.270E-02	1.480E-02	1.270E-02
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	5.630E-01	5.630E-01	5.630E-01	5.630E-01	5.630E-01	5.630E-01	6.430E-01	5.630E-01
RB-88	2.070E-03	2.070E-03	2.070E-03	2.070E-03	2.070E-03	2.070E-03	2.370E-03	2.070E-03
RB-89	7.700E-03	7.700E-03	7.700E-03	7.700E-03	7.700E-03	7.700E-03	9.240E-03	7.700E-03
SR-89	1.360E-03	1.360E-03	1.360E-03	1.360E-03	1.360E-03	1.360E-03	1.570E-03	1.360E-03
SR-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μCi/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-91	1.350E-01	1.350E-01	1.350E-01	1.350E-01	1.350E-01	1.350E-01	1.570E-01	1.350E-01
SR-92	4.860E-02	4.860E-02	4.860E-02	4.860E-02	4.860E-02	4.860E-02	5.410E-02	4.860E-02
Y-90	2.810E-04	2.810E-04	2.810E-04	2.810E-04	2.810E-04	2.810E-04	3.320E-04	2.810E-04
Y-91	6.720E-02	6.720E-02	6.720E-02	6.720E-02	6.720E-02	6.720E-02	7.560E-02	6.720E-02
Y-91M	6.280E-03	6.280E-03	6.280E-03	6.280E-03	6.280E-03	6.280E-03	7.270E-03	6.280E-03
Y-92	1.130E-02	1.130E-02	1.130E-02	1.130E-02	1.130E-02	1.130E-02	1.340E-02	1.130E-02
Y-93	1.150E-02	1.150E-02	1.150E-02	1.150E-02	1.150E-02	1.150E-02	1.570E-02	1.150E-02
ZR-95	1.530E+01	1.530E+01	1.530E+01	1.530E+01	1.530E+01	1.530E+01	1.780E+01	1.530E+01
ZR-97	1.850E-01	1.850E-01	1.850E-01	1.850E-01	1.850E-01	1.850E-01	2.160E-01	1.850E-01
NB-95	8.560E+00	8.560E+00	8.560E+00	8.560E+00	8.560E+00	8.560E+00	1.010E+01	8.560E+00
MO-99	2.500E-01	2.500E-01	2.500E-01	2.500E-01	2.500E-01	2.500E-01	2.900E-01	2.500E-01
TC-99M	1.150E-02	1.150E-02	1.150E-02	1.150E-02	1.150E-02	1.150E-02	1.320E-02	1.150E-02
TC-101	1.270E-03	1.270E-03	1.270E-03	1.270E-03	1.270E-03	1.270E-03	1.420E-03	1.270E-03
RU-103	6.780E+00	6.780E+00	6.780E+00	6.780E+00	6.780E+00	6.780E+00	7.910E+00	6.780E+00
RU-105	3.990E-02	3.990E-02	3.990E-02	3.990E-02	3.990E-02	3.990E-02	4.520E-02	3.990E-02
RU-106	2.640E+01	2.640E+01	2.640E+01	2.640E+01	2.640E+01	2.640E+01	3.170E+01	2.640E+01
AG-108M	3.230E+04	3.230E+04	3.230E+04	3.230E+04	3.230E+04	3.230E+04	3.779E+04	3.230E+04
AG-110M	2.150E+02	2.150E+02	2.150E+02	2.150E+02	2.150E+02	2.150E+02	2.510E+02	2.150E+02
SN-113	9.346E+00	9.346E+00	9.346E+00	9.346E+00	9.346E+00	9.346E+00	1.093E+01	9.346E+00
SN-117M	1.306E+01	1.306E+01	1.306E+01	1.306E+01	1.306E+01	1.306E+01	1.528E+01	1.306E+01
SB-124	3.746E+01	3.746E+01	3.746E+01	3.746E+01	3.746E+01	3.746E+01	4.322E+01	3.746E+01
SB-125	1.461E+02	1.461E+02	1.461E+02	1.461E+02	1.461E+02	1.461E+02	1.650E+02	1.461E+02
SB-126	5.284E+00	5.284E+00	5.284E+00	5.284E+00	5.284E+00	5.284E+00	5.937E+00	5.284E+00
TE-123M	1.060E+02	1.060E+02	1.060E+02	1.060E+02	1.060E+02	1.060E+02	1.241E+02	1.060E+02
TE-125M	9.720E-02	9.720E-02	9.720E-02	9.720E-02	9.720E-02	9.720E-02	1.330E-01	9.720E-02

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
TE-127	1.860E-04	1.860E-04	1.860E-04	1.860E-04	1.860E-04	1.860E-04	2.050E-04	1.860E-04
TE-127M	5.740E-03	5.740E-03	5.740E-03	5.740E-03	5.740E-03	5.740E-03	6.780E-03	5.740E-03
TE-129	1.640E-03	1.640E-03	1.640E-03	1.640E-03	1.640E-03	1.640E-03	1.940E-03	1.640E-03
TE-129M	1.240E+00	1.240E+00	1.240E+00	1.240E+00	1.240E+00	1.240E+00	1.450E+00	1.240E+00
TE-131	1.830E-03	1.830E-03	1.830E-03	1.830E-03	1.830E-03	1.830E-03	2.160E+00	1.830E-03
TE-131M	5.030E-01	5.030E-01	5.030E-01	5.030E-01	5.030E-01	5.030E-01	5.920E-01	5.030E-01
TE-132	2.650E-01	2.650E-01	2.650E-01	2.650E-01	2.650E-01	2.650E-01	3.120E-01	2.650E-01
I-130	3.450E-01	3.450E-01	3.450E-01	3.450E-01	3.450E-01	3.450E-01	4.190E-01	3.450E-01
I-131	1.080E+00	1.080E+00	1.080E+00	1.080E+00	1.080E+00	1.080E+00	1.310E+00	1.080E+00
I-132	7.800E-02	7.800E-02	7.800E-02	7.800E-02	7.800E-02	7.800E-02	9.180E-02	7.800E-02
I-133	1.540E-01	1.540E-01	1.540E-01	1.540E-01	1.540E-01	1.540E-01	1.870E-01	1.540E-01
I-134	2.800E-02	2.800E-02	2.800E-02	2.800E-02	2.800E-02	2.800E-02	3.320E-02	2.800E-02
I-135	1.580E-01	1.580E-01	1.580E-01	1.580E-01	1.580E-01	1.580E-01	1.850E-01	1.580E-01
CS-134	4.300E+02	4.300E+02	4.300E+02	4.300E+02	4.300E+02	4.300E+02	5.010E+02	4.300E+02
CS-136	9.450E+00	9.450E+00	9.450E+00	9.450E+00	9.450E+00	9.450E+00	1.070E+01	9.450E+00
CS-137	6.440E+02	6.440E+02	6.440E+02	6.440E+02	6.440E+02	6.440E+02	7.510E+02	6.440E+02
CS-138	2.250E-02	2.250E-02	2.250E-02	2.250E-02	2.250E-02	2.250E-02	2.570E-02	2.250E-02
BA-133	5.521E+03	5.521E+03	5.521E+03	5.521E+03	5.521E+03	5.521E+03	6.459E+03	5.521E+03
BA-139	6.630E-03	6.630E-03	6.630E-03	6.630E-03	6.630E-03	6.630E-03	7.460E-03	6.630E-03
BA-140	1.290E+00	1.290E+00	1.290E+00	1.290E+00	1.290E+00	1.290E+00	1.470E+00	1.290E+00
BA-141	2.610E-03	2.610E-03	2.610E-03	2.610E-03	2.610E-03	2.610E-03	2.980E-03	2.610E-03
BA-142	2.810E-03	2.810E-03	2.810E-03	2.810E-03	2.810E-03	2.810E-03	3.200E-03	2.810E-03
LA-140	1.200E+00	1.200E+00	1.200E+00	1.200E+00	1.200E+00	1.200E+00	1.360E+00	1.200E+00
LA-142	4.760E-02	4.760E-02	4.760E-02	4.760E-02	4.760E-02	4.760E-02	5.710E-02	4.760E-02
CE-141	8.560E-01	8.560E-01	8.560E-01	8.560E-01	8.560E-01	8.560E-01	9.650E-01	8.560E-01

APPENDIX E

A_i Child Dose Factors for use in the Liquid Dose Calculations

Age group:	CHILD	Pathway:	Shoreline Sediment (SHDp)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
CE-143	1.450E-01	1.450E-01	1.450E-01	1.450E-01	1.450E-01	1.450E-01	1.650E-01	1.450E-01
CE-144	4.350E+00	4.350E+00	4.350E+00	4.350E+00	4.350E+00	4.350E+00	5.040E+00	4.350E+00
PR-143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR-144	1.150E-04	1.150E-04	1.150E-04	1.150E-04	1.150E-04	1.150E-04	1.320E-04	1.150E-04
ND-147	5.260E-01	5.260E-01	5.260E-01	5.260E-01	5.260E-01	5.260E-01	6.310E-01	5.260E-01
EU-152	9.305E+02	9.305E+02	9.305E+02	9.305E+02	9.305E+02	9.305E+02	1.077E+03	9.305E+02
W-187	1.470E-01	1.470E-01	1.470E-01	1.470E-01	1.470E-01	1.470E-01	1.710E-01	1.470E-01
NP-239	1.070E-01	1.070E-01	1.070E-01	1.070E-01	1.070E-01	1.070E-01	1.240E-01	1.070E-01

APPENDIX F

A_i Infant Dose Factors for use in the Liquid Dose Calculations

Age group:	INFANT	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.160E+01	1.160E+01	1.160E+01	1.160E+01	1.160E+01	0.000E+00	1.160E+01
C-14	8.920E+02	1.900E+02	1.900E+02	1.900E+02	1.900E+02	1.900E+02	0.000E+00	1.900E+02
NA-24	2.190E+02	2.190E+02	2.190E+02	2.190E+02	2.190E+02	2.190E+02	0.000E+00	2.190E+02
P-32	6.240E+04	3.670E+03	0.000E+00	0.000E+00	0.000E+00	8.450E+02	0.000E+00	2.420E+03
CR-51	0.000E+00	0.000E+00	3.420E-01	7.470E-02	6.650E-01	1.530E+01	0.000E+00	5.240E-01
MN-54	0.000E+00	7.480E+02	0.000E+00	1.660E+02	0.000E+00	2.750E+02	0.000E+00	1.690E+02
MN-56	0.000E+00	1.220E+00	0.000E+00	1.050E+00	0.000E+00	1.110E+02	0.000E+00	2.100E-01
FE-55	5.230E+02	3.380E+02	0.000E+00	0.000E+00	1.650E+02	4.290E+01	0.000E+00	9.030E+01
FE-59	1.150E+03	2.010E+03	0.000E+00	0.000E+00	5.940E+02	9.590E+02	0.000E+00	7.910E+02
CO-58	0.000E+00	1.350E+02	0.000E+00	0.000E+00	0.000E+00	3.360E+02	0.000E+00	3.360E+02
CO-60	0.000E+00	4.060E+02	0.000E+00	0.000E+00	0.000E+00	9.670E+02	0.000E+00	9.590E+02
NI-63	2.390E+04	1.470E+03	0.000E+00	0.000E+00	0.000E+00	7.340E+01	0.000E+00	8.280E+02
NI-65	6.520E+00	7.380E-01	0.000E+00	0.000E+00	0.000E+00	5.620E+01	0.000E+00	3.360E-01
CU-64	0.000E+00	1.190E+01	0.000E+00	2.010E+01	0.000E+00	2.440E+02	0.000E+00	5.500E+00
ZN-65	6.910E+02	2.370E+03	0.000E+00	1.150E+03	0.000E+00	2.000E+03	0.000E+00	1.090E+03
ZN-69	4.390E-04	7.910E-04	0.000E+00	3.290E-04	0.000E+00	6.450E-02	0.000E+00	5.890E-05
SE-75	3.609E+02	1.388E+02	1.388E+02	2.776E+01	3.331E+02	3.886E+02	0.000E+00	2.776E+03
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.200E-01
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.220E-06
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.800E-76
RB-86	0.000E+00	6.280E+03	0.000E+00	0.000E+00	0.000E+00	1.610E+02	0.000E+00	3.100E+03
RB-88	0.000E+00	1.250E-11	0.000E+00	0.000E+00	0.000E+00	1.220E-11	0.000E+00	6.840E-12
RB-89	0.000E+00	9.960E-14	0.000E+00	0.000E+00	0.000E+00	3.390E-14	0.000E+00	6.860E-14
SR-89	9.380E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.930E+03	0.000E+00	2.690E+03
SR-90	6.960E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.690E+03	0.000E+00	1.770E+05

APPENDIX F

A_i Infant Dose Factors for use in the Liquid Dose Calculations

Age group:	INFANT	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-91	7.830E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.270E+02	0.000E+00	2.830E+01
SR-92	3.350E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.610E+02	0.000E+00	1.240E+00
Y-90	2.870E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.970E+03	0.000E+00	7.700E-02
Y-91	4.230E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.030E+03	0.000E+00	1.130E+00
Y-91M	1.350E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.510E-03	0.000E+00	4.610E-08
Y-92	2.740E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.240E+02	0.000E+00	7.710E-04
Y-93	4.010E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.170E+03	0.000E+00	1.090E-02
ZR-95	7.710E+00	1.880E+00	0.000E+00	2.020E+00	0.000E+00	9.350E+02	0.000E+00	1.330E+00
ZR-97	3.400E-01	5.840E-02	0.000E+00	5.890E-02	0.000E+00	3.720E+03	0.000E+00	2.670E-02
NB-95	1.560E+00	6.440E-01	0.000E+00	4.620E-01	0.000E+00	5.440E+02	0.000E+00	3.720E-01
MO-99	0.000E+00	1.130E+03	0.000E+00	1.680E+03	0.000E+00	3.710E+02	0.000E+00	2.200E+02
TC-99M	1.810E-02	3.740E-02	0.000E+00	4.020E-01	1.950E-02	1.090E+01	0.000E+00	4.820E-01
TC-101	4.570E-17	5.750E-17	0.000E+00	6.840E-16	3.140E-17	9.780E-15	0.000E+00	5.690E-16
RU-103	5.520E+01	0.000E+00	0.000E+00	1.150E+02	0.000E+00	6.710E+02	0.000E+00	1.850E+01
RU-105	7.850E-01	0.000E+00	0.000E+00	5.770E+00	0.000E+00	3.120E+02	0.000E+00	2.640E-01
RU-106	9.060E+02	0.000E+00	0.000E+00	1.070E+03	0.000E+00	6.880E+03	0.000E+00	1.130E+02
AG-108M	3.800E+02	1.462E+02	1.462E+02	2.923E+01	3.508E+02	4.092E+02	0.000E+00	2.923E+03
AG-110M	3.740E+01	2.730E+01	0.000E+00	3.910E+01	0.000E+00	1.420E+03	0.000E+00	1.810E+01
SN-113	1.407E+02	5.412E+01	5.412E+01	1.082E+01	1.299E+02	1.515E+02	0.000E+00	1.082E+03
SN-117M	1.358E+02	5.224E+01	5.224E+01	1.045E+01	1.254E+02	1.463E+02	0.000E+00	1.045E+03
SB-124	8.004E+02	1.178E+01	2.125E+00	0.000E+00	5.012E+02	2.469E+03	0.000E+00	2.480E+02
SB-125	4.626E+02	4.475E+00	5.791E-01	0.000E+00	2.903E+02	6.168E+02	0.000E+00	9.515E+01
SB-126	2.949E+02	5.780E+00	2.264E+00	0.000E+00	1.855E+02	3.055E+03	0.000E+00	1.065E+02
TE-123M	3.428E+02	1.319E+02	1.319E+02	2.637E+01	3.164E+02	3.692E+02	0.000E+00	2.637E+03
TE-125M	8.710E+02	2.910E+02	2.930E+02	0.000E+00	0.000E+00	4.150E+02	0.000E+00	1.180E+02

APPENDIX F

A_i Infant Dose Factors for use in the Liquid Dose Calculations

Age group:	INFANT	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μCi/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
TE-127	1.550E+01	5.200E+00	1.260E+01	3.790E+01	0.000E+00	3.260E+02	0.000E+00	3.340E+00
TE-127M	2.190E+03	7.280E+02	6.340E+02	5.400E+03	0.000E+00	8.850E+02	0.000E+00	2.660E+02
TE-129	7.860E-03	2.710E-03	6.590E-03	1.960E-02	0.000E+00	6.280E-01	0.000E+00	1.840E-03
TE-129M	3.720E+03	1.280E+03	1.430E+03	9.310E+03	0.000E+00	2.220E+03	0.000E+00	5.730E+02
TE-131	1.420E-08	5.250E-09	1.270E-08	3.640E-08	0.000E+00	5.750E-07	0.000E+00	3.990E-09
TE-131M	4.330E+02	1.740E+02	3.540E+02	1.200E+03	0.000E+00	2.940E+03	0.000E+00	1.440E+02
TE-132	7.030E+02	3.480E+02	5.140E+02	2.180E+03	0.000E+00	1.290E+03	0.000E+00	3.250E+02
I-130	1.150E+02	2.530E+02	2.840E+04	2.780E+02	0.000E+00	5.430E+01	0.000E+00	1.020E+02
I-131	1.290E+03	1.520E+03	5.010E+05	1.780E+03	0.000E+00	5.440E+01	0.000E+00	6.700E+02
I-132	1.680E+00	3.410E+00	1.600E+02	3.800E+00	0.000E+00	2.760E+00	0.000E+00	1.210E+00
I-133	3.150E+02	4.590E+02	8.350E+04	5.400E+02	0.000E+00	7.770E+01	0.000E+00	1.340E+02
I-134	2.440E-03	4.990E-03	1.160E-01	5.580E-03	0.000E+00	5.160E-03	0.000E+00	1.780E-03
I-135	3.900E+01	7.750E+01	6.950E+03	8.640E+01	0.000E+00	2.800E+01	0.000E+00	2.830E+01
CS-134	1.420E+04	2.640E+04	0.000E+00	6.810E+03	2.790E+03	7.180E+01	0.000E+00	2.670E+03
CS-136	1.680E+03	4.950E+03	0.000E+00	1.970E+03	4.030E+02	7.510E+01	0.000E+00	1.850E+03
CS-137	1.960E+04	2.300E+04	0.000E+00	6.170E+03	2.500E+03	7.190E+01	0.000E+00	1.630E+03
CS-138	3.330E-06	5.410E-06	0.000E+00	2.700E-06	4.210E-07	8.650E-06	0.000E+00	2.620E-06
BA-133	3.981E+02	1.531E+02	1.531E+02	3.062E+01	3.674E+02	4.287E+02	0.000E+00	3.062E+03
BA-139	8.180E-02	5.420E-05	0.000E+00	3.260E-05	3.290E-05	5.180E+00	0.000E+00	2.370E-03
BA-140	6.260E+03	6.260E+00	0.000E+00	1.490E+00	3.840E+00	1.540E+03	0.000E+00	3.230E+02
BA-141	2.220E-11	1.520E-14	0.000E+00	9.140E-15	9.250E-15	2.710E-10	0.000E+00	7.000E-13
BA-142	2.460E-20	2.040E-23	0.000E+00	1.180E-23	1.240E-23	1.010E-19	0.000E+00	1.210E-21
LA-140	6.460E-01	2.550E-01	0.000E+00	0.000E+00	0.000E+00	2.990E+03	0.000E+00	6.550E-02
LA-142	2.220E-04	8.160E-05	0.000E+00	0.000E+00	0.000E+00	1.390E+01	0.000E+00	1.950E-05
CE-141	2.930E+00	1.790E+00	0.000E+00	5.510E-01	0.000E+00	9.230E+02	0.000E+00	2.100E-01

APPENDIX F

A_i Infant Dose Factors for use in the Liquid Dose Calculations

Age group:	INFANT	Pathway:	Potable Water (PWtr)			Units:	mrem/hr / μ Ci/ml	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
CE-143	4.330E-01	2.870E+02	0.000E+00	8.360E-02	0.000E+00	1.670E+03	0.000E+00	3.270E-02
CE-144	1.120E+02	4.580E+01	0.000E+00	1.850E+01	0.000E+00	6.430E+03	0.000E+00	6.270E+00
PR-143	2.980E+00	1.110E+00	0.000E+00	4.140E-01	0.000E+00	1.570E+03	0.000E+00	1.480E-01
PR-144	3.020E-15	1.170E-15	0.000E+00	4.240E-16	0.000E+00	5.440E-11	0.000E+00	1.520E-16
ND-147	2.020E+00	2.070E+00	0.000E+00	7.980E-01	0.000E+00	1.310E+03	0.000E+00	1.270E-01
EU-152	2.535E+01	6.734E+00	0.000E+00	1.888E+01	0.000E+00	5.981E+02	0.000E+00	5.680E+00
W-187	2.400E+01	1.670E+01	0.000E+00	0.000E+00	0.000E+00	9.790E+02	0.000E+00	5.760E+00
NP-239	3.600E-01	3.220E-02	0.000E+00	6.430E-02	0.000E+00	9.320E+02	0.000E+00	1.820E-02

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	7.630E+02	7.630E+02	7.630E+02	7.630E+02	7.630E+02	0.000E+00	7.630E+02
C-14	2.250E+04	4.500E+03	4.500E+03	4.500E+03	4.500E+03	4.500E+03	0.000E+00	4.500E+03
NA-24	2.440E+06	2.440E+06	2.440E+06	2.440E+06	2.440E+06	2.440E+06	0.000E+00	2.440E+06
P-32	1.710E+10	1.060E+09	0.000E+00	0.000E+00	0.000E+00	1.920E+09	0.000E+00	6.610E+08
CR-51	0.000E+00	0.000E+00	1.710E+04	6.300E+03	3.790E+04	7.190E+06	0.000E+00	2.860E+04
MN-54	0.000E+00	8.410E+06	0.000E+00	2.500E+06	0.000E+00	2.580E+07	0.000E+00	1.610E+06
MN-56	0.000E+00	4.090E-03	0.000E+00	5.190E-03	0.000E+00	1.310E-01	0.000E+00	7.260E-04
FE-55	2.510E+07	1.740E+07	0.000E+00	0.000E+00	9.680E+06	9.950E+06	0.000E+00	4.050E+06
FE-59	2.970E+07	6.980E+07	0.000E+00	0.000E+00	1.950E+07	2.330E+08	0.000E+00	2.680E+07
CO-58	0.000E+00	4.710E+06	0.000E+00	0.000E+00	0.000E+00	9.550E+07	0.000E+00	1.060E+07
CO-60	0.000E+00	1.640E+07	0.000E+00	0.000E+00	0.000E+00	3.080E+08	0.000E+00	3.620E+07
NI-63	6.730E+09	4.660E+08	0.000E+00	0.000E+00	0.000E+00	9.730E+07	0.000E+00	2.260E+08
NI-65	3.700E-01	4.810E-02	0.000E+00	0.000E+00	0.000E+00	1.220E+00	0.000E+00	2.190E-02
CU-64	0.000E+00	2.380E+04	0.000E+00	6.010E+04	0.000E+00	2.030E+06	0.000E+00	1.120E+04
ZN-65	1.370E+09	4.370E+09	0.000E+00	2.920E+09	0.000E+00	2.750E+09	0.000E+00	1.970E+09
ZN-69	2.090E-12	4.000E-12	0.000E+00	2.600E-12	0.000E+00	6.010E-13	0.000E+00	2.780E-13
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.400E-01	0.000E+00	9.720E-02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.260E-28	0.000E+00	1.610E-23
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	2.590E+09	0.000E+00	0.000E+00	0.000E+00	5.120E+08	0.000E+00	1.210E+09
RB-88	0.000E+00	2.140E-45	0.000E+00	0.000E+00	0.000E+00	2.960E-56	0.000E+00	1.140E-45
RB-89	0.000E+00	4.330E-53	0.000E+00	0.000E+00	0.000E+00	2.510E-66	0.000E+00	3.040E-53
SR-89	1.450E+09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.330E+08	0.000E+00	4.160E+07
SR-90	4.680E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.350E+09	0.000E+00	1.150E+10
SR-91	2.890E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.380E+05	0.000E+00	1.170E+03

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	4.880E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.680E+00	0.000E+00	2.110E-02
Y-90	7.080E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.510E+05	0.000E+00	1.900E+00
Y-91	8.590E+03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.730E+06	0.000E+00	2.300E+02
Y-91M	5.980E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.760E-19	0.000E+00	2.320E-21
Y-92	5.580E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.770E-01	0.000E+00	1.630E-06
Y-93	2.230E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.090E+03	0.000E+00	6.170E-03
ZR-95	9.430E+02	3.030E+02	0.000E+00	4.750E+02	0.000E+00	9.590E+05	0.000E+00	2.050E+02
ZR-97	4.330E-01	8.740E-02	0.000E+00	1.320E-01	0.000E+00	2.710E+04	0.000E+00	4.000E-02
NB-95	8.260E+04	4.590E+04	0.000E+00	4.540E+04	0.000E+00	2.790E+08	0.000E+00	2.470E+04
MO-99	0.000E+00	2.480E+07	0.000E+00	5.610E+07	0.000E+00	5.740E+07	0.000E+00	4.710E+06
TC-99M	3.320E+00	9.380E+00	0.000E+00	1.420E+02	4.600E+00	5.550E+03	0.000E+00	1.200E+02
TC-101	2.590E-60	3.740E-60	0.000E+00	6.730E-59	1.910E-60	1.120E-71	0.000E+00	3.670E-59
RU-103	1.020E+03	0.000E+00	0.000E+00	3.890E+03	0.000E+00	1.190E+05	0.000E+00	4.390E+02
RU-105	8.570E-04	0.000E+00	0.000E+00	1.110E-02	0.000E+00	5.240E-01	0.000E+00	3.380E-04
RU-106	2.040E+04	0.000E+00	0.000E+00	3.940E+04	0.000E+00	1.320E+06	0.000E+00	2.580E+03
AG-110M	5.820E+07	5.390E+07	0.000E+00	1.060E+08	0.000E+00	2.200E+10	0.000E+00	3.200E+07
TE-125M	1.630E+07	5.900E+06	4.900E+06	6.630E+07	0.000E+00	6.500E+07	0.000E+00	2.180E+06
TE-127	6.530E+02	2.340E+02	4.840E+02	2.660E+03	0.000E+00	5.150E+04	0.000E+00	1.410E+02
TE-127M	4.580E+07	1.640E+07	1.170E+07	1.860E+08	0.000E+00	1.540E+08	0.000E+00	5.580E+06
TE-129	2.830E-10	1.060E-10	2.170E-10	1.190E-09	0.000E+00	2.130E-10	0.000E+00	6.880E-11
TE-129M	6.020E+07	2.250E+07	2.070E+07	2.510E+08	0.000E+00	3.030E+08	0.000E+00	9.530E+06
TE-131	3.600E-33	1.500E-33	2.960E-33	1.580E-32	0.000E+00	5.100E-34	0.000E+00	1.140E-33
TE-131M	3.610E+05	1.770E+05	2.800E+05	1.790E+06	0.000E+00	1.750E+07	0.000E+00	1.470E+05
TE-132	2.400E+06	1.550E+06	1.720E+06	1.500E+07	0.000E+00	7.350E+07	0.000E+00	1.460E+06
I-130	4.200E+05	1.240E+06	1.050E+08	1.930E+06	0.000E+00	1.070E+06	0.000E+00	4.890E+05

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	2.960E+08	4.230E+08	1.390E+11	7.260E+08	0.000E+00	1.120E+08	0.000E+00	2.430E+08
I-132	1.640E-01	4.390E-01	1.540E+01	7.000E-01	0.000E+00	8.250E-02	0.000E+00	1.540E-01
I-133	3.870E+06	6.730E+06	9.890E+08	1.170E+07	0.000E+00	6.050E+06	0.000E+00	2.050E+06
I-134	2.020E-12	5.480E-12	9.490E-11	8.710E-12	0.000E+00	4.770E-15	0.000E+00	1.960E-12
I-135	1.280E+04	3.360E+04	2.220E+06	5.390E+04	0.000E+00	3.800E+04	0.000E+00	1.240E+04
CS-134	5.650E+09	1.350E+10	0.000E+00	4.350E+09	1.450E+09	2.350E+08	0.000E+00	1.100E+10
CS-136	2.630E+08	1.040E+09	0.000E+00	5.780E+08	7.930E+07	1.180E+08	0.000E+00	7.480E+08
CS-137	7.380E+09	1.010E+10	0.000E+00	3.430E+09	1.140E+09	1.950E+08	0.000E+00	6.610E+09
CS-138	9.050E-24	1.790E-23	0.000E+00	1.310E-23	1.300E-24	7.620E-29	0.000E+00	8.850E-24
BA-139	4.420E-08	3.150E-11	0.000E+00	2.940E-11	1.790E-11	7.830E-08	0.000E+00	1.290E-09
BA-140	2.690E+07	3.380E+04	0.000E+00	1.150E+04	1.930E+04	5.530E+07	0.000E+00	1.760E+06
BA-141	4.090E-46	3.090E-49	0.000E+00	2.880E-49	1.760E-49	1.930E-55	0.000E+00	1.380E-47
BA-142	2.640E-80	2.720E-83	0.000E+00	2.300E-83	1.540E-83	3.720E-98	0.000E+00	1.660E-81
LA-140	4.510E+00	2.270E+00	0.000E+00	0.000E+00	0.000E+00	1.670E+05	0.000E+00	6.010E-01
LA-142	1.860E-11	8.460E-12	0.000E+00	0.000E+00	0.000E+00	6.170E-08	0.000E+00	2.110E-12
CE-141	4.840E+03	3.280E+03	0.000E+00	1.520E+03	0.000E+00	1.250E+07	0.000E+00	3.720E+02
CE-143	4.160E+01	3.070E+04	0.000E+00	1.350E+01	0.000E+00	1.150E+06	0.000E+00	3.400E+00
CE-144	3.580E+05	1.500E+05	0.000E+00	8.870E+04	0.000E+00	1.210E+08	0.000E+00	1.920E+04
PR-143	1.580E+02	6.330E+01	0.000E+00	3.660E+01	0.000E+00	6.920E+05	0.000E+00	7.830E+00
PR-144	5.870E-54	2.440E-54	0.000E+00	1.380E-54	0.000E+00	8.450E-61	0.000E+00	2.990E-55
ND-147	9.420E+01	1.090E+02	0.000E+00	6.360E+01	0.000E+00	5.220E+05	0.000E+00	6.510E+00
W-187	6.510E+03	5.450E+03	0.000E+00	0.000E+00	0.000E+00	1.780E+06	0.000E+00	1.900E+03
NP-239	3.670E+00	3.610E-01	0.000E+00	1.130E+00	0.000E+00	7.410E+04	0.000E+00	1.990E-01

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.560E+03	1.560E+03	1.560E+03	1.560E+03	1.560E+03	0.000E+00	1.560E+03
C-14	2.250E+04	4.500E+03	4.500E+03	4.500E+03	4.500E+03	4.500E+03	0.000E+00	4.500E+03
NA-24	2.930E+05	2.930E+05	2.930E+05	2.930E+05	2.930E+05	2.930E+05	0.000E+00	2.930E+05
P-32	2.050E+10	1.280E+09	0.000E+00	0.000E+00	0.000E+00	2.310E+09	0.000E+00	7.930E+08
CR-51	0.000E+00	0.000E+00	2.050E+03	7.550E+02	4.550E+03	8.620E+05	0.000E+00	3.430E+03
MN-54	0.000E+00	1.010E+06	0.000E+00	3.000E+05	0.000E+00	3.090E+06	0.000E+00	1.930E+05
MN-56	0.000E+00	4.910E-04	0.000E+00	6.230E-04	0.000E+00	1.570E-02	0.000E+00	8.710E-05
FE-55	3.260E+05	2.260E+05	0.000E+00	0.000E+00	1.260E+05	1.290E+05	0.000E+00	5.260E+04
FE-59	3.860E+05	9.070E+05	0.000E+00	0.000E+00	2.540E+05	3.020E+06	0.000E+00	3.480E+05
CO-58	0.000E+00	5.660E+05	0.000E+00	0.000E+00	0.000E+00	1.150E+07	0.000E+00	1.270E+06
CO-60	0.000E+00	1.970E+06	0.000E+00	0.000E+00	0.000E+00	3.700E+07	0.000E+00	4.340E+06
NI-63	8.070E+08	5.600E+07	0.000E+00	0.000E+00	0.000E+00	1.170E+07	0.000E+00	2.710E+07
NI-65	4.440E-02	5.770E-03	0.000E+00	0.000E+00	0.000E+00	1.460E-01	0.000E+00	2.630E-03
CU-64	0.000E+00	2.660E+03	0.000E+00	6.700E+03	0.000E+00	2.260E+05	0.000E+00	1.250E+03
ZN-65	1.650E+08	5.240E+08	0.000E+00	3.500E+08	0.000E+00	3.300E+08	0.000E+00	2.370E+08
ZN-69	2.510E-13	4.800E-13	0.000E+00	3.120E-13	0.000E+00	7.210E-14	0.000E+00	3.340E-14
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.680E-02	0.000E+00	1.170E-02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.520E-29	0.000E+00	1.930E-24
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	3.110E+08	0.000E+00	0.000E+00	0.000E+00	6.140E+07	0.000E+00	1.450E+08
RB-88	0.000E+00	2.570E-46	0.000E+00	0.000E+00	0.000E+00	3.550E-57	0.000E+00	1.360E-46
RB-89	0.000E+00	5.190E-54	0.000E+00	0.000E+00	0.000E+00	3.020E-67	0.000E+00	3.650E-54
SR-89	3.050E+09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.890E+08	0.000E+00	8.750E+07
SR-90	9.830E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.840E+09	0.000E+00	2.410E+10
SR-91	6.070E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.890E+05	0.000E+00	2.450E+03

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	1.030E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.030E+01	0.000E+00	4.440E-02
Y-90	8.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.010E+04	0.000E+00	2.280E-01
Y-91	1.030E+03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.670E+05	0.000E+00	2.760E+01
Y-91M	7.170E-21	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.110E-20	0.000E+00	2.780E-22
Y-92	6.690E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.170E-01	0.000E+00	1.960E-07
Y-93	2.680E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.500E+02	0.000E+00	7.400E-04
ZR-95	1.130E+02	3.630E+01	0.000E+00	5.700E+01	0.000E+00	1.150E+05	0.000E+00	2.460E+01
ZR-97	5.200E-02	1.050E-02	0.000E+00	1.580E-02	0.000E+00	3.250E+03	0.000E+00	4.800E-03
NB-95	9.910E+03	5.510E+03	0.000E+00	5.450E+03	0.000E+00	3.340E+07	0.000E+00	2.960E+03
MO-99	0.000E+00	2.970E+06	0.000E+00	6.730E+06	0.000E+00	6.890E+06	0.000E+00	5.660E+05
TC-99M	3.980E-01	1.130E+00	0.000E+00	1.710E+01	5.520E-01	6.660E+02	0.000E+00	1.430E+01
TC-101	3.110E-61	4.490E-61	0.000E+00	8.080E-60	2.290E-61	1.350E-72	0.000E+00	4.400E-60
RU-103	1.220E+02	0.000E+00	0.000E+00	4.660E+02	0.000E+00	1.430E+04	0.000E+00	5.260E+01
RU-105	1.030E-04	0.000E+00	0.000E+00	1.330E-03	0.000E+00	6.290E-02	0.000E+00	4.060E-05
RU-106	2.450E+03	0.000E+00	0.000E+00	4.730E+03	0.000E+00	1.580E+05	0.000E+00	3.100E+02
AG-110M	6.990E+06	6.460E+06	0.000E+00	1.270E+07	0.000E+00	2.640E+09	0.000E+00	3.840E+06
TE-125M	1.950E+06	7.080E+05	5.880E+05	7.950E+06	0.000E+00	7.800E+06	0.000E+00	2.620E+05
TE-127	7.830E+01	2.810E+01	5.800E+01	3.190E+02	0.000E+00	6.180E+03	0.000E+00	1.700E+01
TE-127M	5.490E+06	1.960E+06	1.400E+06	2.230E+07	0.000E+00	1.840E+07	0.000E+00	6.690E+05
TE-129	3.390E-11	1.270E-11	2.600E-11	1.430E-10	0.000E+00	2.560E-11	0.000E+00	8.260E-12
TE-129M	7.220E+06	2.690E+06	2.480E+06	3.020E+07	0.000E+00	3.640E+07	0.000E+00	1.140E+06
TE-131	4.320E-34	1.810E-34	3.550E-34	1.890E-33	0.000E+00	6.120E-35	0.000E+00	1.360E-34
TE-131M	4.330E+04	2.120E+04	3.360E+04	2.150E+05	0.000E+00	2.100E+06	0.000E+00	1.770E+04
TE-132	2.880E+05	1.860E+05	2.060E+05	1.800E+06	0.000E+00	8.820E+06	0.000E+00	1.750E+05
I-130	5.040E+05	1.490E+06	1.260E+08	2.320E+06	0.000E+00	1.280E+06	0.000E+00	5.870E+05

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	3.550E+08	5.080E+08	1.670E+11	8.710E+08	0.000E+00	1.340E+08	0.000E+00	2.910E+08
I-132	1.970E-01	5.270E-01	1.840E+01	8.400E-01	0.000E+00	9.900E-02	0.000E+00	1.840E-01
I-133	4.640E+06	8.080E+06	1.190E+09	1.410E+07	0.000E+00	7.260E+06	0.000E+00	2.460E+06
I-134	2.420E-12	6.570E-12	1.140E-10	1.050E-11	0.000E+00	5.730E-15	0.000E+00	2.350E-12
I-135	1.540E+04	4.030E+04	2.660E+06	6.470E+04	0.000E+00	4.560E+04	0.000E+00	1.490E+04
CS-134	1.700E+10	4.040E+10	0.000E+00	1.310E+10	4.340E+09	7.060E+08	0.000E+00	3.300E+10
CS-136	7.900E+08	3.120E+09	0.000E+00	1.730E+09	2.380E+08	3.540E+08	0.000E+00	2.240E+09
CS-137	2.210E+10	3.030E+10	0.000E+00	1.030E+10	3.420E+09	5.860E+08	0.000E+00	1.980E+10
CS-138	2.710E-23	5.360E-23	0.000E+00	3.940E-23	3.890E-24	2.290E-28	0.000E+00	2.650E-23
BA-139	5.300E-09	3.780E-12	0.000E+00	3.530E-12	2.140E-12	9.400E-09	0.000E+00	1.550E-10
BA-140	3.230E+06	4.050E+03	0.000E+00	1.380E+03	2.320E+03	6.640E+06	0.000E+00	2.110E+05
BA-141	4.910E-47	3.710E-50	0.000E+00	3.450E-50	2.110E-50	2.310E-56	0.000E+00	1.660E-48
BA-142	3.170E-81	3.260E-84	0.000E+00	2.750E-84	1.850E-84	0.000E+00	0.000E+00	2.000E-82
LA-140	5.410E-01	2.730E-01	0.000E+00	0.000E+00	0.000E+00	2.000E+04	0.000E+00	7.210E-02
LA-142	2.230E-12	1.010E-12	0.000E+00	0.000E+00	0.000E+00	7.410E-09	0.000E+00	2.530E-13
CE-141	5.810E+02	3.930E+02	0.000E+00	1.830E+02	0.000E+00	1.500E+06	0.000E+00	4.460E+01
CE-143	4.990E+00	3.690E+03	0.000E+00	1.620E+00	0.000E+00	1.380E+05	0.000E+00	4.080E-01
CE-144	4.290E+04	1.790E+04	0.000E+00	1.060E+04	0.000E+00	1.450E+07	0.000E+00	2.300E+03
PR-143	1.890E+01	7.600E+00	0.000E+00	4.390E+00	0.000E+00	8.300E+04	0.000E+00	9.390E-01
PR-144	7.050E-55	2.930E-55	0.000E+00	1.650E-55	0.000E+00	1.010E-61	0.000E+00	3.580E-56
ND-147	1.130E+01	1.310E+01	0.000E+00	7.630E+00	0.000E+00	6.270E+04	0.000E+00	7.810E-01
W-187	7.820E+02	6.530E+02	0.000E+00	0.000E+00	0.000E+00	2.140E+05	0.000E+00	2.280E+02
NP-239	4.410E-01	4.330E-02	0.000E+00	1.350E-01	0.000E+00	8.890E+03	0.000E+00	2.390E-02

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Age group:	ADULT	Pathway:	Grs/Cow/Meat (CMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	3.250E+02	3.250E+02	3.250E+02	3.250E+02	3.250E+02	0.000E+00	3.250E+02
C-14	2.060E+04	4.130E+03	4.130E+03	4.130E+03	4.130E+03	4.130E+03	0.000E+00	4.130E+03
NA-24	1.360E-03	1.360E-03	1.360E-03	1.360E-03	1.360E-03	1.360E-03	0.000E+00	1.360E-03
P-32	4.660E+09	2.900E+08	0.000E+00	0.000E+00	0.000E+00	5.240E+08	0.000E+00	1.800E+08
CR-51	0.000E+00	0.000E+00	4.210E+03	1.550E+03	9.350E+03	1.770E+06	0.000E+00	7.050E+03
MN-54	0.000E+00	9.180E+06	0.000E+00	2.730E+06	0.000E+00	2.810E+07	0.000E+00	1.750E+06
MN-56	0.000E+00	1.320E-53	0.000E+00	1.680E-53	0.000E+00	4.220E-52	0.000E+00	2.350E-54
FE-55	2.930E+08	2.030E+08	0.000E+00	0.000E+00	1.130E+08	1.160E+08	0.000E+00	4.720E+07
FE-59	2.660E+08	6.240E+08	0.000E+00	0.000E+00	1.740E+08	2.080E+09	0.000E+00	2.390E+08
CO-58	0.000E+00	1.820E+07	0.000E+00	0.000E+00	0.000E+00	3.690E+08	0.000E+00	4.090E+07
CO-60	0.000E+00	7.520E+07	0.000E+00	0.000E+00	0.000E+00	1.410E+09	0.000E+00	1.660E+08
NI-63	1.890E+10	1.310E+09	0.000E+00	0.000E+00	0.000E+00	2.730E+08	0.000E+00	6.330E+08
NI-65	2.250E-52	2.920E-53	0.000E+00	0.000E+00	0.000E+00	7.400E-52	0.000E+00	1.330E-53
CU-64	0.000E+00	2.710E-07	0.000E+00	6.830E-07	0.000E+00	2.310E-05	0.000E+00	1.270E-07
ZN-65	3.560E+08	1.130E+09	0.000E+00	7.570E+08	0.000E+00	7.130E+08	0.000E+00	5.120E+08
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.650E-57	0.000E+00	6.000E-57
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	4.870E+08	0.000E+00	0.000E+00	0.000E+00	9.600E+07	0.000E+00	2.270E+08
RB-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-89	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-89	3.020E+08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.840E+07	0.000E+00	8.660E+06
SR-90	1.240E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.590E+08	0.000E+00	3.050E+09
SR-91	1.520E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.240E-10	0.000E+00	6.140E-12

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Age group:	ADULT	Pathway:	Grs/Cow/Meat (CMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	1.180E-49	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.340E-48	0.000E+00	5.100E-51
Y-90	1.080E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.140E+06	0.000E+00	2.890E+00
Y-91	1.130E+06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.230E+08	0.000E+00	3.030E+04
Y-91M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Y-92	1.520E-39	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.660E-35	0.000E+00	4.430E-41
Y-93	4.690E-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.490E-07	0.000E+00	1.300E-13
ZR-95	1.870E+06	6.010E+05	0.000E+00	9.420E+05	0.000E+00	1.900E+09	0.000E+00	4.070E+05
ZR-97	2.070E-05	4.170E-06	0.000E+00	6.300E-06	0.000E+00	1.290E+00	0.000E+00	1.910E-06
NB-95	2.300E+06	1.280E+06	0.000E+00	1.260E+06	0.000E+00	7.760E+09	0.000E+00	6.870E+05
MO-99	0.000E+00	1.000E+05	0.000E+00	2.260E+05	0.000E+00	2.320E+05	0.000E+00	1.900E+04
TC-99M	4.450E-21	1.260E-20	0.000E+00	1.910E-19	6.150E-21	7.430E-18	0.000E+00	1.600E-19
TC-101	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU-103	1.050E+08	0.000E+00	0.000E+00	4.010E+08	0.000E+00	1.230E+10	0.000E+00	4.530E+07
RU-105	5.780E-28	0.000E+00	0.000E+00	7.460E-27	0.000E+00	3.530E-25	0.000E+00	2.280E-28
RU-106	2.800E+09	0.000E+00	0.000E+00	5.400E+09	0.000E+00	1.810E+11	0.000E+00	3.540E+08
AG-110M	6.680E+06	6.180E+06	0.000E+00	1.220E+07	0.000E+00	2.520E+09	0.000E+00	3.670E+06
TE-125M	3.590E+08	1.300E+08	1.080E+08	1.460E+09	0.000E+00	1.430E+09	0.000E+00	4.810E+07
TE-127	2.120E-10	7.610E-11	1.570E-10	8.640E-10	0.000E+00	1.670E-08	0.000E+00	4.590E-11
TE-127M	1.120E+09	3.990E+08	2.850E+08	4.530E+09	0.000E+00	3.740E+09	0.000E+00	1.360E+08
TE-129	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-129M	1.130E+09	4.230E+08	3.900E+08	4.730E+09	0.000E+00	5.710E+09	0.000E+00	1.790E+08
TE-131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-131M	4.510E+02	2.210E+02	3.490E+02	2.230E+03	0.000E+00	2.190E+04	0.000E+00	1.840E+02
TE-132	1.420E+06	9.180E+05	1.010E+06	8.840E+06	0.000E+00	4.340E+07	0.000E+00	8.620E+05
I-130	2.110E-06	6.220E-06	5.270E-04	9.700E-06	0.000E+00	5.350E-06	0.000E+00	2.450E-06

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Age group:	ADULT	Pathway:	Grs/Cow/Meat (CMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.070E+07	1.540E+07	5.030E+09	2.630E+07	0.000E+00	4.050E+06	0.000E+00	8.800E+06
I-132	6.970E-59	1.860E-58	6.530E-57	2.970E-58	0.000E+00	3.500E-59	0.000E+00	6.530E-59
I-133	3.650E-01	6.350E-01	9.340E+01	1.110E+00	0.000E+00	5.710E-01	0.000E+00	1.940E-01
I-134	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I-135	4.420E-17	1.160E-16	7.640E-15	1.860E-16	0.000E+00	1.310E-16	0.000E+00	4.270E-17
CS-134	6.580E+08	1.560E+09	0.000E+00	5.060E+08	1.680E+08	2.740E+07	0.000E+00	1.280E+09
CS-136	1.210E+07	4.760E+07	0.000E+00	2.650E+07	3.630E+06	5.410E+06	0.000E+00	3.420E+07
CS-137	8.720E+08	1.190E+09	0.000E+00	4.050E+08	1.350E+08	2.310E+07	0.000E+00	7.810E+08
CS-138	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-139	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-140	2.870E+07	3.610E+04	0.000E+00	1.230E+04	2.070E+04	5.920E+07	0.000E+00	1.880E+06
BA-141	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-142	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA-140	3.710E-02	1.870E-02	0.000E+00	0.000E+00	0.000E+00	1.370E+03	0.000E+00	4.940E-03
LA-142	3.470E-92	1.580E-92	0.000E+00	0.000E+00	0.000E+00	1.150E-88	0.000E+00	3.940E-93
CE-141	1.400E+04	9.500E+03	0.000E+00	4.410E+03	0.000E+00	3.630E+07	0.000E+00	1.080E+03
CE-143	2.010E-02	1.480E+01	0.000E+00	6.530E-03	0.000E+00	5.550E+02	0.000E+00	1.640E-03
CE-144	1.460E+06	6.090E+05	0.000E+00	3.610E+05	0.000E+00	4.930E+08	0.000E+00	7.830E+04
PR-143	2.100E+04	8.410E+03	0.000E+00	4.850E+03	0.000E+00	9.180E+07	0.000E+00	1.040E+03
PR-144	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ND-147	7.070E+03	8.170E+03	0.000E+00	4.780E+03	0.000E+00	3.920E+07	0.000E+00	4.890E+02
W-187	2.070E-02	1.730E-02	0.000E+00	0.000E+00	0.000E+00	5.660E+00	0.000E+00	6.040E-03
NP-239	2.590E-01	2.550E-02	0.000E+00	7.950E-02	0.000E+00	5.230E+03	0.000E+00	1.400E-02

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Age group:	ADULT	Pathway:	Grs/Goat/Meat (GMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	3.900E+01	3.900E+01	3.900E+01	3.900E+01	3.900E+01	0.000E+00	3.900E+01
C-14	2.472E+03	4.956E+02	4.956E+02	4.956E+02	4.956E+02	4.956E+02	0.000E+00	4.956E+02
NA-24	1.632E-04	1.632E-04	1.632E-04	1.632E-04	1.632E-04	1.632E-04	0.000E+00	1.632E-04
P-32	5.592E+08	3.480E+07	0.000E+00	0.000E+00	0.000E+00	6.288E+07	0.000E+00	2.160E+07
CR-51	0.000E+00	0.000E+00	5.052E+02	1.860E+02	1.122E+03	2.124E+05	0.000E+00	8.460E+02
MN-54	0.000E+00	1.102E+06	0.000E+00	3.276E+05	0.000E+00	3.372E+06	0.000E+00	2.100E+05
MN-56	0.000E+00	1.584E-54	0.000E+00	2.016E-54	0.000E+00	5.064E-53	0.000E+00	2.820E-55
FE-55	3.516E+07	2.436E+07	0.000E+00	0.000E+00	1.356E+07	1.392E+07	0.000E+00	5.664E+06
FE-59	3.192E+07	7.488E+07	0.000E+00	0.000E+00	2.088E+07	2.496E+08	0.000E+00	2.868E+07
CO-58	0.000E+00	2.184E+06	0.000E+00	0.000E+00	0.000E+00	4.428E+07	0.000E+00	4.908E+06
CO-60	0.000E+00	9.024E+06	0.000E+00	0.000E+00	0.000E+00	1.692E+08	0.000E+00	1.992E+07
NI-63	2.268E+09	1.572E+08	0.000E+00	0.000E+00	0.000E+00	3.276E+07	0.000E+00	7.596E+07
NI-65	2.700E-53	3.504E-54	0.000E+00	0.000E+00	0.000E+00	8.880E-53	0.000E+00	1.596E-54
CU-64	0.000E+00	3.252E-08	0.000E+00	8.196E-08	0.000E+00	2.772E-06	0.000E+00	1.524E-08
ZN-65	4.272E+07	1.356E+08	0.000E+00	9.084E+07	0.000E+00	8.556E+07	0.000E+00	6.144E+07
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.038E-57	0.000E+00	7.200E-58
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	5.844E+07	0.000E+00	0.000E+00	0.000E+00	1.152E+07	0.000E+00	2.724E+07
RB-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-89	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-89	3.624E+07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.808E+06	0.000E+00	1.039E+06
SR-90	1.488E+09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.308E+07	0.000E+00	3.660E+08
SR-91	1.824E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.688E-11	0.000E+00	7.368E-13

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Age group:	ADULT	Pathway:	Grs/Goat/Meat (GMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	1.416E-50	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.808E-49	0.000E+00	6.120E-52
Y-90	1.296E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.368E+05	0.000E+00	3.468E-01
Y-91	1.356E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.476E+07	0.000E+00	3.636E+03
Y-91M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Y-92	1.824E-40	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.192E-36	0.000E+00	5.316E-42
Y-93	5.628E-13	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.788E-08	0.000E+00	1.560E-14
ZR-95	2.244E+05	7.212E+04	0.000E+00	1.130E+05	0.000E+00	2.280E+08	0.000E+00	4.884E+04
ZR-97	2.484E-06	5.004E-07	0.000E+00	7.560E-07	0.000E+00	1.548E-01	0.000E+00	2.292E-07
NB-95	2.760E+05	1.536E+05	0.000E+00	1.512E+05	0.000E+00	9.312E+08	0.000E+00	8.244E+04
MO-99	0.000E+00	1.200E+04	0.000E+00	2.712E+04	0.000E+00	2.784E+04	0.000E+00	2.280E+03
TC-99M	5.340E-22	1.512E-21	0.000E+00	2.292E-20	7.380E-22	8.916E-19	0.000E+00	1.920E-20
TC-101	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU-103	1.260E+07	0.000E+00	0.000E+00	4.812E+07	0.000E+00	1.476E+09	0.000E+00	5.436E+06
RU-105	6.936E-29	0.000E+00	0.000E+00	8.952E-28	0.000E+00	4.236E-26	0.000E+00	2.736E-29
RU-106	3.360E+08	0.000E+00	0.000E+00	6.480E+08	0.000E+00	2.172E+10	0.000E+00	4.248E+07
AG-110M	8.016E+05	7.416E+05	0.000E+00	1.464E+06	0.000E+00	3.024E+08	0.000E+00	4.404E+05
TE-125M	4.308E+07	1.560E+07	1.296E+07	1.752E+08	0.000E+00	1.716E+08	0.000E+00	5.772E+06
TE-127	2.544E-11	9.132E-12	1.884E-11	1.037E-10	0.000E+00	2.004E-09	0.000E+00	5.508E-12
TE-127M	1.344E+08	4.788E+07	3.420E+07	5.436E+08	0.000E+00	4.488E+08	0.000E+00	1.632E+07
TE-129	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-129M	1.356E+08	5.076E+07	4.680E+07	5.676E+08	0.000E+00	6.852E+08	0.000E+00	2.148E+07
TE-131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-131M	5.412E+01	2.652E+01	4.188E+01	2.676E+02	0.000E+00	2.628E+03	0.000E+00	2.208E+01
TE-132	1.704E+05	1.102E+05	1.212E+05	1.061E+06	0.000E+00	5.208E+06	0.000E+00	1.034E+05
I-130	2.532E-07	7.464E-07	6.324E-05	1.164E-06	0.000E+00	6.420E-07	0.000E+00	2.940E-07

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Age group:	ADULT	Pathway:	Grs/Goat/Meat (GMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.284E+06	1.848E+06	6.036E+08	3.156E+06	0.000E+00	4.860E+05	0.000E+00	1.056E+06
I-132	8.364E-60	2.232E-59	7.836E-58	3.564E-59	0.000E+00	4.200E-60	0.000E+00	7.836E-60
I-133	4.380E-02	7.620E-02	1.121E+01	1.332E-01	0.000E+00	6.852E-02	0.000E+00	2.328E-02
I-134	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I-135	5.304E-18	1.392E-17	9.168E-16	2.232E-17	0.000E+00	1.572E-17	0.000E+00	5.124E-18
CS-134	7.896E+07	1.872E+08	0.000E+00	6.072E+07	2.016E+07	3.288E+06	0.000E+00	1.536E+08
CS-136	1.452E+06	5.712E+06	0.000E+00	3.180E+06	4.356E+05	6.492E+05	0.000E+00	4.104E+06
CS-137	1.046E+08	1.428E+08	0.000E+00	4.860E+07	1.620E+07	2.772E+06	0.000E+00	9.372E+07
CS-138	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-139	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-140	3.444E+06	4.332E+03	0.000E+00	1.476E+03	2.484E+03	7.104E+06	0.000E+00	2.256E+05
BA-141	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-142	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA-140	4.452E-03	2.244E-03	0.000E+00	0.000E+00	0.000E+00	1.644E+02	0.000E+00	5.928E-04
LA-142	4.164E-93	1.896E-93	0.000E+00	0.000E+00	0.000E+00	1.380E-89	0.000E+00	4.728E-94
CE-141	1.680E+03	1.140E+03	0.000E+00	5.292E+02	0.000E+00	4.356E+06	0.000E+00	1.296E+02
CE-143	2.412E-03	1.776E+00	0.000E+00	7.836E-04	0.000E+00	6.660E+01	0.000E+00	1.968E-04
CE-144	1.752E+05	7.308E+04	0.000E+00	4.332E+04	0.000E+00	5.916E+07	0.000E+00	9.396E+03
PR-143	2.520E+03	1.009E+03	0.000E+00	5.820E+02	0.000E+00	1.102E+07	0.000E+00	1.248E+02
PR-144	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ND-147	8.484E+02	9.804E+02	0.000E+00	5.736E+02	0.000E+00	4.704E+06	0.000E+00	5.868E+01
W-187	2.484E-03	2.076E-03	0.000E+00	0.000E+00	0.000E+00	6.792E-01	0.000E+00	7.248E-04
NP-239	3.108E-02	3.060E-03	0.000E+00	9.540E-03	0.000E+00	6.276E+02	0.000E+00	1.680E-03

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Vegetation (VEG)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	2.260E+03	2.260E+03	2.260E+03	2.260E+03	2.260E+03	0.000E+00	2.260E+03
C-14	5.560E+04	1.110E+04	1.110E+04	1.110E+04	1.110E+04	1.110E+04	0.000E+00	1.110E+04
NA-24	2.690E+05	2.690E+05	2.690E+05	2.690E+05	2.690E+05	2.690E+05	0.000E+00	2.690E+05
P-32	1.400E+09	8.730E+07	0.000E+00	0.000E+00	0.000E+00	1.580E+08	0.000E+00	5.430E+07
CR-51	0.000E+00	0.000E+00	2.780E+04	1.020E+04	6.160E+04	1.170E+07	0.000E+00	4.640E+04
MN-54	0.000E+00	3.130E+08	0.000E+00	9.310E+07	0.000E+00	9.590E+08	0.000E+00	5.970E+07
MN-56	0.000E+00	1.580E+01	0.000E+00	2.000E+01	0.000E+00	5.040E+02	0.000E+00	2.800E+00
FE-55	2.100E+08	1.450E+08	0.000E+00	0.000E+00	8.080E+07	8.310E+07	0.000E+00	3.380E+07
FE-59	1.260E+08	2.960E+08	0.000E+00	0.000E+00	8.280E+07	9.880E+08	0.000E+00	1.140E+08
CO-58	0.000E+00	3.070E+07	0.000E+00	0.000E+00	0.000E+00	6.230E+08	0.000E+00	6.890E+07
CO-60	0.000E+00	1.670E+08	0.000E+00	0.000E+00	0.000E+00	3.140E+09	0.000E+00	3.690E+08
NI-63	1.040E+10	7.210E+08	0.000E+00	0.000E+00	0.000E+00	1.500E+08	0.000E+00	3.490E+08
NI-65	6.150E+01	7.990E+00	0.000E+00	0.000E+00	0.000E+00	2.030E+02	0.000E+00	3.640E+00
CU-64	0.000E+00	9.200E+03	0.000E+00	2.320E+04	0.000E+00	7.840E+05	0.000E+00	4.320E+03
ZN-65	3.170E+08	1.010E+09	0.000E+00	6.750E+08	0.000E+00	6.360E+08	0.000E+00	4.560E+08
ZN-69	5.490E-06	1.050E-05	0.000E+00	6.830E-06	0.000E+00	1.580E-06	0.000E+00	7.310E-07
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.470E+00	0.000E+00	3.110E+00
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.940E-16	0.000E+00	2.480E-11
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	2.190E+08	0.000E+00	0.000E+00	0.000E+00	4.330E+07	0.000E+00	1.020E+08
RB-88	0.000E+00	3.430E-22	0.000E+00	0.000E+00	0.000E+00	4.740E-33	0.000E+00	1.820E-22
RB-89	0.000E+00	3.890E-26	0.000E+00	0.000E+00	0.000E+00	2.260E-39	0.000E+00	2.730E-26
SR-89	9.970E+09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.600E+09	0.000E+00	2.860E+08
SR-90	6.050E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.750E+10	0.000E+00	1.480E+11
SR-91	3.050E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.450E+06	0.000E+00	1.230E+04

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Vegetation (VEG)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	4.270E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.450E+03	0.000E+00	1.850E+01
Y-90	1.330E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.410E+08	0.000E+00	3.570E+02
Y-91	5.110E+06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.810E+09	0.000E+00	1.370E+05
Y-91M	5.220E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.530E-08	0.000E+00	2.020E-10
Y-92	9.150E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.600E+04	0.000E+00	2.680E-02
Y-93	1.700E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.380E+06	0.000E+00	4.680E+00
ZR-95	1.170E+06	3.770E+05	0.000E+00	5.910E+05	0.000E+00	1.190E+09	0.000E+00	2.550E+05
ZR-97	3.370E+02	6.810E+01	0.000E+00	1.030E+02	0.000E+00	2.110E+07	0.000E+00	3.110E+01
NB-95	1.420E+05	7.920E+04	0.000E+00	7.830E+04	0.000E+00	4.810E+08	0.000E+00	4.260E+04
MO-99	0.000E+00	6.150E+06	0.000E+00	1.390E+07	0.000E+00	1.430E+07	0.000E+00	1.170E+06
TC-99M	3.100E+00	8.770E+00	0.000E+00	1.330E+02	4.300E+00	5.190E+03	0.000E+00	1.120E+02
TC-101	8.220E-31	1.180E-30	0.000E+00	2.130E-29	6.050E-31	3.560E-42	0.000E+00	1.160E-29
RU-103	4.770E+06	0.000E+00	0.000E+00	1.820E+07	0.000E+00	5.570E+08	0.000E+00	2.060E+06
RU-105	5.390E+01	0.000E+00	0.000E+00	6.960E+02	0.000E+00	3.290E+04	0.000E+00	2.130E+01
RU-106	1.930E+08	0.000E+00	0.000E+00	3.720E+08	0.000E+00	1.250E+10	0.000E+00	2.440E+07
AG-110M	1.050E+07	9.750E+06	0.000E+00	1.920E+07	0.000E+00	3.980E+09	0.000E+00	5.790E+06
TE-125M	9.660E+07	3.500E+07	2.900E+07	3.930E+08	0.000E+00	3.860E+08	0.000E+00	1.290E+07
TE-127	5.660E+03	2.030E+03	4.190E+03	2.310E+04	0.000E+00	4.470E+05	0.000E+00	1.220E+03
TE-127M	3.490E+08	1.250E+08	8.920E+07	1.420E+09	0.000E+00	1.170E+09	0.000E+00	4.260E+07
TE-129	7.630E-04	2.870E-04	5.850E-04	3.210E-03	0.000E+00	5.760E-04	0.000E+00	1.860E-04
TE-129M	2.510E+08	9.380E+07	8.630E+07	1.050E+09	0.000E+00	1.270E+09	0.000E+00	3.980E+07
TE-131	1.500E-15	6.270E-16	1.230E-15	6.570E-15	0.000E+00	2.130E-16	0.000E+00	4.740E-16
TE-131M	9.120E+05	4.460E+05	7.060E+05	4.520E+06	0.000E+00	4.430E+07	0.000E+00	3.720E+05
TE-132	4.300E+06	2.780E+06	3.070E+06	2.680E+07	0.000E+00	1.320E+08	0.000E+00	2.610E+06
I-130	3.920E+05	1.160E+06	9.810E+07	1.810E+06	0.000E+00	9.960E+05	0.000E+00	4.570E+05

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Vegetation (VEG)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	8.080E+07	1.160E+08	3.790E+10	1.980E+08	0.000E+00	3.050E+07	0.000E+00	6.620E+07
I-132	5.760E+01	1.540E+02	5.390E+03	2.450E+02	0.000E+00	2.890E+01	0.000E+00	5.390E+01
I-133	2.090E+06	3.630E+06	5.330E+08	6.330E+06	0.000E+00	3.260E+06	0.000E+00	1.110E+06
I-134	9.650E-05	2.620E-04	4.540E-03	4.170E-04	0.000E+00	2.290E-07	0.000E+00	9.380E-05
I-135	3.900E+04	1.020E+05	6.730E+06	1.640E+05	0.000E+00	1.150E+05	0.000E+00	3.770E+04
CS-134	4.670E+09	1.110E+10	0.000E+00	3.590E+09	1.190E+09	1.940E+08	0.000E+00	9.080E+09
CS-136	4.270E+07	1.680E+08	0.000E+00	9.380E+07	1.290E+07	1.910E+07	0.000E+00	1.210E+08
CS-137	6.360E+09	8.700E+09	0.000E+00	2.950E+09	9.810E+08	1.680E+08	0.000E+00	5.700E+09
CS-138	3.920E-11	7.730E-11	0.000E+00	5.680E-11	5.610E-12	3.300E-16	0.000E+00	3.830E-11
BA-139	2.860E-02	2.030E-05	0.000E+00	1.900E-05	1.150E-05	5.060E-02	0.000E+00	8.360E-04
BA-140	1.280E+08	1.610E+05	0.000E+00	5.490E+04	9.240E+04	2.650E+08	0.000E+00	8.420E+06
BA-141	1.150E-21	8.700E-25	0.000E+00	8.090E-25	4.940E-25	5.430E-31	0.000E+00	3.890E-23
BA-142	5.960E-39	6.120E-42	0.000E+00	5.170E-42	3.470E-42	8.390E-57	0.000E+00	3.750E-40
LA-140	1.980E+03	9.970E+02	0.000E+00	0.000E+00	0.000E+00	7.320E+07	0.000E+00	2.630E+02
LA-142	2.020E-04	9.190E-05	0.000E+00	0.000E+00	0.000E+00	6.710E-01	0.000E+00	2.290E-05
CE-141	1.970E+05	1.330E+05	0.000E+00	6.190E+04	0.000E+00	5.100E+08	0.000E+00	1.510E+04
CE-143	9.980E+02	7.380E+05	0.000E+00	3.250E+02	0.000E+00	2.760E+07	0.000E+00	8.160E+01
CE-144	3.290E+07	1.380E+07	0.000E+00	8.160E+06	0.000E+00	1.110E+10	0.000E+00	1.770E+06
PR-143	6.260E+04	2.510E+04	0.000E+00	1.450E+04	0.000E+00	2.740E+08	0.000E+00	3.100E+03
PR-144	3.090E-26	1.280E-26	0.000E+00	7.230E-27	0.000E+00	4.440E-33	0.000E+00	1.570E-27
ND-147	3.330E+04	3.850E+04	0.000E+00	2.250E+04	0.000E+00	1.850E+08	0.000E+00	2.310E+03
W-187	3.800E+04	3.180E+04	0.000E+00	0.000E+00	0.000E+00	1.040E+07	0.000E+00	1.110E+04
NP-239	1.430E+03	1.400E+02	0.000E+00	4.380E+02	0.000E+00	2.880E+07	0.000E+00	7.740E+01

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.260E+03	1.260E+03	1.260E+03	1.260E+03	1.260E+03	0.000E+00	1.260E+03
C-14	1.820E+04	3.410E+03	3.410E+03	3.410E+03	3.410E+03	3.410E+03	0.000E+00	3.410E+03
NA-24	1.020E+04	1.020E+04	1.020E+04	1.020E+04	1.020E+04	1.020E+04	0.000E+00	1.020E+04
P-32	1.320E+06	7.710E+04	0.000E+00	0.000E+00	0.000E+00	8.640E+04	0.000E+00	5.010E+04
CR-51	0.000E+00	0.000E+00	5.950E+01	2.280E+01	1.440E+04	3.320E+03	0.000E+00	1.000E+02
MN-54	0.000E+00	3.960E+04	0.000E+00	9.840E+03	1.400E+06	7.740E+04	0.000E+00	6.300E+03
MN-56	0.000E+00	1.240E+00	0.000E+00	1.300E+00	9.440E+03	2.020E+04	0.000E+00	1.830E-01
FE-55	2.460E+04	1.700E+04	0.000E+00	0.000E+00	7.210E+04	6.030E+03	0.000E+00	3.940E+03
FE-59	1.180E+04	2.780E+04	0.000E+00	0.000E+00	1.020E+06	1.880E+05	0.000E+00	1.060E+04
CO-58	0.000E+00	1.580E+03	0.000E+00	0.000E+00	9.280E+05	1.060E+05	0.000E+00	2.070E+03
CO-60	0.000E+00	1.150E+04	0.000E+00	0.000E+00	5.970E+06	2.850E+05	0.000E+00	1.480E+04
NI-63	4.320E+05	3.140E+04	0.000E+00	0.000E+00	1.780E+05	1.340E+04	0.000E+00	1.450E+04
NI-65	1.540E+00	2.100E-01	0.000E+00	0.000E+00	5.600E+03	1.230E+04	0.000E+00	9.120E-02
CU-64	0.000E+00	1.460E+00	0.000E+00	4.620E+00	6.780E+03	4.900E+04	0.000E+00	6.150E-01
ZN-65	3.240E+04	1.030E+05	0.000E+00	6.900E+04	8.640E+05	5.340E+04	0.000E+00	4.660E+04
ZN-69	3.380E-02	6.510E-02	0.000E+00	4.220E-02	9.200E+02	1.630E+01	0.000E+00	4.520E-03
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.320E+02	0.000E+00	2.410E+02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.640E-03	0.000E+00	3.130E+02
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.280E+01
RB-86	0.000E+00	1.350E+05	0.000E+00	0.000E+00	0.000E+00	1.660E+04	0.000E+00	5.900E+04
RB-88	0.000E+00	3.870E+02	0.000E+00	0.000E+00	0.000E+00	3.340E-09	0.000E+00	1.930E+02
RB-89	0.000E+00	2.560E+02	0.000E+00	0.000E+00	0.000E+00	9.280E-12	0.000E+00	1.700E+02
SR-89	3.040E+05	0.000E+00	0.000E+00	0.000E+00	1.400E+06	3.500E+05	0.000E+00	8.720E+03
SR-90	9.920E+07	0.000E+00	0.000E+00	0.000E+00	9.600E+06	7.220E+05	0.000E+00	6.100E+06
SR-91	6.190E+01	0.000E+00	0.000E+00	0.000E+00	3.650E+04	1.910E+05	0.000E+00	2.500E+00

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	6.740E+00	0.000E+00	0.000E+00	0.000E+00	1.650E+04	4.300E+04	0.000E+00	2.910E-01
Y-90	2.090E+03	0.000E+00	0.000E+00	0.000E+00	1.700E+05	5.060E+05	0.000E+00	5.610E+01
Y-91	4.620E+05	0.000E+00	0.000E+00	0.000E+00	1.700E+06	3.850E+05	0.000E+00	1.240E+04
Y-91M	2.610E-01	0.000E+00	0.000E+00	0.000E+00	1.920E+03	1.330E+00	0.000E+00	1.020E-02
Y-92	1.030E+01	0.000E+00	0.000E+00	0.000E+00	1.570E+04	7.350E+04	0.000E+00	3.020E-01
Y-93	9.440E+01	0.000E+00	0.000E+00	0.000E+00	4.850E+04	4.220E+05	0.000E+00	2.610E+00
ZR-95	1.070E+05	3.440E+04	0.000E+00	5.420E+04	1.770E+06	1.500E+05	0.000E+00	2.330E+04
ZR-97	9.680E+01	1.960E+01	0.000E+00	2.970E+01	7.870E+04	5.230E+05	0.000E+00	9.040E+00
NB-95	1.410E+04	7.820E+03	0.000E+00	7.740E+03	5.050E+05	1.040E+05	0.000E+00	4.210E+03
MO-99	0.000E+00	1.210E+02	0.000E+00	2.910E+02	9.120E+04	2.480E+05	0.000E+00	2.300E+01
TC-99M	1.030E-03	2.910E-03	0.000E+00	4.420E-02	7.640E+02	4.160E+03	0.000E+00	3.700E-02
TC-101	4.180E-05	6.020E-05	0.000E+00	1.080E-03	3.990E+02	1.090E-11	0.000E+00	5.900E-04
RU-103	1.530E+03	0.000E+00	0.000E+00	5.830E+03	5.050E+05	1.100E+05	0.000E+00	6.580E+02
RU-105	7.900E-01	0.000E+00	0.000E+00	1.020E+00	1.100E+04	4.820E+04	0.000E+00	3.110E-01
RU-106	6.910E+04	0.000E+00	0.000E+00	1.340E+05	9.360E+06	9.120E+05	0.000E+00	8.720E+03
AG-110M	1.080E+04	1.000E+04	0.000E+00	1.970E+04	4.630E+06	3.020E+05	0.000E+00	5.940E+03
TE-125M	3.420E+03	1.580E+03	1.050E+03	1.240E+04	3.140E+05	7.060E+04	0.000E+00	4.670E+02
TE-127	1.400E+00	6.420E-01	1.060E+00	5.100E+00	6.510E+03	5.740E+04	0.000E+00	3.100E-01
TE-127M	1.260E+04	5.770E+03	3.290E+03	4.580E+04	9.600E+05	1.500E+05	0.000E+00	1.570E+03
TE-129	4.980E-02	2.390E-02	3.900E-02	1.870E-01	1.940E+03	1.570E+02	0.000E+00	1.240E-02
TE-129M	9.760E+03	4.670E+03	3.440E+03	3.660E+04	1.160E+06	3.830E+05	0.000E+00	1.580E+03
TE-131	1.110E-02	5.950E-03	9.360E-03	4.370E-02	1.390E+03	1.840E+01	0.000E+00	3.590E-03
TE-131M	6.990E+01	4.360E+01	5.500E+01	3.090E+02	1.460E+05	5.560E+05	0.000E+00	2.900E+01
TE-132	2.600E+02	2.150E+02	1.900E+02	1.460E+03	2.880E+05	5.100E+05	0.000E+00	1.620E+02
I-130	4.580E+03	1.340E+04	1.140E+06	2.090E+04	0.000E+00	7.690E+03	0.000E+00	5.280E+03

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	2.520E+04	3.580E+04	1.190E+07	6.130E+04	0.000E+00	6.280E+03	0.000E+00	2.050E+04
I-132	1.160E+03	3.260E+03	1.140E+05	5.180E+03	0.000E+00	4.060E+02	0.000E+00	1.160E+03
I-133	8.640E+03	1.480E+04	2.150E+06	2.580E+04	0.000E+00	8.880E+03	0.000E+00	4.520E+03
I-134	6.440E+02	1.730E+03	2.980E+04	2.750E+03	0.000E+00	1.010E+00	0.000E+00	6.150E+02
I-135	2.680E+03	6.980E+03	4.480E+05	1.110E+04	0.000E+00	5.250E+03	0.000E+00	2.570E+03
CS-134	3.730E+05	8.480E+05	0.000E+00	2.870E+05	9.760E+04	1.040E+04	0.000E+00	7.280E+05
CS-136	3.900E+04	1.460E+05	0.000E+00	8.560E+04	1.200E+04	1.170E+04	0.000E+00	1.100E+05
CS-137	4.780E+05	6.210E+05	0.000E+00	2.220E+05	7.520E+04	8.400E+03	0.000E+00	4.280E+05
CS-138	3.310E+02	6.210E+02	0.000E+00	4.800E+02	4.860E+01	1.860E-03	0.000E+00	3.240E+02
BA-139	9.360E-01	6.660E-04	0.000E+00	6.220E-04	3.760E+03	8.960E+02	0.000E+00	2.740E-02
BA-140	3.900E+04	4.900E+01	0.000E+00	1.670E+01	1.270E+06	2.180E+05	0.000E+00	2.570E+03
BA-141	1.000E-01	7.530E-05	0.000E+00	7.000E-05	1.940E+03	1.160E-07	0.000E+00	3.360E-03
BA-142	2.630E-02	2.700E-05	0.000E+00	2.290E-05	1.190E+03	1.570E-16	0.000E+00	1.660E-03
LA-140	3.440E+02	1.740E+02	0.000E+00	0.000E+00	1.360E+05	4.580E+05	0.000E+00	4.580E+01
LA-142	6.830E-01	3.100E-01	0.000E+00	0.000E+00	6.330E+03	2.110E+03	0.000E+00	7.720E-02
CE-141	1.990E+04	1.350E+04	0.000E+00	6.260E+03	3.620E+05	1.200E+05	0.000E+00	1.530E+03
CE-143	1.860E+02	1.380E+02	0.000E+00	6.080E+01	7.980E+04	2.260E+05	0.000E+00	1.530E+01
CE-144	3.430E+06	1.430E+06	0.000E+00	8.480E+05	7.780E+06	8.160E+05	0.000E+00	1.840E+05
PR-143	9.360E+03	3.750E+03	0.000E+00	2.160E+03	2.810E+05	2.000E+05	0.000E+00	4.640E+02
PR-144	3.010E-02	1.250E-02	0.000E+00	7.050E-03	1.020E+03	2.150E-08	0.000E+00	1.530E-03
ND-147	5.270E+03	6.100E+03	0.000E+00	3.560E+03	2.210E+05	1.730E+05	0.000E+00	3.650E+02
W-187	8.480E+00	7.080E+00	0.000E+00	0.000E+00	2.900E+04	1.550E+05	0.000E+00	2.480E+00
NP-239	2.300E+02	2.260E+01	0.000E+00	7.000E+01	3.760E+04	1.190E+05	0.000E+00	1.240E+01

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NA-24	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.390E+07	1.190E+07
P-32	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CR-51	4.660E+06	4.660E+06	4.660E+06	4.660E+06	4.660E+06	4.660E+06	5.510E+06	4.660E+06
MN-54	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.630E+09	1.390E+09
MN-56	9.020E+05	9.020E+05	9.020E+05	9.020E+05	9.020E+05	9.020E+05	1.070E+06	9.020E+05
FE-55	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
FE-59	2.730E+08	2.730E+08	2.730E+08	2.730E+08	2.730E+08	2.730E+08	3.210E+08	2.730E+08
CO-58	3.790E+08	3.790E+08	3.790E+08	3.790E+08	3.790E+08	3.790E+08	4.440E+08	3.790E+08
CO-60	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.530E+10	2.150E+10
NI-63	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NI-65	2.970E+05	2.970E+05	2.970E+05	2.970E+05	2.970E+05	2.970E+05	3.450E+05	2.970E+05
CU-64	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.880E+05	6.070E+05
ZN-65	7.470E+08	7.470E+08	7.470E+08	7.470E+08	7.470E+08	7.470E+08	8.590E+08	7.470E+08
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	4.870E+03	4.870E+03	4.870E+03	4.870E+03	4.870E+03	4.870E+03	7.080E+03	4.870E+03
BR-84	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.360E+05	2.030E+05
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	8.990E+06	8.990E+06	8.990E+06	8.990E+06	8.990E+06	8.990E+06	1.030E+07	8.990E+06
RB-88	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.780E+04	3.310E+04
RB-89	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.480E+05	1.230E+05
SR-89	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.510E+04	2.160E+04
SR-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-91	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.510E+06	2.150E+06

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	7.770E+05	7.770E+05	7.770E+05	7.770E+05	7.770E+05	7.770E+05	8.630E+05	7.770E+05
Y-90	4.490E+03	4.490E+03	4.490E+03	4.490E+03	4.490E+03	4.490E+03	5.310E+03	4.490E+03
Y-91	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.210E+06	1.070E+06
Y-91M	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.160E+05	1.000E+05
Y-92	1.800E+05	1.800E+05	1.800E+05	1.800E+05	1.800E+05	1.800E+05	2.140E+05	1.800E+05
Y-93	1.830E+05	1.830E+05	1.830E+05	1.830E+05	1.830E+05	1.830E+05	2.510E+05	1.830E+05
ZR-95	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.840E+08	2.450E+08
ZR-97	2.960E+06	2.960E+06	2.960E+06	2.960E+06	2.960E+06	2.960E+06	3.440E+06	2.960E+06
NB-95	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.610E+08	1.370E+08
MO-99	3.990E+06	3.990E+06	3.990E+06	3.990E+06	3.990E+06	3.990E+06	4.630E+06	3.990E+06
TC-99M	1.840E+05	1.840E+05	1.840E+05	1.840E+05	1.840E+05	1.840E+05	2.110E+05	1.840E+05
TC-101	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.260E+04	2.040E+04
RU-103	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.260E+08	1.080E+08
RU-105	6.360E+05	6.360E+05	6.360E+05	6.360E+05	6.360E+05	6.360E+05	7.210E+05	6.360E+05
RU-106	4.220E+08	4.220E+08	4.220E+08	4.220E+08	4.220E+08	4.220E+08	5.070E+08	4.220E+08
AG-110M	3.440E+09	3.440E+09	3.440E+09	3.440E+09	3.440E+09	3.440E+09	4.010E+09	3.440E+09
TE-125M	1.550E+06	1.550E+06	1.550E+06	1.550E+06	1.550E+06	1.550E+06	2.130E+06	1.550E+06
TE-127	2.980E+03	2.980E+03	2.980E+03	2.980E+03	2.980E+03	2.980E+03	3.280E+03	2.980E+03
TE-127M	9.160E+04	9.160E+04	9.160E+04	9.160E+04	9.160E+04	9.160E+04	1.080E+05	9.160E+04
TE-129	2.620E+04	2.620E+04	2.620E+04	2.620E+04	2.620E+04	2.620E+04	3.100E+04	2.620E+04
TE-129M	1.980E+07	1.980E+07	1.980E+07	1.980E+07	1.980E+07	1.980E+07	2.310E+07	1.980E+07
TE-131	2.920E+04	2.920E+04	2.920E+04	2.920E+04	2.920E+04	2.920E+04	3.450E+07	2.920E+04
TE-131M	8.030E+06	8.030E+06	8.030E+06	8.030E+06	8.030E+06	8.030E+06	9.460E+06	8.030E+06
TE-132	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.980E+06	4.230E+06
I-130	5.510E+06	5.510E+06	5.510E+06	5.510E+06	5.510E+06	5.510E+06	6.690E+06	5.510E+06

APPENDIX G

R_i Adult Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	ADULT	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.720E+07	1.720E+07	1.720E+07	1.720E+07	1.720E+07	1.720E+07	2.090E+07	1.720E+07
I-132	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.470E+06	1.250E+06
I-133	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.980E+06	2.450E+06
I-134	4.470E+05	4.470E+05	4.470E+05	4.470E+05	4.470E+05	4.470E+05	5.300E+05	4.470E+05
I-135	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.950E+06	2.530E+06
CS-134	6.860E+09	6.860E+09	6.860E+09	6.860E+09	6.860E+09	6.860E+09	8.000E+09	6.860E+09
CS-136	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.710E+08	1.510E+08
CS-137	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.200E+10	1.030E+10
CS-138	3.590E+05	3.590E+05	3.590E+05	3.590E+05	3.590E+05	3.590E+05	4.100E+05	3.590E+05
BA-139	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.190E+05	1.060E+05
BA-140	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.350E+07	2.050E+07
BA-141	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.750E+04	4.170E+04
BA-142	4.490E+04	4.490E+04	4.490E+04	4.490E+04	4.490E+04	4.490E+04	5.110E+04	4.490E+04
LA-140	1.920E+07	1.920E+07	1.920E+07	1.920E+07	1.920E+07	1.920E+07	2.180E+07	1.920E+07
LA-142	7.600E+05	7.600E+05	7.600E+05	7.600E+05	7.600E+05	7.600E+05	9.120E+05	7.600E+05
CE-141	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.540E+07	1.370E+07
CE-143	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.630E+06	2.310E+06
CE-144	6.950E+07	6.950E+07	6.950E+07	6.950E+07	6.950E+07	6.950E+07	8.040E+07	6.950E+07
PR-143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR-144	1.830E+03	1.830E+03	1.830E+03	1.830E+03	1.830E+03	1.830E+03	2.110E+03	1.830E+03
ND-147	8.390E+06	8.390E+06	8.390E+06	8.390E+06	8.390E+06	8.390E+06	1.010E+07	8.390E+06
W-187	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.730E+06	2.350E+06
NP-239	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.980E+06	1.710E+06

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	9.940E+02	9.940E+02	9.940E+02	9.940E+02	9.940E+02	0.000E+00	9.940E+02
C-14	4.150E+04	8.310E+03	8.310E+03	8.310E+03	8.310E+03	8.310E+03	0.000E+00	8.310E+03
NA-24	4.260E+06	4.260E+06	4.260E+06	4.260E+06	4.260E+06	4.260E+06	0.000E+00	4.260E+06
P-32	3.150E+10	1.950E+09	0.000E+00	0.000E+00	0.000E+00	2.650E+09	0.000E+00	1.220E+09
CR-51	0.000E+00	0.000E+00	2.770E+04	1.090E+04	7.130E+04	8.390E+06	0.000E+00	4.990E+04
MN-54	0.000E+00	1.400E+07	0.000E+00	4.180E+06	0.000E+00	2.870E+07	0.000E+00	2.780E+06
MN-56	0.000E+00	7.250E-03	0.000E+00	9.180E-03	0.000E+00	4.770E-01	0.000E+00	1.290E-03
FE-55	4.450E+07	3.160E+07	0.000E+00	0.000E+00	2.000E+07	1.370E+07	0.000E+00	7.360E+06
FE-59	5.180E+07	1.210E+08	0.000E+00	0.000E+00	3.810E+07	2.860E+08	0.000E+00	4.670E+07
CO-58	0.000E+00	7.940E+06	0.000E+00	0.000E+00	0.000E+00	1.090E+08	0.000E+00	1.830E+07
CO-60	0.000E+00	2.780E+07	0.000E+00	0.000E+00	0.000E+00	3.620E+08	0.000E+00	6.260E+07
NI-63	1.180E+10	8.350E+08	0.000E+00	0.000E+00	0.000E+00	1.330E+08	0.000E+00	4.010E+08
NI-65	6.770E-01	8.650E-02	0.000E+00	0.000E+00	0.000E+00	4.690E+00	0.000E+00	3.940E-02
CU-64	0.000E+00	4.250E+04	0.000E+00	1.070E+05	0.000E+00	3.290E+06	0.000E+00	2.000E+04
ZN-65	2.110E+09	7.320E+09	0.000E+00	4.680E+09	0.000E+00	3.100E+09	0.000E+00	3.410E+09
ZN-69	3.850E-12	7.330E-12	0.000E+00	4.790E-12	0.000E+00	1.350E-11	0.000E+00	5.130E-13
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.790E-01
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.880E-23
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	4.730E+09	0.000E+00	0.000E+00	0.000E+00	7.000E+08	0.000E+00	2.220E+09
RB-88	0.000E+00	3.890E-45	0.000E+00	0.000E+00	0.000E+00	3.330E-52	0.000E+00	2.070E-45
RB-89	0.000E+00	7.660E-53	0.000E+00	0.000E+00	0.000E+00	1.170E-61	0.000E+00	5.420E-53
SR-89	2.670E+09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.190E+08	0.000E+00	7.660E+07
SR-90	6.610E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.860E+09	0.000E+00	1.630E+10
SR-91	5.310E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.410E+05	0.000E+00	2.110E+03

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	8.940E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.280E+01	0.000E+00	3.810E-02
Y-90	1.300E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.070E+06	0.000E+00	3.510E+00
Y-91	1.580E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.480E+06	0.000E+00	4.240E+02
Y-91M	1.090E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.170E-18	0.000E+00	4.180E-21
Y-92	1.030E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.830E+00	0.000E+00	2.980E-06
Y-93	4.120E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.260E+04	0.000E+00	1.130E-02
ZR-95	1.650E+03	5.200E+02	0.000E+00	7.650E+02	0.000E+00	1.200E+06	0.000E+00	3.580E+02
ZR-97	7.880E-01	1.560E-01	0.000E+00	2.370E-01	0.000E+00	4.220E+04	0.000E+00	7.190E-02
NB-95	1.410E+05	7.810E+04	0.000E+00	7.570E+04	0.000E+00	3.340E+08	0.000E+00	4.300E+04
MO-99	0.000E+00	4.470E+07	0.000E+00	1.020E+08	0.000E+00	8.010E+07	0.000E+00	8.530E+06
TC-99M	5.760E+00	1.610E+01	0.000E+00	2.390E+02	8.920E+00	1.050E+04	0.000E+00	2.080E+02
TC-101	4.740E-60	6.750E-60	0.000E+00	1.220E-58	4.110E-60	1.150E-66	0.000E+00	6.630E-59
RU-103	1.810E+03	0.000E+00	0.000E+00	6.380E+03	0.000E+00	1.510E+05	0.000E+00	7.740E+02
RU-105	1.560E-03	0.000E+00	0.000E+00	1.970E-02	0.000E+00	1.260E+00	0.000E+00	6.070E-04
RU-106	3.750E+04	0.000E+00	0.000E+00	7.240E+04	0.000E+00	1.800E+06	0.000E+00	4.730E+03
AG-110M	9.630E+07	9.110E+07	0.000E+00	1.740E+08	0.000E+00	2.560E+10	0.000E+00	5.540E+07
TE-125M	3.000E+07	1.080E+07	8.390E+06	0.000E+00	0.000E+00	8.860E+07	0.000E+00	4.020E+06
TE-127	1.210E+03	4.290E+02	8.350E+02	4.900E+03	0.000E+00	9.340E+04	0.000E+00	2.600E+02
TE-127M	8.440E+07	2.990E+07	2.010E+07	3.420E+08	0.000E+00	2.100E+08	0.000E+00	1.000E+07
TE-129	5.200E-10	1.940E-10	3.720E-10	2.180E-09	0.000E+00	2.840E-09	0.000E+00	1.270E-10
TE-129M	1.100E+08	4.090E+07	3.550E+07	4.610E+08	0.000E+00	4.130E+08	0.000E+00	1.740E+07
TE-131	6.580E-33	2.710E-33	5.070E-33	2.880E-32	0.000E+00	5.400E-34	0.000E+00	2.060E-33
TE-131M	6.570E+05	3.150E+05	4.740E+05	3.290E+06	0.000E+00	2.530E+07	0.000E+00	2.630E+05
TE-132	4.290E+06	2.720E+06	2.870E+06	2.610E+07	0.000E+00	8.610E+07	0.000E+00	2.560E+06
I-130	7.380E+05	2.140E+06	1.740E+08	3.290E+06	0.000E+00	1.640E+06	0.000E+00	8.530E+05

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	5.370E+08	7.520E+08	2.190E+11	1.290E+09	0.000E+00	1.490E+08	0.000E+00	4.040E+08
I-132	2.910E-01	7.620E-01	2.570E+01	1.200E+00	0.000E+00	3.320E-01	0.000E+00	2.740E-01
I-133	7.070E+06	1.200E+07	1.670E+09	2.100E+07	0.000E+00	9.070E+06	0.000E+00	3.660E+06
I-134	3.580E-12	9.500E-12	1.580E-10	1.500E-11	0.000E+00	1.250E-13	0.000E+00	3.410E-12
I-135	2.280E+04	5.870E+04	3.780E+06	9.270E+04	0.000E+00	6.510E+04	0.000E+00	2.180E+04
CS-134	9.820E+09	2.310E+10	0.000E+00	7.340E+09	2.800E+09	2.870E+08	0.000E+00	1.070E+10
CS-136	4.480E+08	1.760E+09	0.000E+00	9.600E+08	1.510E+08	1.420E+08	0.000E+00	1.180E+09
CS-137	1.340E+10	1.780E+10	0.000E+00	6.060E+09	2.350E+09	2.530E+08	0.000E+00	6.200E+09
CS-138	1.640E-23	3.150E-23	0.000E+00	2.330E-23	2.710E-24	1.430E-26	0.000E+00	1.580E-23
BA-139	8.170E-08	5.750E-11	0.000E+00	5.420E-11	3.960E-11	7.290E-07	0.000E+00	2.380E-09
BA-140	4.850E+07	5.950E+04	0.000E+00	2.020E+04	4.000E+04	7.480E+07	0.000E+00	3.130E+06
BA-141	7.520E-46	5.620E-49	0.000E+00	5.210E-49	3.850E-49	1.600E-51	0.000E+00	2.510E-47
BA-142	4.790E-80	4.790E-83	0.000E+00	4.050E-83	3.190E-83	1.470E-91	0.000E+00	2.950E-81
LA-140	8.100E+00	3.980E+00	0.000E+00	0.000E+00	0.000E+00	2.290E+05	0.000E+00	1.060E+00
LA-142	3.360E-11	1.490E-11	0.000E+00	0.000E+00	0.000E+00	4.540E-07	0.000E+00	3.710E-12
CE-141	8.880E+03	5.930E+03	0.000E+00	2.790E+03	0.000E+00	1.700E+07	0.000E+00	6.810E+02
CE-143	7.640E+01	5.560E+04	0.000E+00	2.490E+01	0.000E+00	1.670E+06	0.000E+00	6.210E+00
CE-144	6.580E+05	2.720E+05	0.000E+00	1.630E+05	0.000E+00	1.660E+08	0.000E+00	3.540E+04
PR-143	2.900E+02	1.160E+02	0.000E+00	6.730E+01	0.000E+00	9.540E+05	0.000E+00	1.440E+01
PR-144	1.080E-53	4.430E-54	0.000E+00	2.540E-54	0.000E+00	1.190E-56	0.000E+00	5.490E-55
ND-147	1.810E+02	1.970E+02	0.000E+00	1.160E+02	0.000E+00	7.110E+05	0.000E+00	1.180E+01
W-187	1.190E+04	9.710E+03	0.000E+00	0.000E+00	0.000E+00	2.630E+06	0.000E+00	3.400E+03
NP-239	7.010E+00	6.610E-01	0.000E+00	2.070E+00	0.000E+00	1.060E+05	0.000E+00	3.670E-01

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	2.030E+03	2.030E+03	2.030E+03	2.030E+03	2.030E+03	0.000E+00	2.030E+03
C-14	4.150E+04	8.310E+03	8.310E+03	8.310E+03	8.310E+03	8.310E+03	0.000E+00	8.310E+03
NA-24	5.110E+05	5.110E+05	5.110E+05	5.110E+05	5.110E+05	5.110E+05	0.000E+00	5.110E+05
P-32	3.780E+10	2.340E+09	0.000E+00	0.000E+00	0.000E+00	3.180E+09	0.000E+00	1.470E+09
CR-51	0.000E+00	0.000E+00	3.330E+03	1.310E+03	8.550E+03	1.010E+06	0.000E+00	5.990E+03
MN-54	0.000E+00	1.680E+06	0.000E+00	5.020E+05	0.000E+00	3.450E+06	0.000E+00	3.340E+05
MN-56	0.000E+00	8.700E-04	0.000E+00	1.100E-03	0.000E+00	5.730E-02	0.000E+00	1.550E-04
FE-55	5.790E+05	4.110E+05	0.000E+00	0.000E+00	2.600E+05	1.780E+05	0.000E+00	9.570E+04
FE-59	6.740E+05	1.570E+06	0.000E+00	0.000E+00	4.960E+05	3.720E+06	0.000E+00	6.070E+05
CO-58	0.000E+00	9.520E+05	0.000E+00	0.000E+00	0.000E+00	1.310E+07	0.000E+00	2.190E+06
CO-60	0.000E+00	3.340E+06	0.000E+00	0.000E+00	0.000E+00	4.350E+07	0.000E+00	7.520E+06
NI-63	1.420E+09	1.000E+08	0.000E+00	0.000E+00	0.000E+00	1.590E+07	0.000E+00	4.810E+07
NI-65	8.120E-02	1.040E-02	0.000E+00	0.000E+00	0.000E+00	5.630E-01	0.000E+00	4.730E-03
CU-64	0.000E+00	4.730E+03	0.000E+00	1.200E+04	0.000E+00	3.670E+05	0.000E+00	2.230E+03
ZN-65	2.530E+08	8.780E+08	0.000E+00	5.620E+08	0.000E+00	3.720E+08	0.000E+00	4.100E+08
ZN-69	4.620E-13	8.800E-13	0.000E+00	5.750E-13	0.000E+00	1.620E-12	0.000E+00	6.160E-14
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.150E-02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.450E-24
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	5.670E+08	0.000E+00	0.000E+00	0.000E+00	8.400E+07	0.000E+00	2.670E+08
RB-88	0.000E+00	4.670E-46	0.000E+00	0.000E+00	0.000E+00	4.000E-53	0.000E+00	2.490E-46
RB-89	0.000E+00	9.190E-54	0.000E+00	0.000E+00	0.000E+00	1.410E-62	0.000E+00	6.500E-54
SR-89	5.620E+09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.690E+08	0.000E+00	1.610E+08
SR-90	1.390E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.900E+09	0.000E+00	3.430E+10
SR-91	1.120E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.060E+05	0.000E+00	4.440E+03

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	1.880E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.780E+01	0.000E+00	8.000E-02
Y-90	1.560E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.290E+05	0.000E+00	4.210E-01
Y-91	1.900E+03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.770E+05	0.000E+00	5.080E+01
Y-91M	1.310E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.200E-19	0.000E+00	5.020E-22
Y-92	1.240E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.390E-01	0.000E+00	3.580E-07
Y-93	4.940E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.510E+03	0.000E+00	1.360E-03
ZR-95	1.980E+02	6.250E+01	0.000E+00	9.180E+01	0.000E+00	1.440E+05	0.000E+00	4.300E+01
ZR-97	9.460E-02	1.870E-02	0.000E+00	2.840E-02	0.000E+00	5.070E+03	0.000E+00	8.620E-03
NB-95	1.690E+04	9.370E+03	0.000E+00	9.080E+03	0.000E+00	4.010E+07	0.000E+00	5.160E+03
MO-99	0.000E+00	5.370E+06	0.000E+00	1.230E+07	0.000E+00	9.610E+06	0.000E+00	1.020E+06
TC-99M	6.910E-01	1.930E+00	0.000E+00	2.870E+01	1.070E+00	1.270E+03	0.000E+00	2.500E+01
TC-101	5.690E-61	8.100E-61	0.000E+00	1.460E-59	4.930E-61	1.380E-67	0.000E+00	7.950E-60
RU-103	2.170E+02	0.000E+00	0.000E+00	7.660E+02	0.000E+00	1.810E+04	0.000E+00	9.290E+01
RU-105	1.880E-04	0.000E+00	0.000E+00	2.370E-03	0.000E+00	1.520E-01	0.000E+00	7.290E-05
RU-106	4.500E+03	0.000E+00	0.000E+00	8.680E+03	0.000E+00	2.160E+05	0.000E+00	5.670E+02
AG-110M	1.160E+07	1.090E+07	0.000E+00	2.080E+07	0.000E+00	3.070E+09	0.000E+00	6.650E+06
TE-125M	3.600E+06	1.300E+06	1.010E+06	0.000E+00	0.000E+00	1.060E+07	0.000E+00	4.820E+05
TE-127	1.450E+02	5.150E+01	1.000E+02	5.880E+02	0.000E+00	1.120E+04	0.000E+00	3.120E+01
TE-127M	1.010E+07	3.590E+06	2.410E+06	4.100E+07	0.000E+00	2.520E+07	0.000E+00	1.200E+06
TE-129	6.240E-11	2.330E-11	4.460E-11	2.620E-10	0.000E+00	3.410E-10	0.000E+00	1.520E-11
TE-129M	1.320E+07	4.900E+06	4.260E+06	5.530E+07	0.000E+00	4.960E+07	0.000E+00	2.090E+06
TE-131	7.900E-34	3.260E-34	6.090E-34	3.450E-33	0.000E+00	6.480E-35	0.000E+00	2.470E-34
TE-131M	7.880E+04	3.780E+04	5.690E+04	3.940E+05	0.000E+00	3.030E+06	0.000E+00	3.150E+04
TE-132	5.150E+05	3.260E+05	3.440E+05	3.130E+06	0.000E+00	1.030E+07	0.000E+00	3.070E+05
I-130	8.860E+05	2.560E+06	2.090E+08	3.950E+06	0.000E+00	1.970E+06	0.000E+00	1.020E+06

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	6.450E+08	9.030E+08	2.630E+11	1.550E+09	0.000E+00	1.790E+08	0.000E+00	4.850E+08
I-132	3.500E-01	9.150E-01	3.080E+01	1.440E+00	0.000E+00	3.980E-01	0.000E+00	3.280E-01
I-133	8.480E+06	1.440E+07	2.010E+09	2.520E+07	0.000E+00	1.090E+07	0.000E+00	4.390E+06
I-134	4.300E-12	1.140E-11	1.900E-10	1.800E-11	0.000E+00	1.500E-13	0.000E+00	4.090E-12
I-135	2.740E+04	7.040E+04	4.530E+06	1.110E+05	0.000E+00	7.810E+04	0.000E+00	2.610E+04
CS-134	2.940E+10	6.930E+10	0.000E+00	2.200E+10	8.410E+09	8.620E+08	0.000E+00	3.220E+10
CS-136	1.340E+09	5.290E+09	0.000E+00	2.880E+09	4.540E+08	4.260E+08	0.000E+00	3.550E+09
CS-137	4.020E+10	5.340E+10	0.000E+00	1.820E+10	7.060E+09	7.600E+08	0.000E+00	1.860E+10
CS-138	4.920E-23	9.450E-23	0.000E+00	6.980E-23	8.120E-24	4.290E-26	0.000E+00	4.730E-23
BA-139	9.800E-09	6.900E-12	0.000E+00	6.500E-12	4.750E-12	8.750E-08	0.000E+00	2.860E-10
BA-140	5.820E+06	7.130E+03	0.000E+00	2.420E+03	4.800E+03	8.980E+06	0.000E+00	3.750E+05
BA-141	9.030E-47	6.740E-50	0.000E+00	6.260E-50	4.610E-50	1.920E-52	0.000E+00	3.010E-48
BA-142	5.750E-81	5.750E-84	0.000E+00	4.860E-84	3.820E-84	1.760E-92	0.000E+00	3.540E-82
LA-140	9.720E-01	4.780E-01	0.000E+00	0.000E+00	0.000E+00	2.740E+04	0.000E+00	1.270E-01
LA-142	4.030E-12	1.790E-12	0.000E+00	0.000E+00	0.000E+00	5.440E-08	0.000E+00	4.450E-13
CE-141	1.070E+03	7.120E+02	0.000E+00	3.350E+02	0.000E+00	2.040E+06	0.000E+00	8.170E+01
CE-143	9.170E+00	6.670E+03	0.000E+00	2.990E+00	0.000E+00	2.000E+05	0.000E+00	7.450E-01
CE-144	7.900E+04	3.270E+04	0.000E+00	1.950E+04	0.000E+00	1.990E+07	0.000E+00	4.240E+03
PR-143	3.480E+01	1.390E+01	0.000E+00	8.080E+00	0.000E+00	1.150E+05	0.000E+00	1.730E+00
PR-144	1.300E-54	5.320E-55	0.000E+00	3.050E-55	0.000E+00	1.430E-57	0.000E+00	6.590E-56
ND-147	2.170E+01	2.360E+01	0.000E+00	1.390E+01	0.000E+00	8.530E+04	0.000E+00	1.420E+00
W-187	1.430E+03	1.170E+03	0.000E+00	0.000E+00	0.000E+00	3.150E+05	0.000E+00	4.080E+02
NP-239	8.410E-01	7.930E-02	0.000E+00	2.490E-01	0.000E+00	1.280E+04	0.000E+00	4.410E-02

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Age group:	TEEN	Pathway:	Grs/Cow/Meat (CMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.940E+02	1.940E+02	1.940E+02	1.940E+02	1.940E+02	0.000E+00	1.940E+02
C-14	1.740E+04	3.490E+03	3.490E+03	3.490E+03	3.490E+03	3.490E+03	0.000E+00	3.490E+03
NA-24	1.080E-03	1.080E-03	1.080E-03	1.080E-03	1.080E-03	1.080E-03	0.000E+00	1.080E-03
P-32	3.930E+09	2.440E+08	0.000E+00	0.000E+00	0.000E+00	3.310E+08	0.000E+00	1.530E+08
CR-51	0.000E+00	0.000E+00	3.130E+03	1.240E+03	8.050E+03	9.470E+05	0.000E+00	5.640E+03
MN-54	0.000E+00	7.000E+06	0.000E+00	2.090E+06	0.000E+00	1.440E+07	0.000E+00	1.390E+06
MN-56	0.000E+00	1.070E-53	0.000E+00	1.360E-53	0.000E+00	7.070E-52	0.000E+00	1.910E-54
FE-55	2.380E+08	1.690E+08	0.000E+00	0.000E+00	1.070E+08	7.310E+07	0.000E+00	3.940E+07
FE-59	2.120E+08	4.950E+08	0.000E+00	0.000E+00	1.560E+08	1.170E+09	0.000E+00	1.910E+08
CO-58	0.000E+00	1.410E+07	0.000E+00	0.000E+00	0.000E+00	1.940E+08	0.000E+00	3.240E+07
CO-60	0.000E+00	5.830E+07	0.000E+00	0.000E+00	0.000E+00	7.600E+08	0.000E+00	1.310E+08
NI-63	1.520E+10	1.070E+09	0.000E+00	0.000E+00	0.000E+00	1.710E+08	0.000E+00	5.150E+08
NI-65	1.880E-52	2.410E-53	0.000E+00	0.000E+00	0.000E+00	1.300E-51	0.000E+00	1.100E-53
CU-64	0.000E+00	2.210E-07	0.000E+00	5.600E-07	0.000E+00	1.720E-05	0.000E+00	1.040E-07
ZN-65	2.500E+08	8.690E+08	0.000E+00	5.560E+08	0.000E+00	3.680E+08	0.000E+00	4.050E+08
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.070E-57
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	4.070E+08	0.000E+00	0.000E+00	0.000E+00	6.020E+07	0.000E+00	1.910E+08
RB-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-89	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-89	2.550E+08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.030E+07	0.000E+00	7.290E+06
SR-90	8.050E+09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.260E+08	0.000E+00	1.990E+09
SR-91	1.280E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.800E-10	0.000E+00	5.090E-12

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Age group:	TEEN	Pathway:	Grs/Cow/Meat (CMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	9.880E-50	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.520E-48	0.000E+00	4.210E-51
Y-90	9.060E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.470E+05	0.000E+00	2.440E+00
Y-91	9.540E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.910E+08	0.000E+00	2.560E+04
Y-91M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Y-92	1.280E-39	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.520E-35	0.000E+00	3.710E-41
Y-93	3.960E-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.210E-07	0.000E+00	1.090E-13
ZR-95	1.500E+06	4.730E+05	0.000E+00	6.950E+05	0.000E+00	1.090E+09	0.000E+00	3.250E+05
ZR-97	1.720E-05	3.410E-06	0.000E+00	5.170E-06	0.000E+00	9.230E-01	0.000E+00	1.570E-06
NB-95	1.790E+06	9.950E+05	0.000E+00	9.650E+05	0.000E+00	4.260E+09	0.000E+00	5.480E+05
MO-99	0.000E+00	8.270E+04	0.000E+00	1.890E+05	0.000E+00	1.480E+05	0.000E+00	1.580E+04
TC-99M	3.530E-21	9.850E-21	0.000E+00	1.470E-19	5.470E-21	6.470E-18	0.000E+00	1.280E-19
TC-101	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU-103	8.570E+07	0.000E+00	0.000E+00	3.020E+08	0.000E+00	7.160E+09	0.000E+00	3.660E+07
RU-105	4.830E-28	0.000E+00	0.000E+00	6.090E-27	0.000E+00	3.900E-25	0.000E+00	1.880E-28
RU-106	2.360E+09	0.000E+00	0.000E+00	4.550E+09	0.000E+00	1.130E+11	0.000E+00	2.970E+08
AG-110M	5.060E+06	4.790E+06	0.000E+00	9.130E+06	0.000E+00	1.340E+09	0.000E+00	2.910E+06
TE-125M	3.030E+08	1.090E+08	8.470E+07	0.000E+00	0.000E+00	8.940E+08	0.000E+00	4.050E+07
TE-127	1.800E-10	6.380E-11	1.240E-10	7.290E-10	0.000E+00	1.390E-08	0.000E+00	3.870E-11
TE-127M	9.410E+08	3.340E+08	2.240E+08	3.820E+09	0.000E+00	2.350E+09	0.000E+00	1.120E+08
TE-129	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-129M	9.500E+08	3.530E+08	3.070E+08	3.970E+09	0.000E+00	3.570E+09	0.000E+00	1.500E+08
TE-131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-131M	3.760E+02	1.800E+02	2.710E+02	1.880E+03	0.000E+00	1.450E+04	0.000E+00	1.500E+02
TE-132	1.160E+06	7.360E+05	7.750E+05	7.060E+06	0.000E+00	2.330E+07	0.000E+00	6.920E+05
I-130	1.700E-06	4.910E-06	4.000E-04	7.560E-06	0.000E+00	3.770E-06	0.000E+00	1.960E-06

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Age group:	TEEN	Pathway:	Grs/Cow/Meat (CMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	8.920E+06	1.250E+07	3.650E+09	2.150E+07	0.000E+00	2.470E+06	0.000E+00	6.710E+06
I-132	5.660E-59	1.480E-58	4.990E-57	2.330E-58	0.000E+00	6.450E-59	0.000E+00	5.320E-59
I-133	3.050E-01	5.180E-01	7.230E+01	9.090E-01	0.000E+00	3.920E-01	0.000E+00	1.580E-01
I-134	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I-135	3.600E-17	9.260E-17	5.960E-15	1.460E-16	0.000E+00	1.030E-16	0.000E+00	3.430E-17
CS-134	5.230E+08	1.230E+09	0.000E+00	3.910E+08	1.490E+08	1.530E+07	0.000E+00	5.710E+08
CS-136	9.400E+06	3.700E+07	0.000E+00	2.010E+07	3.170E+06	2.980E+06	0.000E+00	2.480E+07
CS-137	7.240E+08	9.630E+08	0.000E+00	3.280E+08	1.270E+08	1.370E+07	0.000E+00	3.360E+08
CS-138	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-139	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-140	2.380E+07	2.910E+04	0.000E+00	9.870E+03	1.960E+04	3.660E+07	0.000E+00	1.530E+06
BA-141	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-142	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA-140	3.050E-02	1.500E-02	0.000E+00	0.000E+00	0.000E+00	8.610E+02	0.000E+00	3.990E-03
LA-142	2.870E-92	1.280E-92	0.000E+00	0.000E+00	0.000E+00	3.880E-88	0.000E+00	3.180E-93
CE-141	1.180E+04	7.870E+03	0.000E+00	3.710E+03	0.000E+00	2.250E+07	0.000E+00	9.040E+02
CE-143	1.690E-02	1.230E+01	0.000E+00	5.510E-03	0.000E+00	3.690E+02	0.000E+00	1.370E-03
CE-144	1.230E+06	5.080E+05	0.000E+00	3.040E+05	0.000E+00	3.090E+08	0.000E+00	6.600E+04
PR-143	1.760E+04	7.040E+03	0.000E+00	4.090E+03	0.000E+00	5.800E+07	0.000E+00	8.780E+02
PR-144	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ND-147	6.230E+03	6.770E+03	0.000E+00	3.980E+03	0.000E+00	2.440E+07	0.000E+00	4.060E+02
W-187	1.730E-02	1.410E-02	0.000E+00	0.000E+00	0.000E+00	3.820E+00	0.000E+00	4.940E-03
NP-239	2.260E-01	2.140E-02	0.000E+00	6.700E-02	0.000E+00	3.440E+03	0.000E+00	1.190E-02

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Age group:	TEEN	Pathway:	Grs/Goat/Meat (GMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	2.328E+01	2.328E+01	2.328E+01	2.328E+01	2.328E+01	0.000E+00	2.328E+01
C-14	2.088E+03	4.188E+02	4.188E+02	4.188E+02	4.188E+02	4.188E+02	0.000E+00	4.188E+02
NA-24	1.296E-04	1.296E-04	1.296E-04	1.296E-04	1.296E-04	1.296E-04	0.000E+00	1.296E-04
P-32	4.716E+08	2.928E+07	0.000E+00	0.000E+00	0.000E+00	3.972E+07	0.000E+00	1.836E+07
CR-51	0.000E+00	0.000E+00	3.756E+02	1.488E+02	9.660E+02	1.136E+05	0.000E+00	6.768E+02
MN-54	0.000E+00	8.400E+05	0.000E+00	2.508E+05	0.000E+00	1.728E+06	0.000E+00	1.668E+05
MN-56	0.000E+00	1.284E-54	0.000E+00	1.632E-54	0.000E+00	8.484E-53	0.000E+00	2.292E-55
FE-55	2.856E+07	2.028E+07	0.000E+00	0.000E+00	1.284E+07	8.772E+06	0.000E+00	4.728E+06
FE-59	2.544E+07	5.940E+07	0.000E+00	0.000E+00	1.872E+07	1.404E+08	0.000E+00	2.292E+07
CO-58	0.000E+00	1.692E+06	0.000E+00	0.000E+00	0.000E+00	2.328E+07	0.000E+00	3.888E+06
CO-60	0.000E+00	6.996E+06	0.000E+00	0.000E+00	0.000E+00	9.120E+07	0.000E+00	1.572E+07
NI-63	1.824E+09	1.284E+08	0.000E+00	0.000E+00	0.000E+00	2.052E+07	0.000E+00	6.180E+07
NI-65	2.256E-53	2.892E-54	0.000E+00	0.000E+00	0.000E+00	1.560E-52	0.000E+00	1.320E-54
CU-64	0.000E+00	2.652E-08	0.000E+00	6.720E-08	0.000E+00	2.064E-06	0.000E+00	1.248E-08
ZN-65	3.000E+07	1.043E+08	0.000E+00	6.672E+07	0.000E+00	4.416E+07	0.000E+00	4.860E+07
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.084E-58
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	4.884E+07	0.000E+00	0.000E+00	0.000E+00	7.224E+06	0.000E+00	2.292E+07
RB-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-89	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-89	3.060E+07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.636E+06	0.000E+00	8.748E+05
SR-90	9.660E+08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.712E+07	0.000E+00	2.388E+08
SR-91	1.536E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.960E-11	0.000E+00	6.108E-13

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Age group:	TEEN	Pathway:	Grs/Goat/Meat (GMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	1.186E-50	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.024E-49	0.000E+00	5.052E-52
Y-90	1.087E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.964E+04	0.000E+00	2.928E-01
Y-91	1.145E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.692E+07	0.000E+00	3.072E+03
Y-91M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Y-92	1.536E-40	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.224E-36	0.000E+00	4.452E-42
Y-93	4.752E-13	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.452E-08	0.000E+00	1.308E-14
ZR-95	1.800E+05	5.676E+04	0.000E+00	8.340E+04	0.000E+00	1.308E+08	0.000E+00	3.900E+04
ZR-97	2.064E-06	4.092E-07	0.000E+00	6.204E-07	0.000E+00	1.108E-01	0.000E+00	1.884E-07
NB-95	2.148E+05	1.194E+05	0.000E+00	1.158E+05	0.000E+00	5.112E+08	0.000E+00	6.576E+04
MO-99	0.000E+00	9.924E+03	0.000E+00	2.268E+04	0.000E+00	1.776E+04	0.000E+00	1.896E+03
TC-99M	4.236E-22	1.182E-21	0.000E+00	1.764E-20	6.564E-22	7.764E-19	0.000E+00	1.536E-20
TC-101	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU-103	1.028E+07	0.000E+00	0.000E+00	3.624E+07	0.000E+00	8.592E+08	0.000E+00	4.392E+06
RU-105	5.796E-29	0.000E+00	0.000E+00	7.308E-28	0.000E+00	4.680E-26	0.000E+00	2.256E-29
RU-106	2.832E+08	0.000E+00	0.000E+00	5.460E+08	0.000E+00	1.356E+10	0.000E+00	3.564E+07
AG-110M	6.072E+05	5.748E+05	0.000E+00	1.096E+06	0.000E+00	1.608E+08	0.000E+00	3.492E+05
TE-125M	3.636E+07	1.308E+07	1.016E+07	0.000E+00	0.000E+00	1.073E+08	0.000E+00	4.860E+06
TE-127	2.160E-11	7.656E-12	1.488E-11	8.748E-11	0.000E+00	1.668E-09	0.000E+00	4.644E-12
TE-127M	1.129E+08	4.008E+07	2.688E+07	4.584E+08	0.000E+00	2.820E+08	0.000E+00	1.344E+07
TE-129	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-129M	1.140E+08	4.236E+07	3.684E+07	4.764E+08	0.000E+00	4.284E+08	0.000E+00	1.800E+07
TE-131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-131M	4.512E+01	2.160E+01	3.252E+01	2.256E+02	0.000E+00	1.740E+03	0.000E+00	1.800E+01
TE-132	1.392E+05	8.832E+04	9.300E+04	8.472E+05	0.000E+00	2.796E+06	0.000E+00	8.304E+04
I-130	2.040E-07	5.892E-07	4.800E-05	9.072E-07	0.000E+00	4.524E-07	0.000E+00	2.352E-07

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Age group:	TEEN	Pathway:	Grs/Goat/Meat (GMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.070E+06	1.500E+06	4.380E+08	2.580E+06	0.000E+00	2.964E+05	0.000E+00	8.052E+05
I-132	6.792E-60	1.776E-59	5.988E-58	2.796E-59	0.000E+00	7.740E-60	0.000E+00	6.384E-60
I-133	3.660E-02	6.216E-02	8.676E+00	1.091E-01	0.000E+00	4.704E-02	0.000E+00	1.896E-02
I-134	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I-135	4.320E-18	1.111E-17	7.152E-16	1.752E-17	0.000E+00	1.236E-17	0.000E+00	4.116E-18
CS-134	6.276E+07	1.476E+08	0.000E+00	4.692E+07	1.788E+07	1.836E+06	0.000E+00	6.852E+07
CS-136	1.128E+06	4.440E+06	0.000E+00	2.412E+06	3.804E+05	3.576E+05	0.000E+00	2.976E+06
CS-137	8.688E+07	1.156E+08	0.000E+00	3.936E+07	1.524E+07	1.644E+06	0.000E+00	4.032E+07
CS-138	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-139	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-140	2.856E+06	3.492E+03	0.000E+00	1.184E+03	2.352E+03	4.392E+06	0.000E+00	1.836E+05
BA-141	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-142	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA-140	3.660E-03	1.800E-03	0.000E+00	0.000E+00	0.000E+00	1.033E+02	0.000E+00	4.788E-04
LA-142	3.444E-93	1.536E-93	0.000E+00	0.000E+00	0.000E+00	4.656E-89	0.000E+00	3.816E-94
CE-141	1.416E+03	9.444E+02	0.000E+00	4.452E+02	0.000E+00	2.700E+06	0.000E+00	1.085E+02
CE-143	2.028E-03	1.476E+00	0.000E+00	6.612E-04	0.000E+00	4.428E+01	0.000E+00	1.644E-04
CE-144	1.476E+05	6.096E+04	0.000E+00	3.648E+04	0.000E+00	3.708E+07	0.000E+00	7.920E+03
PR-143	2.112E+03	8.448E+02	0.000E+00	4.908E+02	0.000E+00	6.960E+06	0.000E+00	1.054E+02
PR-144	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ND-147	7.476E+02	8.124E+02	0.000E+00	4.776E+02	0.000E+00	2.928E+06	0.000E+00	4.872E+01
W-187	2.076E-03	1.692E-03	0.000E+00	0.000E+00	0.000E+00	4.584E-01	0.000E+00	5.928E-04
NP-239	2.712E-02	2.568E-03	0.000E+00	8.040E-03	0.000E+00	4.128E+02	0.000E+00	1.428E-03

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Vegetation (VEG)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	2.590E+03	2.590E+03	2.590E+03	2.590E+03	2.590E+03	0.000E+00	2.590E+03
C-14	9.010E+04	1.800E+04	1.800E+04	1.800E+04	1.800E+04	1.800E+04	0.000E+00	1.800E+04
NA-24	2.390E+05	2.390E+05	2.390E+05	2.390E+05	2.390E+05	2.390E+05	0.000E+00	2.390E+05
P-32	1.610E+09	9.970E+07	0.000E+00	0.000E+00	0.000E+00	1.350E+08	0.000E+00	6.240E+07
CR-51	0.000E+00	0.000E+00	3.430E+04	1.350E+04	8.810E+04	1.040E+07	0.000E+00	6.170E+04
MN-54	0.000E+00	4.540E+08	0.000E+00	1.360E+08	0.000E+00	9.320E+08	0.000E+00	9.010E+07
MN-56	0.000E+00	1.420E+01	0.000E+00	1.800E+01	0.000E+00	9.360E+02	0.000E+00	2.530E+00
FE-55	3.260E+08	2.310E+08	0.000E+00	0.000E+00	1.470E+08	1.000E+08	0.000E+00	5.390E+07
FE-59	1.790E+08	4.190E+08	0.000E+00	0.000E+00	1.320E+08	9.900E+08	0.000E+00	1.620E+08
CO-58	0.000E+00	4.360E+07	0.000E+00	0.000E+00	0.000E+00	6.010E+08	0.000E+00	1.000E+08
CO-60	0.000E+00	2.490E+08	0.000E+00	0.000E+00	0.000E+00	3.240E+09	0.000E+00	5.600E+08
NI-63	1.610E+10	1.130E+09	0.000E+00	0.000E+00	0.000E+00	1.810E+08	0.000E+00	5.450E+08
NI-65	5.720E+01	7.310E+00	0.000E+00	0.000E+00	0.000E+00	3.970E+02	0.000E+00	3.330E+00
CU-64	0.000E+00	8.340E+03	0.000E+00	2.110E+04	0.000E+00	6.470E+05	0.000E+00	3.920E+03
ZN-65	4.240E+08	1.470E+09	0.000E+00	9.420E+08	0.000E+00	6.230E+08	0.000E+00	6.870E+08
ZN-69	5.140E-06	9.800E-06	0.000E+00	6.400E-06	0.000E+00	1.810E-05	0.000E+00	6.860E-07
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.910E+00
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.250E-11
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	2.740E+08	0.000E+00	0.000E+00	0.000E+00	4.050E+07	0.000E+00	1.290E+08
RB-88	0.000E+00	3.170E-22	0.000E+00	0.000E+00	0.000E+00	2.720E-29	0.000E+00	1.690E-22
RB-89	0.000E+00	3.500E-26	0.000E+00	0.000E+00	0.000E+00	5.360E-35	0.000E+00	2.470E-26
SR-89	1.510E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.800E+09	0.000E+00	4.340E+08
SR-90	7.510E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.110E+10	0.000E+00	1.850E+11
SR-91	2.850E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.290E+06	0.000E+00	1.130E+04

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Vegetation (VEG)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	3.970E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.010E+04	0.000E+00	1.690E+01
Y-90	1.240E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.020E+08	0.000E+00	3.350E+02
Y-91	7.840E+06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.210E+09	0.000E+00	2.100E+05
Y-91M	4.860E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.290E-07	0.000E+00	1.860E-10
Y-92	8.600E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.360E+04	0.000E+00	2.490E-02
Y-93	1.590E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.860E+06	0.000E+00	4.360E+00
ZR-95	1.720E+06	5.430E+05	0.000E+00	7.980E+05	0.000E+00	1.250E+09	0.000E+00	3.730E+05
ZR-97	3.120E+02	6.180E+01	0.000E+00	9.370E+01	0.000E+00	1.670E+07	0.000E+00	2.850E+01
NB-95	1.920E+05	1.070E+05	0.000E+00	1.030E+05	0.000E+00	4.560E+08	0.000E+00	5.870E+04
MO-99	0.000E+00	5.650E+06	0.000E+00	1.290E+07	0.000E+00	1.010E+07	0.000E+00	1.080E+06
TC-99M	2.740E+00	7.630E+00	0.000E+00	1.140E+02	4.240E+00	5.010E+03	0.000E+00	9.890E+01
TC-101	7.640E-31	1.090E-30	0.000E+00	1.970E-29	6.620E-31	1.860E-37	0.000E+00	1.070E-29
RU-103	6.820E+06	0.000E+00	0.000E+00	2.400E+07	0.000E+00	5.700E+08	0.000E+00	2.920E+06
RU-105	5.000E+01	0.000E+00	0.000E+00	6.310E+02	0.000E+00	4.040E+04	0.000E+00	1.940E+01
RU-106	3.100E+08	0.000E+00	0.000E+00	5.970E+08	0.000E+00	1.480E+10	0.000E+00	3.900E+07
AG-110M	1.520E+07	1.430E+07	0.000E+00	2.740E+07	0.000E+00	4.030E+09	0.000E+00	8.720E+06
TE-125M	1.480E+08	5.340E+07	4.140E+07	0.000E+00	0.000E+00	4.370E+08	0.000E+00	1.980E+07
TE-127	5.330E+03	1.890E+03	3.680E+03	2.160E+04	0.000E+00	4.120E+05	0.000E+00	1.150E+03
TE-127M	5.510E+08	1.960E+08	1.310E+08	2.240E+09	0.000E+00	1.370E+09	0.000E+00	6.560E+07
TE-129	7.140E-04	2.660E-04	5.100E-04	3.000E-03	0.000E+00	3.910E-03	0.000E+00	1.740E-04
TE-129M	3.620E+08	1.340E+08	1.170E+08	1.510E+09	0.000E+00	1.360E+09	0.000E+00	5.730E+07
TE-131	1.390E-15	5.750E-16	1.070E-15	6.100E-15	0.000E+00	1.140E-16	0.000E+00	4.360E-16
TE-131M	8.440E+05	4.050E+05	6.090E+05	4.220E+06	0.000E+00	3.250E+07	0.000E+00	3.380E+05
TE-132	3.910E+06	2.470E+06	2.610E+06	2.370E+07	0.000E+00	7.840E+07	0.000E+00	2.330E+06
I-130	3.510E+05	1.010E+06	8.280E+07	1.560E+06	0.000E+00	7.800E+05	0.000E+00	4.050E+05

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Vegetation (VEG)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	7.690E+07	1.080E+08	3.140E+10	1.850E+08	0.000E+00	2.130E+07	0.000E+00	5.780E+07
I-132	5.190E+01	1.360E+02	4.580E+03	2.140E+02	0.000E+00	5.920E+01	0.000E+00	4.880E+01
I-133	1.940E+06	3.290E+06	4.590E+08	5.760E+06	0.000E+00	2.490E+06	0.000E+00	1.000E+06
I-134	8.720E-05	2.310E-04	3.850E-03	3.640E-04	0.000E+00	3.050E-06	0.000E+00	8.310E-05
I-135	3.520E+04	9.070E+04	5.830E+06	1.430E+05	0.000E+00	1.000E+05	0.000E+00	3.360E+04
CS-134	7.100E+09	1.670E+10	0.000E+00	5.310E+09	2.030E+09	2.080E+08	0.000E+00	7.750E+09
CS-136	4.370E+07	1.720E+08	0.000E+00	9.370E+07	1.480E+07	1.380E+07	0.000E+00	1.160E+08
CS-137	1.010E+10	1.350E+10	0.000E+00	4.590E+09	1.780E+09	1.920E+08	0.000E+00	4.690E+09
CS-138	3.610E-11	6.940E-11	0.000E+00	5.120E-11	5.960E-12	3.150E-14	0.000E+00	3.470E-11
BA-139	2.690E-02	1.890E-05	0.000E+00	1.780E-05	1.300E-05	2.400E-01	0.000E+00	7.830E-04
BA-140	1.380E+08	1.690E+05	0.000E+00	5.740E+04	1.140E+05	2.130E+08	0.000E+00	8.900E+06
BA-141	1.080E-21	8.040E-25	0.000E+00	7.460E-25	5.500E-25	2.290E-27	0.000E+00	3.590E-23
BA-142	5.490E-39	5.490E-42	0.000E+00	4.640E-42	3.650E-42	1.680E-50	0.000E+00	3.380E-40
LA-140	1.810E+03	8.880E+02	0.000E+00	0.000E+00	0.000E+00	5.100E+07	0.000E+00	2.360E+02
LA-142	1.850E-04	8.240E-05	0.000E+00	0.000E+00	0.000E+00	2.510E+00	0.000E+00	2.050E-05
CE-141	2.830E+05	1.890E+05	0.000E+00	8.890E+04	0.000E+00	5.400E+08	0.000E+00	2.170E+04
CE-143	9.330E+02	6.790E+05	0.000E+00	3.040E+02	0.000E+00	2.040E+07	0.000E+00	7.580E+01
CE-144	5.270E+07	2.180E+07	0.000E+00	1.300E+07	0.000E+00	1.330E+10	0.000E+00	2.830E+06
PR-143	7.000E+04	2.800E+04	0.000E+00	1.630E+04	0.000E+00	2.300E+08	0.000E+00	3.490E+03
PR-144	2.900E-26	1.190E-26	0.000E+00	6.800E-27	0.000E+00	3.190E-29	0.000E+00	1.470E-27
ND-147	3.620E+04	3.940E+04	0.000E+00	2.310E+04	0.000E+00	1.420E+08	0.000E+00	2.360E+03
W-187	3.540E+04	2.880E+04	0.000E+00	0.000E+00	0.000E+00	7.800E+06	0.000E+00	1.010E+04
NP-239	1.390E+03	1.310E+02	0.000E+00	4.100E+02	0.000E+00	2.100E+07	0.000E+00	7.260E+01

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.270E+03	1.270E+03	1.270E+03	1.270E+03	1.270E+03	0.000E+00	1.270E+03
C-14	2.600E+04	4.870E+03	4.870E+03	4.870E+03	4.870E+03	4.870E+03	0.000E+00	4.870E+03
NA-24	1.380E+04	1.380E+04	1.380E+04	1.380E+04	1.380E+04	1.380E+04	0.000E+00	1.380E+04
P-32	1.890E+06	1.100E+05	0.000E+00	0.000E+00	0.000E+00	9.280E+04	0.000E+00	7.160E+04
CR-51	0.000E+00	0.000E+00	7.500E+01	3.070E+01	2.100E+04	3.000E+03	0.000E+00	1.350E+02
MN-54	0.000E+00	5.110E+04	0.000E+00	1.270E+04	1.980E+06	6.680E+04	0.000E+00	8.400E+03
MN-56	0.000E+00	1.700E+00	0.000E+00	1.790E+00	1.520E+04	5.740E+04	0.000E+00	2.520E-01
FE-55	3.340E+04	2.380E+04	0.000E+00	0.000E+00	1.240E+05	6.390E+03	0.000E+00	5.540E+03
FE-59	1.590E+04	3.700E+04	0.000E+00	0.000E+00	1.530E+06	1.780E+05	0.000E+00	1.430E+04
CO-58	0.000E+00	2.070E+03	0.000E+00	0.000E+00	1.340E+06	9.520E+04	0.000E+00	2.780E+03
CO-60	0.000E+00	1.510E+04	0.000E+00	0.000E+00	8.720E+06	2.590E+05	0.000E+00	1.980E+04
NI-63	5.800E+05	4.340E+04	0.000E+00	0.000E+00	3.070E+05	1.420E+04	0.000E+00	1.980E+04
NI-65	2.180E+00	2.930E-01	0.000E+00	0.000E+00	9.360E+03	3.670E+04	0.000E+00	1.270E-01
CU-64	0.000E+00	2.030E+00	0.000E+00	6.410E+00	1.110E+04	6.140E+04	0.000E+00	8.480E-01
ZN-65	3.860E+04	1.340E+05	0.000E+00	8.640E+04	1.240E+06	4.660E+04	0.000E+00	6.240E+04
ZN-69	4.830E-02	9.200E-02	0.000E+00	6.020E-02	1.580E+03	2.850E+02	0.000E+00	6.460E-03
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.440E+02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.330E+02
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.830E+01
RB-86	0.000E+00	1.900E+05	0.000E+00	0.000E+00	0.000E+00	1.770E+04	0.000E+00	8.400E+04
RB-88	0.000E+00	5.460E+02	0.000E+00	0.000E+00	0.000E+00	2.920E-05	0.000E+00	2.720E+02
RB-89	0.000E+00	3.520E+02	0.000E+00	0.000E+00	0.000E+00	3.380E-07	0.000E+00	2.330E+02
SR-89	4.340E+05	0.000E+00	0.000E+00	0.000E+00	2.420E+06	3.710E+05	0.000E+00	1.250E+04
SR-90	1.080E+08	0.000E+00	0.000E+00	0.000E+00	1.650E+07	7.650E+05	0.000E+00	6.680E+06
SR-91	8.800E+01	0.000E+00	0.000E+00	0.000E+00	6.070E+04	2.590E+05	0.000E+00	3.510E+00

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	9.520E+00	0.000E+00	0.000E+00	0.000E+00	2.740E+04	1.190E+05	0.000E+00	4.060E-01
Y-90	2.980E+03	0.000E+00	0.000E+00	0.000E+00	2.930E+05	5.590E+05	0.000E+00	8.000E+01
Y-91	6.610E+05	0.000E+00	0.000E+00	0.000E+00	2.940E+06	4.090E+05	0.000E+00	1.770E+04
Y-91M	3.700E-01	0.000E+00	0.000E+00	0.000E+00	3.200E+03	3.020E+01	0.000E+00	1.420E-02
Y-92	1.470E+01	0.000E+00	0.000E+00	0.000E+00	2.680E+04	1.650E+05	0.000E+00	4.290E-01
Y-93	1.350E+02	0.000E+00	0.000E+00	0.000E+00	8.320E+04	5.790E+05	0.000E+00	3.720E+00
ZR-95	1.460E+05	4.580E+04	0.000E+00	6.740E+04	2.690E+06	1.490E+05	0.000E+00	3.150E+04
ZR-97	1.380E+02	2.720E+01	0.000E+00	4.120E+01	1.300E+05	6.300E+05	0.000E+00	1.260E+01
NB-95	1.860E+04	1.030E+04	0.000E+00	1.000E+04	7.510E+05	9.680E+04	0.000E+00	5.660E+03
MO-99	0.000E+00	1.690E+02	0.000E+00	4.110E+02	1.540E+05	2.690E+05	0.000E+00	3.220E+01
TC-99M	1.380E-03	3.860E-03	0.000E+00	5.760E-02	1.150E+03	6.130E+03	0.000E+00	4.990E-02
TC-101	5.920E-05	8.400E-05	0.000E+00	1.520E-03	6.670E+02	8.720E-07	0.000E+00	8.240E-04
RU-103	2.100E+03	0.000E+00	0.000E+00	7.430E+03	7.830E+05	1.090E+05	0.000E+00	8.960E+02
RU-105	1.120E+00	0.000E+00	0.000E+00	1.410E+00	1.820E+04	9.040E+04	0.000E+00	4.340E-01
RU-106	9.840E+04	0.000E+00	0.000E+00	1.900E+05	1.610E+07	9.600E+05	0.000E+00	1.240E+04
AG-110M	1.380E+04	1.310E+04	0.000E+00	2.500E+04	6.750E+06	2.730E+05	0.000E+00	7.990E+03
TE-125M	4.880E+03	2.240E+03	1.400E+03	0.000E+00	5.360E+05	7.500E+04	0.000E+00	6.670E+02
TE-127	2.010E+00	9.120E-01	1.420E+00	7.280E+00	1.120E+04	8.080E+04	0.000E+00	4.420E-01
TE-127M	1.800E+04	8.160E+03	4.380E+03	6.540E+04	1.660E+06	1.590E+05	0.000E+00	2.180E+03
TE-129	7.100E-02	3.380E-02	5.180E-02	2.660E-01	3.300E+03	1.620E+03	0.000E+00	1.760E-02
TE-129M	1.390E+04	6.580E+03	4.580E+03	5.190E+04	1.980E+06	4.050E+05	0.000E+00	2.250E+03
TE-131	1.580E-02	8.320E-03	1.240E-02	6.180E-02	2.340E+03	1.510E+01	0.000E+00	5.040E-03
TE-131M	9.840E+01	6.010E+01	7.250E+01	4.390E+02	2.380E+05	6.210E+05	0.000E+00	4.020E+01
TE-132	3.600E+02	2.900E+02	2.460E+02	1.950E+03	4.490E+05	4.630E+05	0.000E+00	2.190E+02
I-130	6.240E+03	1.790E+04	1.490E+06	2.750E+04	0.000E+00	9.120E+03	0.000E+00	7.170E+03

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	3.540E+04	4.910E+04	1.460E+07	8.400E+04	0.000E+00	6.490E+03	0.000E+00	2.640E+04
I-132	1.590E+03	4.380E+03	1.510E+05	6.920E+03	0.000E+00	1.270E+03	0.000E+00	1.580E+03
I-133	1.220E+04	2.050E+04	2.920E+06	3.590E+04	0.000E+00	1.030E+04	0.000E+00	6.220E+03
I-134	8.880E+02	2.320E+03	3.950E+04	3.660E+03	0.000E+00	2.040E+01	0.000E+00	8.400E+02
I-135	3.700E+03	9.440E+03	6.210E+05	1.490E+04	0.000E+00	6.950E+03	0.000E+00	3.490E+03
CS-134	5.020E+05	1.130E+06	0.000E+00	3.750E+05	1.460E+05	9.760E+03	0.000E+00	5.490E+05
CS-136	5.150E+04	1.940E+05	0.000E+00	1.100E+05	1.780E+04	1.090E+04	0.000E+00	1.370E+05
CS-137	6.700E+05	8.480E+05	0.000E+00	3.040E+05	1.210E+05	8.480E+03	0.000E+00	3.110E+05
CS-138	4.660E+02	8.560E+02	0.000E+00	6.620E+02	7.870E+01	2.700E-01	0.000E+00	4.460E+02
BA-139	1.340E+00	9.440E-04	0.000E+00	8.880E-04	6.460E+03	6.450E+03	0.000E+00	3.900E-02
BA-140	5.470E+04	6.700E+01	0.000E+00	2.280E+01	2.030E+06	2.290E+05	0.000E+00	3.520E+03
BA-141	1.420E-01	1.060E-04	0.000E+00	9.840E-05	3.290E+03	7.460E-04	0.000E+00	4.740E-03
BA-142	3.700E-02	3.700E-05	0.000E+00	3.140E-05	1.910E+03	4.790E-10	0.000E+00	2.270E-03
LA-140	4.790E+02	2.360E+02	0.000E+00	0.000E+00	2.140E+05	4.870E+05	0.000E+00	6.260E+01
LA-142	9.600E-01	4.250E-01	0.000E+00	0.000E+00	1.020E+04	1.200E+04	0.000E+00	1.060E-01
CE-141	2.840E+04	1.900E+04	0.000E+00	8.880E+03	6.140E+05	1.260E+05	0.000E+00	2.170E+03
CE-143	2.660E+02	1.940E+02	0.000E+00	8.640E+01	1.300E+05	2.550E+05	0.000E+00	2.160E+01
CE-144	4.890E+06	2.020E+06	0.000E+00	1.210E+06	1.340E+07	8.640E+05	0.000E+00	2.620E+05
PR-143	1.340E+04	5.310E+03	0.000E+00	3.090E+03	4.830E+05	2.140E+05	0.000E+00	6.620E+02
PR-144	4.300E-02	1.760E-02	0.000E+00	1.010E-02	1.750E+03	2.350E-04	0.000E+00	2.180E-03
ND-147	7.860E+03	8.560E+03	0.000E+00	5.020E+03	3.720E+05	1.820E+05	0.000E+00	5.130E+02
W-187	1.200E+01	9.760E+00	0.000E+00	0.000E+00	4.740E+04	1.770E+05	0.000E+00	3.430E+00
NP-239	3.380E+02	3.190E+01	0.000E+00	1.000E+02	6.490E+04	1.320E+05	0.000E+00	1.770E+01

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NA-24	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.390E+07	1.190E+07
P-32	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CR-51	4.660E+06	4.660E+06	4.660E+06	4.660E+06	4.660E+06	4.660E+06	5.510E+06	4.660E+06
MN-54	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.630E+09	1.390E+09
MN-56	9.020E+05	9.020E+05	9.020E+05	9.020E+05	9.020E+05	9.020E+05	1.070E+06	9.020E+05
FE-55	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
FE-59	2.730E+08	2.730E+08	2.730E+08	2.730E+08	2.730E+08	2.730E+08	3.210E+08	2.730E+08
CO-58	3.790E+08	3.790E+08	3.790E+08	3.790E+08	3.790E+08	3.790E+08	4.440E+08	3.790E+08
CO-60	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.530E+10	2.150E+10
NI-63	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NI-65	2.970E+05	2.970E+05	2.970E+05	2.970E+05	2.970E+05	2.970E+05	3.450E+05	2.970E+05
CU-64	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.880E+05	6.070E+05
ZN-65	7.470E+08	7.470E+08	7.470E+08	7.470E+08	7.470E+08	7.470E+08	8.590E+08	7.470E+08
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	4.870E+03	4.870E+03	4.870E+03	4.870E+03	4.870E+03	4.870E+03	7.080E+03	4.870E+03
BR-84	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.360E+05	2.030E+05
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	8.990E+06	8.990E+06	8.990E+06	8.990E+06	8.990E+06	8.990E+06	1.030E+07	8.990E+06
RB-88	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.780E+04	3.310E+04
RB-89	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.480E+05	1.230E+05
SR-89	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.510E+04	2.160E+04
SR-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-91	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.510E+06	2.150E+06

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	7.770E+05	7.770E+05	7.770E+05	7.770E+05	7.770E+05	7.770E+05	8.630E+05	7.770E+05
Y-90	4.490E+03	4.490E+03	4.490E+03	4.490E+03	4.490E+03	4.490E+03	5.310E+03	4.490E+03
Y-91	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.210E+06	1.070E+06
Y-91M	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.160E+05	1.000E+05
Y-92	1.800E+05	1.800E+05	1.800E+05	1.800E+05	1.800E+05	1.800E+05	2.140E+05	1.800E+05
Y-93	1.830E+05	1.830E+05	1.830E+05	1.830E+05	1.830E+05	1.830E+05	2.510E+05	1.830E+05
ZR-95	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.840E+08	2.450E+08
ZR-97	2.960E+06	2.960E+06	2.960E+06	2.960E+06	2.960E+06	2.960E+06	3.440E+06	2.960E+06
NB-95	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.610E+08	1.370E+08
MO-99	3.990E+06	3.990E+06	3.990E+06	3.990E+06	3.990E+06	3.990E+06	4.630E+06	3.990E+06
TC-99M	1.840E+05	1.840E+05	1.840E+05	1.840E+05	1.840E+05	1.840E+05	2.110E+05	1.840E+05
TC-101	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.260E+04	2.040E+04
RU-103	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.260E+08	1.080E+08
RU-105	6.360E+05	6.360E+05	6.360E+05	6.360E+05	6.360E+05	6.360E+05	7.210E+05	6.360E+05
RU-106	4.220E+08	4.220E+08	4.220E+08	4.220E+08	4.220E+08	4.220E+08	5.070E+08	4.220E+08
AG-110M	3.440E+09	3.440E+09	3.440E+09	3.440E+09	3.440E+09	3.440E+09	4.010E+09	3.440E+09
TE-125M	1.550E+06	1.550E+06	1.550E+06	1.550E+06	1.550E+06	1.550E+06	2.130E+06	1.550E+06
TE-127	2.980E+03	2.980E+03	2.980E+03	2.980E+03	2.980E+03	2.980E+03	3.280E+03	2.980E+03
TE-127M	9.160E+04	9.160E+04	9.160E+04	9.160E+04	9.160E+04	9.160E+04	1.080E+05	9.160E+04
TE-129	2.620E+04	2.620E+04	2.620E+04	2.620E+04	2.620E+04	2.620E+04	3.100E+04	2.620E+04
TE-129M	1.980E+07	1.980E+07	1.980E+07	1.980E+07	1.980E+07	1.980E+07	2.310E+07	1.980E+07
TE-131	2.920E+04	2.920E+04	2.920E+04	2.920E+04	2.920E+04	2.920E+04	3.450E+07	2.920E+04
TE-131M	8.030E+06	8.030E+06	8.030E+06	8.030E+06	8.030E+06	8.030E+06	9.460E+06	8.030E+06
TE-132	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.980E+06	4.230E+06
I-130	5.510E+06	5.510E+06	5.510E+06	5.510E+06	5.510E+06	5.510E+06	6.690E+06	5.510E+06

APPENDIX H

R_i Teen Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	TEEN	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.720E+07	1.720E+07	1.720E+07	1.720E+07	1.720E+07	1.720E+07	2.090E+07	1.720E+07
I-132	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.470E+06	1.250E+06
I-133	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.980E+06	2.450E+06
I-134	4.470E+05	4.470E+05	4.470E+05	4.470E+05	4.470E+05	4.470E+05	5.300E+05	4.470E+05
I-135	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.950E+06	2.530E+06
CS-134	6.860E+09	6.860E+09	6.860E+09	6.860E+09	6.860E+09	6.860E+09	8.000E+09	6.860E+09
CS-136	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.710E+08	1.510E+08
CS-137	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.200E+10	1.030E+10
CS-138	3.590E+05	3.590E+05	3.590E+05	3.590E+05	3.590E+05	3.590E+05	4.100E+05	3.590E+05
BA-139	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.190E+05	1.060E+05
BA-140	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.350E+07	2.050E+07
BA-141	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.750E+04	4.170E+04
BA-142	4.490E+04	4.490E+04	4.490E+04	4.490E+04	4.490E+04	4.490E+04	5.110E+04	4.490E+04
LA-140	1.920E+07	1.920E+07	1.920E+07	1.920E+07	1.920E+07	1.920E+07	2.180E+07	1.920E+07
LA-142	7.600E+05	7.600E+05	7.600E+05	7.600E+05	7.600E+05	7.600E+05	9.120E+05	7.600E+05
CE-141	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.540E+07	1.370E+07
CE-143	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.630E+06	2.310E+06
CE-144	6.950E+07	6.950E+07	6.950E+07	6.950E+07	6.950E+07	6.950E+07	8.040E+07	6.950E+07
PR-143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR-144	1.830E+03	1.830E+03	1.830E+03	1.830E+03	1.830E+03	1.830E+03	2.110E+03	1.830E+03
ND-147	8.390E+06	8.390E+06	8.390E+06	8.390E+06	8.390E+06	8.390E+06	1.010E+07	8.390E+06
W-187	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.730E+06	2.350E+06
NP-239	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.980E+06	1.710E+06

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.570E+03	1.570E+03	1.570E+03	1.570E+03	1.570E+03	0.000E+00	1.570E+03
C-14	1.020E+05	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.040E+04	0.000E+00	2.040E+04
NA-24	8.850E+06	8.850E+06	8.850E+06	8.850E+06	8.850E+06	8.850E+06	0.000E+00	8.850E+06
P-32	7.780E+10	3.640E+09	0.000E+00	0.000E+00	0.000E+00	2.150E+09	0.000E+00	3.000E+09
CR-51	0.000E+00	0.000E+00	5.650E+04	1.540E+04	1.030E+05	5.400E+06	0.000E+00	1.020E+05
MN-54	0.000E+00	2.100E+07	0.000E+00	5.880E+06	0.000E+00	1.760E+07	0.000E+00	5.590E+06
MN-56	0.000E+00	1.260E-02	0.000E+00	1.530E-02	0.000E+00	1.830E+00	0.000E+00	2.860E-03
FE-55	1.120E+08	5.930E+07	0.000E+00	0.000E+00	3.350E+07	1.100E+07	0.000E+00	1.840E+07
FE-59	1.200E+08	1.950E+08	0.000E+00	0.000E+00	5.640E+07	2.030E+08	0.000E+00	9.690E+07
CO-58	0.000E+00	1.210E+07	0.000E+00	0.000E+00	0.000E+00	7.070E+07	0.000E+00	3.710E+07
CO-60	0.000E+00	4.320E+07	0.000E+00	0.000E+00	0.000E+00	2.390E+08	0.000E+00	1.270E+08
NI-63	2.960E+10	1.590E+09	0.000E+00	0.000E+00	0.000E+00	1.070E+08	0.000E+00	1.010E+09
NI-65	1.660E+00	1.560E-01	0.000E+00	0.000E+00	0.000E+00	1.910E+01	0.000E+00	9.100E-02
CU-64	0.000E+00	7.460E+04	0.000E+00	1.800E+05	0.000E+00	3.500E+06	0.000E+00	4.510E+04
ZN-65	4.130E+09	1.100E+10	0.000E+00	6.940E+09	0.000E+00	1.930E+09	0.000E+00	6.850E+09
ZN-69	9.460E-12	1.370E-11	0.000E+00	8.300E-12	0.000E+00	8.620E-10	0.000E+00	1.260E-12
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.400E-01
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.510E-23
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	8.770E+09	0.000E+00	0.000E+00	0.000E+00	5.640E+08	0.000E+00	5.390E+09
RB-88	0.000E+00	7.160E-45	0.000E+00	0.000E+00	0.000E+00	3.510E-46	0.000E+00	4.970E-45
RB-89	0.000E+00	1.340E-52	0.000E+00	0.000E+00	0.000E+00	1.170E-54	0.000E+00	1.190E-52
SR-89	6.620E+09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.560E+08	0.000E+00	1.890E+08
SR-90	1.120E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.510E+09	0.000E+00	2.830E+10
SR-91	1.300E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.880E+05	0.000E+00	4.920E+03

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	2.180E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.130E+01	0.000E+00	8.750E-02
Y-90	3.220E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.170E+05	0.000E+00	8.620E+00
Y-91	3.900E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.200E+06	0.000E+00	1.040E+03
Y-91M	2.670E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.240E-16	0.000E+00	9.730E-21
Y-92	2.530E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.310E+00	0.000E+00	7.240E-06
Y-93	1.010E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.510E+04	0.000E+00	2.780E-02
ZR-95	3.830E+03	8.420E+02	0.000E+00	1.210E+03	0.000E+00	8.790E+05	0.000E+00	7.500E+02
ZR-97	1.920E+00	2.770E-01	0.000E+00	3.980E-01	0.000E+00	4.200E+04	0.000E+00	1.640E-01
NB-95	3.180E+05	1.240E+05	0.000E+00	1.160E+05	0.000E+00	2.290E+08	0.000E+00	8.840E+04
MO-99	0.000E+00	8.140E+07	0.000E+00	1.740E+08	0.000E+00	6.730E+07	0.000E+00	2.010E+07
TC-99M	1.320E+01	2.590E+01	0.000E+00	3.760E+02	1.320E+01	1.470E+04	0.000E+00	4.290E+02
TC-101	1.160E-59	1.220E-59	0.000E+00	2.080E-58	6.440E-60	3.870E-59	0.000E+00	1.540E-58
RU-103	4.280E+03	0.000E+00	0.000E+00	1.080E+04	0.000E+00	1.110E+05	0.000E+00	1.650E+03
RU-105	3.820E-03	0.000E+00	0.000E+00	3.360E-02	0.000E+00	2.490E+00	0.000E+00	1.390E-03
RU-106	9.240E+04	0.000E+00	0.000E+00	1.250E+05	0.000E+00	1.440E+06	0.000E+00	1.150E+04
AG-110M	2.090E+08	1.410E+08	0.000E+00	2.630E+08	0.000E+00	1.680E+10	0.000E+00	1.130E+08
TE-125M	7.380E+07	2.000E+07	2.070E+07	0.000E+00	0.000E+00	7.120E+07	0.000E+00	9.840E+06
TE-127	2.980E+03	8.020E+02	2.060E+03	8.470E+03	0.000E+00	1.160E+05	0.000E+00	6.380E+02
TE-127M	2.080E+08	5.600E+07	4.970E+07	5.930E+08	0.000E+00	1.680E+08	0.000E+00	2.470E+07
TE-129	1.280E-09	3.580E-10	9.160E-10	3.750E-09	0.000E+00	7.990E-08	0.000E+00	3.050E-10
TE-129M	2.710E+08	7.580E+07	8.750E+07	7.970E+08	0.000E+00	3.310E+08	0.000E+00	4.210E+07
TE-131	1.620E-32	4.920E-33	1.240E-32	4.890E-32	0.000E+00	8.490E-32	0.000E+00	4.810E-33
TE-131M	1.600E+06	5.530E+05	1.140E+06	5.350E+06	0.000E+00	2.240E+07	0.000E+00	5.890E+05
TE-132	1.020E+07	4.530E+06	6.600E+06	4.210E+07	0.000E+00	4.570E+07	0.000E+00	5.480E+06
I-130	1.730E+06	3.490E+06	3.840E+08	5.220E+06	0.000E+00	1.630E+06	0.000E+00	1.800E+06

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.300E+09	1.310E+09	4.330E+11	2.150E+09	0.000E+00	1.170E+08	0.000E+00	7.450E+08
I-132	6.890E-01	1.270E+00	5.870E+01	1.940E+00	0.000E+00	1.490E+00	0.000E+00	5.820E-01
I-133	1.720E+07	2.120E+07	3.940E+09	3.540E+07	0.000E+00	8.560E+06	0.000E+00	8.030E+06
I-134	8.480E-12	1.570E-11	3.620E-10	2.410E-11	0.000E+00	1.040E-11	0.000E+00	7.250E-12
I-135	5.400E+04	9.720E+04	8.610E+06	1.490E+05	0.000E+00	7.400E+04	0.000E+00	4.600E+04
CS-134	2.260E+10	3.720E+10	0.000E+00	1.150E+10	4.130E+09	2.000E+08	0.000E+00	7.840E+09
CS-136	1.010E+09	2.780E+09	0.000E+00	1.480E+09	2.210E+08	9.770E+07	0.000E+00	1.800E+09
CS-137	3.220E+10	3.090E+10	0.000E+00	1.010E+10	3.620E+09	1.930E+08	0.000E+00	4.550E+09
CS-138	3.980E-23	5.530E-23	0.000E+00	3.890E-23	4.190E-24	2.550E-23	0.000E+00	3.510E-23
BA-139	2.010E-07	1.070E-10	0.000E+00	9.360E-11	6.300E-11	1.160E-05	0.000E+00	5.820E-09
BA-140	1.170E+08	1.030E+05	0.000E+00	3.340E+04	6.120E+04	5.930E+07	0.000E+00	6.840E+06
BA-141	1.850E-45	1.040E-48	0.000E+00	8.960E-49	6.090E-48	1.050E-45	0.000E+00	6.020E-47
BA-142	1.150E-79	8.310E-83	0.000E+00	6.720E-83	4.890E-83	1.510E-81	0.000E+00	6.450E-81
LA-140	1.940E+01	6.780E+00	0.000E+00	0.000E+00	0.000E+00	1.890E+05	0.000E+00	2.290E+00
LA-142	8.100E-11	2.580E-11	0.000E+00	0.000E+00	0.000E+00	5.120E-06	0.000E+00	8.090E-12
CE-141	2.190E+04	1.090E+04	0.000E+00	4.780E+03	0.000E+00	1.360E+07	0.000E+00	1.620E+03
CE-143	1.870E+02	1.020E+05	0.000E+00	4.260E+01	0.000E+00	1.490E+06	0.000E+00	1.470E+01
CE-144	1.620E+06	5.090E+05	0.000E+00	2.820E+05	0.000E+00	1.330E+08	0.000E+00	8.660E+04
PR-143	7.180E+02	2.160E+02	0.000E+00	1.170E+02	0.000E+00	7.750E+05	0.000E+00	3.560E+01
PR-144	2.680E-53	8.290E-54	0.000E+00	4.380E-54	0.000E+00	1.780E-50	0.000E+00	1.350E-54
ND-147	4.450E+02	3.600E+02	0.000E+00	1.980E+02	0.000E+00	5.700E+05	0.000E+00	2.790E+01
W-187	2.890E+04	1.710E+04	0.000E+00	0.000E+00	0.000E+00	2.400E+06	0.000E+00	7.670E+03
NP-239	1.720E+01	1.240E+00	0.000E+00	3.580E+00	0.000E+00	9.170E+04	0.000E+00	8.710E-01

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	3.200E+03	3.200E+03	3.200E+03	3.200E+03	3.200E+03	0.000E+00	3.200E+03
C-14	1.020E+05	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.040E+04	0.000E+00	2.040E+04
NA-24	1.060E+06	1.060E+06	1.060E+06	1.060E+06	1.060E+06	1.060E+06	0.000E+00	1.060E+06
P-32	9.330E+10	4.370E+09	0.000E+00	0.000E+00	0.000E+00	2.580E+09	0.000E+00	3.600E+09
CR-51	0.000E+00	0.000E+00	6.780E+03	1.850E+03	1.240E+04	6.480E+05	0.000E+00	1.220E+04
MN-54	0.000E+00	2.520E+06	0.000E+00	7.060E+05	0.000E+00	2.110E+06	0.000E+00	6.700E+05
MN-56	0.000E+00	1.520E-03	0.000E+00	1.840E-03	0.000E+00	2.200E-01	0.000E+00	3.430E-04
FE-55	1.450E+06	7.710E+05	0.000E+00	0.000E+00	4.360E+05	1.430E+05	0.000E+00	2.390E+05
FE-59	1.560E+06	2.530E+06	0.000E+00	0.000E+00	7.330E+05	2.630E+06	0.000E+00	1.260E+06
CO-58	0.000E+00	1.450E+06	0.000E+00	0.000E+00	0.000E+00	8.490E+06	0.000E+00	4.450E+06
CO-60	0.000E+00	5.180E+06	0.000E+00	0.000E+00	0.000E+00	2.870E+07	0.000E+00	1.530E+07
NI-63	3.560E+09	1.900E+08	0.000E+00	0.000E+00	0.000E+00	1.280E+07	0.000E+00	1.210E+08
NI-65	1.990E-01	1.870E-02	0.000E+00	0.000E+00	0.000E+00	2.290E+00	0.000E+00	1.090E-02
CU-64	0.000E+00	8.320E+03	0.000E+00	2.010E+04	0.000E+00	3.900E+05	0.000E+00	5.020E+03
ZN-65	4.960E+08	1.320E+09	0.000E+00	8.330E+08	0.000E+00	2.320E+08	0.000E+00	8.220E+08
ZN-69	1.140E-12	1.640E-12	0.000E+00	9.960E-13	0.000E+00	1.030E-10	0.000E+00	1.520E-13
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.280E-02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.820E-24
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	1.050E+09	0.000E+00	0.000E+00	0.000E+00	6.770E+07	0.000E+00	6.470E+08
RB-88	0.000E+00	8.590E-46	0.000E+00	0.000E+00	0.000E+00	4.210E-47	0.000E+00	5.970E-46
RB-89	0.000E+00	1.610E-53	0.000E+00	0.000E+00	0.000E+00	1.410E-55	0.000E+00	1.430E-53
SR-89	1.390E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.380E+08	0.000E+00	3.970E+08
SR-90	2.350E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.160E+09	0.000E+00	5.950E+10
SR-91	2.740E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.040E+05	0.000E+00	1.030E+04

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	4.580E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.680E+01	0.000E+00	1.840E-01
Y-90	3.870E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.100E+05	0.000E+00	1.030E+00
Y-91	4.680E+03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.240E+05	0.000E+00	1.250E+02
Y-91M	3.210E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.280E-17	0.000E+00	1.170E-21
Y-92	3.040E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.770E-01	0.000E+00	8.690E-07
Y-93	1.210E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.810E+03	0.000E+00	3.330E-03
ZR-95	4.600E+02	1.010E+02	0.000E+00	1.450E+02	0.000E+00	1.050E+05	0.000E+00	9.000E+01
ZR-97	2.300E-01	3.330E-02	0.000E+00	4.780E-02	0.000E+00	5.040E+03	0.000E+00	1.960E-02
NB-95	3.810E+04	1.490E+04	0.000E+00	1.400E+04	0.000E+00	2.750E+07	0.000E+00	1.060E+04
MO-99	0.000E+00	9.760E+06	0.000E+00	2.090E+07	0.000E+00	8.080E+06	0.000E+00	2.420E+06
TC-99M	1.590E+00	3.110E+00	0.000E+00	4.520E+01	1.580E+00	1.770E+03	0.000E+00	5.150E+01
TC-101	1.400E-60	1.460E-60	0.000E+00	2.490E-59	7.720E-61	4.640E-60	0.000E+00	1.850E-59
RU-103	5.140E+02	0.000E+00	0.000E+00	1.290E+03	0.000E+00	1.330E+04	0.000E+00	1.980E+02
RU-105	4.580E-04	0.000E+00	0.000E+00	4.030E-03	0.000E+00	2.990E-01	0.000E+00	1.660E-04
RU-106	1.110E+04	0.000E+00	0.000E+00	1.500E+04	0.000E+00	1.720E+05	0.000E+00	1.380E+03
AG-110M	2.510E+07	1.690E+07	0.000E+00	3.150E+07	0.000E+00	2.010E+09	0.000E+00	1.350E+07
TE-125M	8.850E+06	2.400E+06	2.480E+06	0.000E+00	0.000E+00	8.540E+06	0.000E+00	1.180E+06
TE-127	3.570E+02	9.630E+01	2.470E+02	1.020E+03	0.000E+00	1.390E+04	0.000E+00	7.660E+01
TE-127M	2.500E+07	6.720E+06	5.970E+06	7.120E+07	0.000E+00	2.020E+07	0.000E+00	2.960E+06
TE-129	1.540E-10	4.300E-11	1.100E-10	4.510E-10	0.000E+00	9.590E-09	0.000E+00	3.660E-11
TE-129M	3.260E+07	9.090E+06	1.050E+07	9.560E+07	0.000E+00	3.970E+07	0.000E+00	5.060E+06
TE-131	1.940E-33	5.910E-34	1.480E-33	5.860E-33	0.000E+00	1.020E-32	0.000E+00	5.770E-34
TE-131M	1.920E+05	6.640E+04	1.360E+05	6.420E+05	0.000E+00	2.690E+06	0.000E+00	7.060E+04
TE-132	1.230E+06	5.440E+05	7.920E+05	5.050E+06	0.000E+00	5.480E+06	0.000E+00	6.570E+05
I-130	2.070E+06	4.190E+06	4.610E+08	6.260E+06	0.000E+00	1.960E+06	0.000E+00	2.160E+06

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.560E+09	1.570E+09	5.200E+11	2.580E+09	0.000E+00	1.400E+08	0.000E+00	8.940E+08
I-132	8.270E-01	1.520E+00	7.050E+01	2.330E+00	0.000E+00	1.790E+00	0.000E+00	6.990E-01
I-133	2.060E+07	2.550E+07	4.730E+09	4.250E+07	0.000E+00	1.030E+07	0.000E+00	9.640E+06
I-134	1.020E-11	1.890E-11	4.350E-10	2.890E-11	0.000E+00	1.250E-11	0.000E+00	8.700E-12
I-135	6.480E+04	1.170E+05	1.030E+07	1.790E+05	0.000E+00	8.880E+04	0.000E+00	5.520E+04
CS-134	6.790E+10	1.110E+11	0.000E+00	3.450E+10	1.240E+10	6.010E+08	0.000E+00	2.350E+10
CS-136	3.030E+09	8.340E+09	0.000E+00	4.440E+09	6.630E+08	2.930E+08	0.000E+00	5.400E+09
CS-137	9.670E+10	9.260E+10	0.000E+00	3.020E+10	1.090E+10	5.800E+08	0.000E+00	1.370E+10
CS-138	1.190E-22	1.660E-22	0.000E+00	1.170E-22	1.260E-23	7.640E-23	0.000E+00	1.050E-22
BA-139	2.410E-08	1.290E-11	0.000E+00	1.120E-11	7.560E-12	1.390E-06	0.000E+00	6.980E-10
BA-140	1.410E+07	1.230E+04	0.000E+00	4.010E+03	7.340E+03	7.120E+06	0.000E+00	8.200E+05
BA-141	2.220E-46	1.240E-49	0.000E+00	1.080E-49	7.300E-49	1.270E-46	0.000E+00	7.230E-48
BA-142	1.390E-80	9.970E-84	0.000E+00	8.070E-84	5.870E-84	1.810E-82	0.000E+00	7.740E-82
LA-140	2.330E+00	8.140E-01	0.000E+00	0.000E+00	0.000E+00	2.270E+04	0.000E+00	2.740E-01
LA-142	9.730E-12	3.100E-12	0.000E+00	0.000E+00	0.000E+00	6.140E-07	0.000E+00	9.710E-13
CE-141	2.620E+03	1.310E+03	0.000E+00	5.740E+02	0.000E+00	1.630E+06	0.000E+00	1.940E+02
CE-143	2.250E+01	1.220E+04	0.000E+00	5.120E+00	0.000E+00	1.790E+05	0.000E+00	1.770E+00
CE-144	1.950E+05	6.110E+04	0.000E+00	3.380E+04	0.000E+00	1.590E+07	0.000E+00	1.040E+04
PR-143	8.620E+01	2.590E+01	0.000E+00	1.400E+01	0.000E+00	9.300E+04	0.000E+00	4.280E+00
PR-144	3.220E-54	9.950E-55	0.000E+00	5.260E-55	0.000E+00	2.140E-51	0.000E+00	1.620E-55
ND-147	5.330E+01	4.320E+01	0.000E+00	2.370E+01	0.000E+00	6.850E+04	0.000E+00	3.350E+00
W-187	3.470E+03	2.050E+03	0.000E+00	0.000E+00	0.000E+00	2.880E+05	0.000E+00	9.210E+02
NP-239	2.070E+00	1.490E-01	0.000E+00	4.300E-01	0.000E+00	1.100E+04	0.000E+00	1.040E-01

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Age group:	CHILD	Pathway:	Grs/Cow/Meat (CMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	2.340E+02	2.340E+02	2.340E+02	2.340E+02	2.340E+02	0.000E+00	2.340E+02
C-14	3.280E+04	6.560E+03	6.560E+03	6.560E+03	6.560E+03	6.560E+03	0.000E+00	6.560E+03
NA-24	1.720E-03	1.720E-03	1.720E-03	1.720E-03	1.720E-03	1.720E-03	0.000E+00	1.720E-03
P-32	7.420E+09	3.470E+08	0.000E+00	0.000E+00	0.000E+00	2.050E+08	0.000E+00	2.860E+08
CR-51	0.000E+00	0.000E+00	4.880E+03	1.330E+03	8.910E+03	4.660E+05	0.000E+00	8.790E+03
MN-54	0.000E+00	8.010E+06	0.000E+00	2.250E+06	0.000E+00	6.720E+06	0.000E+00	2.130E+06
MN-56	0.000E+00	1.430E-53	0.000E+00	1.730E-53	0.000E+00	2.070E-51	0.000E+00	3.230E-54
FE-55	4.570E+08	2.420E+08	0.000E+00	0.000E+00	1.370E+08	4.490E+07	0.000E+00	7.510E+07
FE-59	3.760E+08	6.090E+08	0.000E+00	0.000E+00	1.770E+08	6.340E+08	0.000E+00	3.030E+08
CO-58	0.000E+00	1.640E+07	0.000E+00	0.000E+00	0.000E+00	9.580E+07	0.000E+00	5.020E+07
CO-60	0.000E+00	6.930E+07	0.000E+00	0.000E+00	0.000E+00	3.840E+08	0.000E+00	2.040E+08
NI-63	2.910E+10	1.560E+09	0.000E+00	0.000E+00	0.000E+00	1.050E+08	0.000E+00	9.910E+08
NI-65	3.520E-52	3.310E-53	0.000E+00	0.000E+00	0.000E+00	4.060E-51	0.000E+00	1.930E-53
CU-64	0.000E+00	2.970E-07	0.000E+00	7.180E-07	0.000E+00	1.390E-05	0.000E+00	1.800E-07
ZN-65	3.750E+08	1.000E+09	0.000E+00	6.300E+08	0.000E+00	1.760E+08	0.000E+00	6.220E+08
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.520E-57
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	5.770E+08	0.000E+00	0.000E+00	0.000E+00	3.710E+07	0.000E+00	3.550E+08
RB-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-89	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-89	4.820E+08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.870E+07	0.000E+00	1.380E+07
SR-90	1.040E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.400E+08	0.000E+00	2.640E+09
SR-91	2.400E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.300E-10	0.000E+00	9.050E-12

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Age group:	CHILD	Pathway:	Grs/Cow/Meat (CMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	1.850E-49	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.490E-48	0.000E+00	7.400E-51
Y-90	1.710E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.880E+05	0.000E+00	4.590E+00
Y-91	1.800E+06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.400E+08	0.000E+00	4.820E+04
Y-91M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Y-92	2.410E-39	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.960E-35	0.000E+00	6.890E-41
Y-93	7.440E-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.110E-07	0.000E+00	2.040E-13
ZR-95	2.660E+06	5.850E+05	0.000E+00	8.380E+05	0.000E+00	6.110E+08	0.000E+00	5.210E+05
ZR-97	3.200E-05	4.630E-06	0.000E+00	6.650E-06	0.000E+00	7.010E-01	0.000E+00	2.730E-06
NB-95	3.100E+06	1.210E+06	0.000E+00	1.130E+06	0.000E+00	2.230E+09	0.000E+00	8.620E+05
MO-99	0.000E+00	1.150E+05	0.000E+00	2.460E+05	0.000E+00	9.510E+04	0.000E+00	2.840E+04
TC-99M	6.190E-21	1.210E-20	0.000E+00	1.760E-19	6.160E-21	6.910E-18	0.000E+00	2.010E-19
TC-101	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU-103	1.550E+08	0.000E+00	0.000E+00	3.900E+08	0.000E+00	4.010E+09	0.000E+00	5.960E+07
RU-105	9.020E-28	0.000E+00	0.000E+00	7.930E-27	0.000E+00	5.890E-25	0.000E+00	3.270E-28
RU-106	4.440E+09	0.000E+00	0.000E+00	5.990E+09	0.000E+00	6.900E+10	0.000E+00	5.540E+08
AG-110M	8.390E+06	5.670E+06	0.000E+00	1.060E+07	0.000E+00	6.740E+08	0.000E+00	4.530E+06
TE-125M	5.690E+08	1.540E+08	1.600E+08	0.000E+00	0.000E+00	5.490E+08	0.000E+00	7.590E+07
TE-127	3.380E-10	9.120E-11	2.340E-10	9.630E-10	0.000E+00	1.320E-08	0.000E+00	7.260E-11
TE-127M	1.770E+09	4.780E+08	4.240E+08	5.060E+09	0.000E+00	1.440E+09	0.000E+00	2.110E+08
TE-129	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-129M	1.790E+09	5.000E+08	5.770E+08	5.260E+09	0.000E+00	2.180E+09	0.000E+00	2.780E+08
TE-131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-131M	7.000E+02	2.420E+02	4.980E+02	2.340E+03	0.000E+00	9.820E+03	0.000E+00	2.580E+02
TE-132	2.120E+06	9.380E+05	1.370E+06	8.710E+06	0.000E+00	9.450E+06	0.000E+00	1.130E+06
I-130	3.030E-06	6.130E-06	6.750E-04	9.160E-06	0.000E+00	2.870E-06	0.000E+00	3.160E-06

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Age group:	CHILD	Pathway:	Grs/Cow/Meat (CMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.650E+07	1.660E+07	5.500E+09	2.730E+07	0.000E+00	1.480E+06	0.000E+00	9.460E+06
I-132	1.020E-58	1.880E-58	8.730E-57	2.880E-58	0.000E+00	2.210E-58	0.000E+00	8.650E-59
I-133	5.670E-01	7.020E-01	1.300E+02	1.170E+00	0.000E+00	2.830E-01	0.000E+00	2.660E-01
I-134	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I-135	6.510E-17	1.170E-16	1.040E-14	1.800E-16	0.000E+00	8.930E-17	0.000E+00	5.550E-17
CS-134	9.220E+08	1.510E+09	0.000E+00	4.690E+08	1.680E+08	8.160E+06	0.000E+00	3.190E+08
CS-136	1.620E+07	4.460E+07	0.000E+00	2.370E+07	3.540E+06	1.570E+06	0.000E+00	2.880E+07
CS-137	1.330E+09	1.280E+09	0.000E+00	4.160E+08	1.500E+08	7.990E+06	0.000E+00	1.880E+08
CS-138	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-139	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-140	4.380E+07	3.840E+04	0.000E+00	1.250E+04	2.290E+04	2.220E+07	0.000E+00	2.560E+06
BA-141	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-142	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA-140	5.590E-02	1.950E-02	0.000E+00	0.000E+00	0.000E+00	5.440E+02	0.000E+00	6.580E-03
LA-142	5.300E-92	1.690E-92	0.000E+00	0.000E+00	0.000E+00	3.350E-87	0.000E+00	5.290E-93
CE-141	2.220E+04	1.110E+04	0.000E+00	4.850E+03	0.000E+00	1.380E+07	0.000E+00	1.640E+03
CE-143	3.170E-02	1.720E+01	0.000E+00	7.210E-03	0.000E+00	2.520E+02	0.000E+00	2.490E-03
CE-144	2.320E+06	7.260E+05	0.000E+00	4.020E+05	0.000E+00	1.890E+08	0.000E+00	1.240E+05
PR-143	3.340E+04	1.000E+04	0.000E+00	5.430E+03	0.000E+00	3.600E+07	0.000E+00	1.660E+03
PR-144	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ND-147	1.170E+04	9.470E+03	0.000E+00	5.190E+03	0.000E+00	1.500E+07	0.000E+00	7.330E+02
W-187	3.210E-02	1.900E-02	0.000E+00	0.000E+00	0.000E+00	2.670E+00	0.000E+00	8.530E-03
NP-239	4.260E-01	3.060E-02	0.000E+00	8.850E-02	0.000E+00	2.260E+03	0.000E+00	2.150E-02

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Age group:	CHILD	Pathway:	Grs/Goat/Meat (GMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	2.808E+01	2.808E+01	2.808E+01	2.808E+01	2.808E+01	0.000E+00	2.808E+01
C-14	3.936E+03	7.872E+02	7.872E+02	7.872E+02	7.872E+02	7.872E+02	0.000E+00	7.872E+02
NA-24	2.064E-04	2.064E-04	2.064E-04	2.064E-04	2.064E-04	2.064E-04	0.000E+00	2.064E-04
P-32	8.904E+08	4.164E+07	0.000E+00	0.000E+00	0.000E+00	2.460E+07	0.000E+00	3.432E+07
CR-51	0.000E+00	0.000E+00	5.856E+02	1.596E+02	1.069E+03	5.592E+04	0.000E+00	1.055E+03
MN-54	0.000E+00	9.612E+05	0.000E+00	2.700E+05	0.000E+00	8.064E+05	0.000E+00	2.556E+05
MN-56	0.000E+00	1.716E-54	0.000E+00	2.076E-54	0.000E+00	2.484E-52	0.000E+00	3.876E-55
FE-55	5.484E+07	2.904E+07	0.000E+00	0.000E+00	1.644E+07	5.388E+06	0.000E+00	9.012E+06
FE-59	4.512E+07	7.308E+07	0.000E+00	0.000E+00	2.124E+07	7.608E+07	0.000E+00	3.636E+07
CO-58	0.000E+00	1.968E+06	0.000E+00	0.000E+00	0.000E+00	1.150E+07	0.000E+00	6.024E+06
CO-60	0.000E+00	8.316E+06	0.000E+00	0.000E+00	0.000E+00	4.608E+07	0.000E+00	2.448E+07
NI-63	3.492E+09	1.872E+08	0.000E+00	0.000E+00	0.000E+00	1.260E+07	0.000E+00	1.189E+08
NI-65	4.224E-53	3.972E-54	0.000E+00	0.000E+00	0.000E+00	4.872E-52	0.000E+00	2.316E-54
CU-64	0.000E+00	3.564E-08	0.000E+00	8.616E-08	0.000E+00	1.668E-06	0.000E+00	2.160E-08
ZN-65	4.500E+07	1.200E+08	0.000E+00	7.560E+07	0.000E+00	2.112E+07	0.000E+00	7.464E+07
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.142E-57
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	6.924E+07	0.000E+00	0.000E+00	0.000E+00	4.452E+06	0.000E+00	4.260E+07
RB-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-89	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-89	5.784E+07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.244E+06	0.000E+00	1.656E+06
SR-90	1.248E+09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.680E+07	0.000E+00	3.168E+08
SR-91	2.880E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.360E-11	0.000E+00	1.086E-12

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Age group:	CHILD	Pathway:	Grs/Goat/Meat (GMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	2.220E-50	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.188E-49	0.000E+00	8.880E-52
Y-90	2.052E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.856E+04	0.000E+00	5.508E-01
Y-91	2.160E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.880E+07	0.000E+00	5.784E+03
Y-91M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Y-92	2.892E-40	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.352E-36	0.000E+00	8.268E-42
Y-93	8.928E-13	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.332E-08	0.000E+00	2.448E-14
ZR-95	3.192E+05	7.020E+04	0.000E+00	1.006E+05	0.000E+00	7.332E+07	0.000E+00	6.252E+04
ZR-97	3.840E-06	5.556E-07	0.000E+00	7.980E-07	0.000E+00	8.412E-02	0.000E+00	3.276E-07
NB-95	3.720E+05	1.452E+05	0.000E+00	1.356E+05	0.000E+00	2.676E+08	0.000E+00	1.034E+05
MO-99	0.000E+00	1.380E+04	0.000E+00	2.952E+04	0.000E+00	1.141E+04	0.000E+00	3.408E+03
TC-99M	7.428E-22	1.452E-21	0.000E+00	2.112E-20	7.392E-22	8.292E-19	0.000E+00	2.412E-20
TC-101	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU-103	1.860E+07	0.000E+00	0.000E+00	4.680E+07	0.000E+00	4.812E+08	0.000E+00	7.152E+06
RU-105	1.082E-28	0.000E+00	0.000E+00	9.516E-28	0.000E+00	7.068E-26	0.000E+00	3.924E-29
RU-106	5.328E+08	0.000E+00	0.000E+00	7.188E+08	0.000E+00	8.280E+09	0.000E+00	6.648E+07
AG-110M	1.007E+06	6.804E+05	0.000E+00	1.272E+06	0.000E+00	8.088E+07	0.000E+00	5.436E+05
TE-125M	6.828E+07	1.848E+07	1.920E+07	0.000E+00	0.000E+00	6.588E+07	0.000E+00	9.108E+06
TE-127	4.056E-11	1.094E-11	2.808E-11	1.156E-10	0.000E+00	1.584E-09	0.000E+00	8.712E-12
TE-127M	2.124E+08	5.736E+07	5.088E+07	6.072E+08	0.000E+00	1.728E+08	0.000E+00	2.532E+07
TE-129	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-129M	2.148E+08	6.000E+07	6.924E+07	6.312E+08	0.000E+00	2.616E+08	0.000E+00	3.336E+07
TE-131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-131M	8.400E+01	2.904E+01	5.976E+01	2.808E+02	0.000E+00	1.178E+03	0.000E+00	3.096E+01
TE-132	2.544E+05	1.126E+05	1.644E+05	1.045E+06	0.000E+00	1.134E+06	0.000E+00	1.356E+05
I-130	3.636E-07	7.356E-07	8.100E-05	1.099E-06	0.000E+00	3.444E-07	0.000E+00	3.792E-07

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Age group:	CHILD	Pathway:	Grs/Goat/Meat (GMEAT)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.980E+06	1.992E+06	6.600E+08	3.276E+06	0.000E+00	1.776E+05	0.000E+00	1.135E+06
I-132	1.224E-59	2.256E-59	1.048E-57	3.456E-59	0.000E+00	2.652E-59	0.000E+00	1.038E-59
I-133	6.804E-02	8.424E-02	1.560E+01	1.404E-01	0.000E+00	3.396E-02	0.000E+00	3.192E-02
I-134	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I-135	7.812E-18	1.404E-17	1.248E-15	2.160E-17	0.000E+00	1.072E-17	0.000E+00	6.660E-18
CS-134	1.106E+08	1.812E+08	0.000E+00	5.628E+07	2.016E+07	9.792E+05	0.000E+00	3.828E+07
CS-136	1.944E+06	5.352E+06	0.000E+00	2.844E+06	4.248E+05	1.884E+05	0.000E+00	3.456E+06
CS-137	1.596E+08	1.536E+08	0.000E+00	4.992E+07	1.800E+07	9.588E+05	0.000E+00	2.256E+07
CS-138	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-139	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-140	5.256E+06	4.608E+03	0.000E+00	1.500E+03	2.748E+03	2.664E+06	0.000E+00	3.072E+05
BA-141	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-142	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA-140	6.708E-03	2.340E-03	0.000E+00	0.000E+00	0.000E+00	6.528E+01	0.000E+00	7.896E-04
LA-142	6.360E-93	2.028E-93	0.000E+00	0.000E+00	0.000E+00	4.020E-88	0.000E+00	6.348E-94
CE-141	2.664E+03	1.332E+03	0.000E+00	5.820E+02	0.000E+00	1.656E+06	0.000E+00	1.968E+02
CE-143	3.804E-03	2.064E+00	0.000E+00	8.652E-04	0.000E+00	3.024E+01	0.000E+00	2.988E-04
CE-144	2.784E+05	8.712E+04	0.000E+00	4.824E+04	0.000E+00	2.268E+07	0.000E+00	1.488E+04
PR-143	4.008E+03	1.200E+03	0.000E+00	6.516E+02	0.000E+00	4.320E+06	0.000E+00	1.992E+02
PR-144	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ND-147	1.404E+03	1.136E+03	0.000E+00	6.228E+02	0.000E+00	1.800E+06	0.000E+00	8.796E+01
W-187	3.852E-03	2.280E-03	0.000E+00	0.000E+00	0.000E+00	3.204E-01	0.000E+00	1.024E-03
NP-239	5.112E-02	3.672E-03	0.000E+00	1.062E-02	0.000E+00	2.712E+02	0.000E+00	2.580E-03

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Vegetation (VEG)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	4.010E+03	4.010E+03	4.010E+03	4.010E+03	4.010E+03	0.000E+00	4.010E+03
C-14	2.170E+05	4.340E+04	4.340E+04	4.340E+04	4.340E+04	4.340E+04	0.000E+00	4.340E+04
NA-24	3.730E+05	3.730E+05	3.730E+05	3.730E+05	3.730E+05	3.730E+05	0.000E+00	3.730E+05
P-32	3.370E+09	1.580E+08	0.000E+00	0.000E+00	0.000E+00	9.310E+07	0.000E+00	1.300E+08
CR-51	0.000E+00	0.000E+00	6.500E+04	1.780E+04	1.190E+05	6.210E+06	0.000E+00	1.170E+05
MN-54	0.000E+00	6.650E+08	0.000E+00	1.860E+08	0.000E+00	5.580E+08	0.000E+00	1.770E+08
MN-56	0.000E+00	1.860E+01	0.000E+00	2.250E+01	0.000E+00	2.700E+03	0.000E+00	4.200E+00
FE-55	8.010E+08	4.250E+08	0.000E+00	0.000E+00	2.400E+08	7.870E+07	0.000E+00	1.320E+08
FE-59	3.980E+08	6.430E+08	0.000E+00	0.000E+00	1.860E+08	6.700E+08	0.000E+00	3.200E+08
CO-58	0.000E+00	6.440E+07	0.000E+00	0.000E+00	0.000E+00	3.760E+08	0.000E+00	1.970E+08
CO-60	0.000E+00	3.780E+08	0.000E+00	0.000E+00	0.000E+00	2.100E+09	0.000E+00	1.120E+09
NI-63	3.950E+10	2.110E+09	0.000E+00	0.000E+00	0.000E+00	1.420E+08	0.000E+00	1.340E+09
NI-65	1.050E+02	9.890E+00	0.000E+00	0.000E+00	0.000E+00	1.210E+03	0.000E+00	5.770E+00
CU-64	0.000E+00	1.100E+04	0.000E+00	2.660E+04	0.000E+00	5.160E+05	0.000E+00	6.640E+03
ZN-65	8.130E+08	2.160E+09	0.000E+00	1.360E+09	0.000E+00	3.800E+08	0.000E+00	1.350E+09
ZN-69	9.490E-06	1.370E-05	0.000E+00	8.320E-06	0.000E+00	8.640E-04	0.000E+00	1.270E-06
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.370E+00
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.820E-11
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	4.520E+08	0.000E+00	0.000E+00	0.000E+00	2.910E+07	0.000E+00	2.780E+08
RB-88	0.000E+00	4.380E-22	0.000E+00	0.000E+00	0.000E+00	2.150E-23	0.000E+00	3.040E-22
RB-89	0.000E+00	4.610E-26	0.000E+00	0.000E+00	0.000E+00	4.020E-28	0.000E+00	4.090E-26
SR-89	3.600E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.390E+09	0.000E+00	1.030E+09
SR-90	1.240E+12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.670E+10	0.000E+00	3.150E+11
SR-91	5.240E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.160E+06	0.000E+00	1.980E+04

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Vegetation (VEG)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	7.280E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.380E+04	0.000E+00	2.920E+01
Y-90	2.310E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.570E+07	0.000E+00	6.180E+02
Y-91	1.860E+07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.480E+09	0.000E+00	4.990E+05
Y-91M	8.910E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.740E-05	0.000E+00	3.240E-10
Y-92	1.580E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.580E+04	0.000E+00	4.530E-02
Y-93	2.930E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.370E+06	0.000E+00	8.040E+00
ZR-95	3.860E+06	8.480E+05	0.000E+00	1.210E+06	0.000E+00	8.850E+08	0.000E+00	7.550E+05
ZR-97	5.700E+02	8.240E+01	0.000E+00	1.180E+02	0.000E+00	1.250E+07	0.000E+00	4.860E+01
NB-95	4.110E+05	1.600E+05	0.000E+00	1.500E+05	0.000E+00	2.960E+08	0.000E+00	1.140E+05
MO-99	0.000E+00	7.710E+06	0.000E+00	1.650E+07	0.000E+00	6.380E+06	0.000E+00	1.910E+06
TC-99M	4.710E+00	9.230E+00	0.000E+00	1.340E+02	4.690E+00	5.260E+03	0.000E+00	1.530E+02
TC-101	1.410E-30	1.470E-30	0.000E+00	2.510E-29	7.780E-31	4.680E-30	0.000E+00	1.870E-29
RU-103	1.530E+07	0.000E+00	0.000E+00	3.860E+07	0.000E+00	3.970E+08	0.000E+00	5.900E+06
RU-105	9.160E+01	0.000E+00	0.000E+00	8.050E+02	0.000E+00	5.980E+04	0.000E+00	3.320E+01
RU-106	7.450E+08	0.000E+00	0.000E+00	1.010E+09	0.000E+00	1.160E+10	0.000E+00	9.300E+07
AG-110M	3.210E+07	2.170E+07	0.000E+00	4.040E+07	0.000E+00	2.580E+09	0.000E+00	1.730E+07
TE-125M	3.510E+08	9.500E+07	9.840E+07	0.000E+00	0.000E+00	3.380E+08	0.000E+00	4.670E+07
TE-127	9.850E+03	2.650E+03	6.810E+03	2.800E+04	0.000E+00	3.850E+05	0.000E+00	2.110E+03
TE-127M	1.320E+09	3.560E+08	3.160E+08	3.770E+09	0.000E+00	1.070E+09	0.000E+00	1.570E+08
TE-129	1.320E-03	3.690E-04	9.430E-04	3.870E-03	0.000E+00	8.230E-02	0.000E+00	3.140E-04
TE-129M	8.410E+08	2.350E+08	2.710E+08	2.470E+09	0.000E+00	1.030E+09	0.000E+00	1.310E+08
TE-131	2.570E-15	7.830E-16	1.960E-15	7.770E-15	0.000E+00	1.350E-14	0.000E+00	7.640E-16
TE-131M	1.540E+06	5.330E+05	1.100E+06	5.160E+06	0.000E+00	2.160E+07	0.000E+00	5.680E+05
TE-132	7.000E+06	3.100E+06	4.510E+06	2.880E+07	0.000E+00	3.120E+07	0.000E+00	3.740E+06
I-130	6.160E+05	1.240E+06	1.370E+08	1.860E+06	0.000E+00	5.820E+05	0.000E+00	6.410E+05

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Vegetation (VEG)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.430E+08	1.440E+08	4.750E+10	2.360E+08	0.000E+00	1.280E+07	0.000E+00	8.170E+07
I-132	9.220E+01	1.690E+02	7.860E+03	2.590E+02	0.000E+00	1.990E+02	0.000E+00	7.790E+01
I-133	3.530E+06	4.370E+06	8.110E+08	7.280E+06	0.000E+00	1.760E+06	0.000E+00	1.650E+06
I-134	1.550E-04	2.880E-04	6.620E-03	4.400E-04	0.000E+00	1.910E-04	0.000E+00	1.320E-04
I-135	6.260E+04	1.130E+05	9.970E+06	1.730E+05	0.000E+00	8.580E+04	0.000E+00	5.330E+04
CS-134	1.600E+10	2.630E+10	0.000E+00	8.150E+09	2.930E+09	1.420E+08	0.000E+00	5.550E+09
CS-136	8.240E+07	2.270E+08	0.000E+00	1.210E+08	1.800E+07	7.960E+06	0.000E+00	1.470E+08
CS-137	2.390E+10	2.290E+10	0.000E+00	7.460E+09	2.680E+09	1.430E+08	0.000E+00	3.380E+09
CS-138	6.570E-11	9.130E-11	0.000E+00	6.430E-11	6.920E-12	4.210E-11	0.000E+00	5.790E-11
BA-139	4.950E-02	2.640E-05	0.000E+00	2.310E-05	1.560E-05	2.860E+00	0.000E+00	1.440E-03
BA-140	2.770E+08	2.420E+05	0.000E+00	7.890E+04	1.450E+05	1.400E+08	0.000E+00	1.610E+07
BA-141	1.990E-21	1.110E-24	0.000E+00	9.620E-25	6.530E-24	1.130E-21	0.000E+00	6.460E-23
BA-142	9.930E-39	7.150E-42	0.000E+00	5.780E-42	4.200E-42	1.300E-40	0.000E+00	5.540E-40
LA-140	3.250E+03	1.130E+03	0.000E+00	0.000E+00	0.000E+00	3.160E+07	0.000E+00	3.820E+02
LA-142	3.360E-04	1.070E-04	0.000E+00	0.000E+00	0.000E+00	2.120E+01	0.000E+00	3.350E-05
CE-141	6.560E+05	3.270E+05	0.000E+00	1.430E+05	0.000E+00	4.080E+08	0.000E+00	4.860E+04
CE-143	1.720E+03	9.310E+05	0.000E+00	3.910E+02	0.000E+00	1.360E+07	0.000E+00	1.350E+02
CE-144	1.270E+08	3.980E+07	0.000E+00	2.210E+07	0.000E+00	1.040E+10	0.000E+00	6.780E+06
PR-143	1.460E+05	4.370E+04	0.000E+00	2.370E+04	0.000E+00	1.570E+08	0.000E+00	7.230E+03
PR-144	5.380E-26	1.660E-26	0.000E+00	8.800E-27	0.000E+00	3.580E-23	0.000E+00	2.710E-27
ND-147	7.150E+04	5.790E+04	0.000E+00	3.180E+04	0.000E+00	9.170E+07	0.000E+00	4.480E+03
W-187	6.430E+04	3.810E+04	0.000E+00	0.000E+00	0.000E+00	5.350E+06	0.000E+00	1.710E+04
NP-239	2.560E+03	1.840E+02	0.000E+00	5.310E+02	0.000E+00	1.360E+07	0.000E+00	1.290E+02

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	1.120E+03	1.120E+03	1.120E+03	1.120E+03	1.120E+03	0.000E+00	1.120E+03
C-14	3.590E+04	6.730E+03	6.730E+03	6.730E+03	6.730E+03	6.730E+03	0.000E+00	6.730E+03
NA-24	1.610E+04	1.610E+04	1.610E+04	1.610E+04	1.610E+04	1.610E+04	0.000E+00	1.610E+04
P-32	2.600E+06	1.140E+05	0.000E+00	0.000E+00	0.000E+00	4.220E+04	0.000E+00	9.880E+04
CR-51	0.000E+00	0.000E+00	8.550E+01	2.430E+01	1.700E+04	1.080E+03	0.000E+00	1.540E+02
MN-54	0.000E+00	4.290E+04	0.000E+00	1.000E+04	1.580E+06	2.290E+04	0.000E+00	9.510E+03
MN-56	0.000E+00	1.660E+00	0.000E+00	1.670E+00	1.310E+04	1.230E+05	0.000E+00	3.120E-01
FE-55	4.740E+04	2.520E+04	0.000E+00	0.000E+00	1.110E+05	2.870E+03	0.000E+00	7.770E+03
FE-59	2.070E+04	3.340E+04	0.000E+00	0.000E+00	1.270E+06	7.070E+04	0.000E+00	1.670E+04
CO-58	0.000E+00	1.770E+03	0.000E+00	0.000E+00	1.110E+06	3.440E+04	0.000E+00	3.160E+03
CO-60	0.000E+00	1.310E+04	0.000E+00	0.000E+00	7.070E+06	9.620E+04	0.000E+00	2.260E+04
NI-63	8.210E+05	4.620E+04	0.000E+00	0.000E+00	2.750E+05	6.330E+03	0.000E+00	2.800E+04
NI-65	2.990E+00	2.960E-01	0.000E+00	0.000E+00	8.180E+03	8.400E+04	0.000E+00	1.640E-01
CU-64	0.000E+00	1.990E+00	0.000E+00	6.030E+00	9.580E+03	3.670E+04	0.000E+00	1.070E+00
ZN-65	4.260E+04	1.130E+05	0.000E+00	7.140E+04	9.950E+05	1.630E+04	0.000E+00	7.030E+04
ZN-69	6.700E-02	9.660E-02	0.000E+00	5.850E-02	1.420E+03	1.020E+04	0.000E+00	8.920E-03
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.740E+02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.480E+02
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.530E+01
RB-86	0.000E+00	1.980E+05	0.000E+00	0.000E+00	0.000E+00	7.990E+03	0.000E+00	1.140E+05
RB-88	0.000E+00	5.620E+02	0.000E+00	0.000E+00	0.000E+00	1.720E+01	0.000E+00	3.660E+02
RB-89	0.000E+00	3.450E+02	0.000E+00	0.000E+00	0.000E+00	1.890E+00	0.000E+00	2.900E+02
SR-89	5.990E+05	0.000E+00	0.000E+00	0.000E+00	2.160E+06	1.670E+05	0.000E+00	1.720E+04
SR-90	1.010E+08	0.000E+00	0.000E+00	0.000E+00	1.480E+07	3.430E+05	0.000E+00	6.440E+06
SR-91	1.210E+02	0.000E+00	0.000E+00	0.000E+00	5.330E+04	1.740E+05	0.000E+00	4.590E+00

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	1.310E+01	0.000E+00	0.000E+00	0.000E+00	2.400E+04	2.420E+05	0.000E+00	5.250E-01
Y-90	4.110E+03	0.000E+00	0.000E+00	0.000E+00	2.620E+05	2.680E+05	0.000E+00	1.110E+02
Y-91	9.140E+05	0.000E+00	0.000E+00	0.000E+00	2.630E+06	1.840E+05	0.000E+00	2.440E+04
Y-91M	5.070E-01	0.000E+00	0.000E+00	0.000E+00	2.810E+03	1.720E+03	0.000E+00	1.840E-02
Y-92	2.030E+01	0.000E+00	0.000E+00	0.000E+00	2.390E+04	2.390E+05	0.000E+00	5.810E-01
Y-93	1.860E+02	0.000E+00	0.000E+00	0.000E+00	7.440E+04	3.880E+05	0.000E+00	5.110E+00
ZR-95	1.900E+05	4.180E+04	0.000E+00	5.960E+04	2.230E+06	6.110E+04	0.000E+00	3.700E+04
ZR-97	1.880E+02	2.720E+01	0.000E+00	3.880E+01	1.130E+05	3.510E+05	0.000E+00	1.600E+01
NB-95	2.350E+04	9.180E+03	0.000E+00	8.620E+03	6.140E+05	3.700E+04	0.000E+00	6.550E+03
MO-99	0.000E+00	1.720E+02	0.000E+00	3.920E+02	1.350E+05	1.270E+05	0.000E+00	4.260E+01
TC-99M	1.780E-03	3.480E-03	0.000E+00	5.070E-02	9.510E+02	4.810E+03	0.000E+00	5.770E-02
TC-101	8.100E-05	8.510E-05	0.000E+00	1.450E-03	5.850E+02	1.630E+01	0.000E+00	1.080E-03
RU-103	2.790E+03	0.000E+00	0.000E+00	7.030E+03	6.620E+05	4.480E+04	0.000E+00	1.070E+03
RU-105	1.530E+00	0.000E+00	0.000E+00	1.340E+00	1.590E+04	9.950E+04	0.000E+00	5.550E-01
RU-106	1.360E+05	0.000E+00	0.000E+00	1.840E+05	1.430E+07	4.290E+05	0.000E+00	1.690E+04
AG-110M	1.690E+04	1.140E+04	0.000E+00	2.120E+04	5.480E+06	1.000E+05	0.000E+00	9.140E+03
TE-125M	6.730E+03	2.330E+03	1.920E+03	0.000E+00	4.770E+05	3.380E+04	0.000E+00	9.140E+02
TE-127	2.770E+00	9.510E-01	1.960E+00	7.070E+00	1.000E+04	5.620E+04	0.000E+00	6.100E-01
TE-127M	2.490E+04	8.550E+03	6.070E+03	6.360E+04	1.480E+06	7.140E+04	0.000E+00	3.020E+03
TE-129	9.770E-02	3.500E-02	7.140E-02	2.570E-01	2.930E+03	2.550E+04	0.000E+00	2.380E-02
TE-129M	1.920E+04	6.840E+03	6.330E+03	5.030E+04	1.760E+06	1.820E+05	0.000E+00	3.040E+03
TE-131	2.170E-02	8.440E-03	1.700E-02	5.880E-02	2.050E+03	1.330E+03	0.000E+00	6.590E-03
TE-131M	1.340E+02	5.920E+01	9.770E+01	4.000E+02	2.060E+05	3.080E+05	0.000E+00	5.070E+01
TE-132	4.810E+02	2.720E+02	3.170E+02	1.770E+03	3.770E+05	1.380E+05	0.000E+00	2.630E+02
I-130	8.180E+03	1.640E+04	1.850E+06	2.450E+04	0.000E+00	5.110E+03	0.000E+00	8.440E+03

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	4.810E+04	4.810E+04	1.620E+07	7.880E+04	0.000E+00	2.840E+03	0.000E+00	2.730E+04
I-132	2.120E+03	4.070E+03	1.940E+05	6.250E+03	0.000E+00	3.200E+03	0.000E+00	1.880E+03
I-133	1.660E+04	2.030E+04	3.850E+06	3.380E+04	0.000E+00	5.480E+03	0.000E+00	7.700E+03
I-134	1.170E+03	2.160E+03	5.070E+04	3.300E+03	0.000E+00	9.550E+02	0.000E+00	9.950E+02
I-135	4.920E+03	8.730E+03	7.920E+05	1.340E+04	0.000E+00	4.440E+03	0.000E+00	4.140E+03
CS-134	6.510E+05	1.010E+06	0.000E+00	3.300E+05	1.210E+05	3.850E+03	0.000E+00	2.250E+05
CS-136	6.510E+04	1.710E+05	0.000E+00	9.550E+04	1.450E+04	4.180E+03	0.000E+00	1.160E+05
CS-137	9.060E+05	8.250E+05	0.000E+00	2.820E+05	1.040E+05	3.620E+03	0.000E+00	1.280E+05
CS-138	6.330E+02	8.400E+02	0.000E+00	6.220E+02	6.810E+01	2.700E+02	0.000E+00	5.550E+02
BA-139	1.840E+00	9.840E-04	0.000E+00	8.620E-04	5.770E+03	5.770E+04	0.000E+00	5.360E-02
BA-140	7.400E+04	6.480E+01	0.000E+00	2.110E+01	1.740E+06	1.020E+05	0.000E+00	4.330E+03
BA-141	1.960E-01	1.090E-04	0.000E+00	9.470E-05	2.920E+03	2.750E+02	0.000E+00	6.360E-03
BA-142	5.000E-02	3.600E-05	0.000E+00	2.910E-05	1.640E+03	2.740E+00	0.000E+00	2.790E-03
LA-140	6.440E+02	2.250E+02	0.000E+00	0.000E+00	1.830E+05	2.260E+05	0.000E+00	7.550E+01
LA-142	1.300E+00	4.110E-01	0.000E+00	0.000E+00	8.700E+03	7.580E+04	0.000E+00	1.290E-01
CE-141	3.920E+04	1.950E+04	0.000E+00	8.550E+03	5.440E+05	5.660E+04	0.000E+00	2.900E+03
CE-143	3.660E+02	1.990E+02	0.000E+00	8.360E+01	1.150E+05	1.270E+05	0.000E+00	2.870E+01
CE-144	6.770E+06	2.120E+06	0.000E+00	1.170E+06	1.200E+07	3.880E+05	0.000E+00	3.610E+05
PR-143	1.850E+04	5.550E+03	0.000E+00	3.000E+03	4.330E+05	9.730E+04	0.000E+00	9.140E+02
PR-144	5.960E-02	1.850E-02	0.000E+00	9.770E-03	1.570E+03	1.970E+02	0.000E+00	3.000E-03
ND-147	1.080E+04	8.730E+03	0.000E+00	4.810E+03	3.280E+05	8.210E+04	0.000E+00	6.810E+02
W-187	1.630E+01	9.660E+00	0.000E+00	0.000E+00	4.110E+04	9.100E+04	0.000E+00	4.330E+00
NP-239	4.660E+02	3.340E+01	0.000E+00	9.730E+01	5.810E+04	6.400E+04	0.000E+00	2.350E+01

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NA-24	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.390E+07	1.190E+07
P-32	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CR-51	4.660E+06	4.660E+06	4.660E+06	4.660E+06	4.660E+06	4.660E+06	5.510E+06	4.660E+06
MN-54	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.630E+09	1.390E+09
MN-56	9.020E+05	9.020E+05	9.020E+05	9.020E+05	9.020E+05	9.020E+05	1.070E+06	9.020E+05
FE-55	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
FE-59	2.730E+08	2.730E+08	2.730E+08	2.730E+08	2.730E+08	2.730E+08	3.210E+08	2.730E+08
CO-58	3.790E+08	3.790E+08	3.790E+08	3.790E+08	3.790E+08	3.790E+08	4.440E+08	3.790E+08
CO-60	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.530E+10	2.150E+10
NI-63	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NI-65	2.970E+05	2.970E+05	2.970E+05	2.970E+05	2.970E+05	2.970E+05	3.450E+05	2.970E+05
CU-64	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.880E+05	6.070E+05
ZN-65	7.470E+08	7.470E+08	7.470E+08	7.470E+08	7.470E+08	7.470E+08	8.590E+08	7.470E+08
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	4.870E+03	4.870E+03	4.870E+03	4.870E+03	4.870E+03	4.870E+03	7.080E+03	4.870E+03
BR-84	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.360E+05	2.030E+05
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	8.990E+06	8.990E+06	8.990E+06	8.990E+06	8.990E+06	8.990E+06	1.030E+07	8.990E+06
RB-88	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.780E+04	3.310E+04
RB-89	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.480E+05	1.230E+05
SR-89	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.510E+04	2.160E+04
SR-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-91	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.510E+06	2.150E+06

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	7.770E+05	7.770E+05	7.770E+05	7.770E+05	7.770E+05	7.770E+05	8.630E+05	7.770E+05
Y-90	4.490E+03	4.490E+03	4.490E+03	4.490E+03	4.490E+03	4.490E+03	5.310E+03	4.490E+03
Y-91	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.210E+06	1.070E+06
Y-91M	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.160E+05	1.000E+05
Y-92	1.800E+05	1.800E+05	1.800E+05	1.800E+05	1.800E+05	1.800E+05	2.140E+05	1.800E+05
Y-93	1.830E+05	1.830E+05	1.830E+05	1.830E+05	1.830E+05	1.830E+05	2.510E+05	1.830E+05
ZR-95	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.840E+08	2.450E+08
ZR-97	2.960E+06	2.960E+06	2.960E+06	2.960E+06	2.960E+06	2.960E+06	3.440E+06	2.960E+06
NB-95	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.610E+08	1.370E+08
MO-99	3.990E+06	3.990E+06	3.990E+06	3.990E+06	3.990E+06	3.990E+06	4.630E+06	3.990E+06
TC-99M	1.840E+05	1.840E+05	1.840E+05	1.840E+05	1.840E+05	1.840E+05	2.110E+05	1.840E+05
TC-101	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.260E+04	2.040E+04
RU-103	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.260E+08	1.080E+08
RU-105	6.360E+05	6.360E+05	6.360E+05	6.360E+05	6.360E+05	6.360E+05	7.210E+05	6.360E+05
RU-106	4.220E+08	4.220E+08	4.220E+08	4.220E+08	4.220E+08	4.220E+08	5.070E+08	4.220E+08
AG-110M	3.440E+09	3.440E+09	3.440E+09	3.440E+09	3.440E+09	3.440E+09	4.010E+09	3.440E+09
TE-125M	1.550E+06	1.550E+06	1.550E+06	1.550E+06	1.550E+06	1.550E+06	2.130E+06	1.550E+06
TE-127	2.980E+03	2.980E+03	2.980E+03	2.980E+03	2.980E+03	2.980E+03	3.280E+03	2.980E+03
TE-127M	9.160E+04	9.160E+04	9.160E+04	9.160E+04	9.160E+04	9.160E+04	1.080E+05	9.160E+04
TE-129	2.620E+04	2.620E+04	2.620E+04	2.620E+04	2.620E+04	2.620E+04	3.100E+04	2.620E+04
TE-129M	1.980E+07	1.980E+07	1.980E+07	1.980E+07	1.980E+07	1.980E+07	2.310E+07	1.980E+07
TE-131	2.920E+04	2.920E+04	2.920E+04	2.920E+04	2.920E+04	2.920E+04	3.450E+07	2.920E+04
TE-131M	8.030E+06	8.030E+06	8.030E+06	8.030E+06	8.030E+06	8.030E+06	9.460E+06	8.030E+06
TE-132	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.980E+06	4.230E+06
I-130	5.510E+06	5.510E+06	5.510E+06	5.510E+06	5.510E+06	5.510E+06	6.690E+06	5.510E+06

APPENDIX I

R_i Child Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	CHILD	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.720E+07	1.720E+07	1.720E+07	1.720E+07	1.720E+07	1.720E+07	2.090E+07	1.720E+07
I-132	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.470E+06	1.250E+06
I-133	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.980E+06	2.450E+06
I-134	4.470E+05	4.470E+05	4.470E+05	4.470E+05	4.470E+05	4.470E+05	5.300E+05	4.470E+05
I-135	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.950E+06	2.530E+06
CS-134	6.860E+09	6.860E+09	6.860E+09	6.860E+09	6.860E+09	6.860E+09	8.000E+09	6.860E+09
CS-136	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.710E+08	1.510E+08
CS-137	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.200E+10	1.030E+10
CS-138	3.590E+05	3.590E+05	3.590E+05	3.590E+05	3.590E+05	3.590E+05	4.100E+05	3.590E+05
BA-139	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.190E+05	1.060E+05
BA-140	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.350E+07	2.050E+07
BA-141	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.750E+04	4.170E+04
BA-142	4.490E+04	4.490E+04	4.490E+04	4.490E+04	4.490E+04	4.490E+04	5.110E+04	4.490E+04
LA-140	1.920E+07	1.920E+07	1.920E+07	1.920E+07	1.920E+07	1.920E+07	2.180E+07	1.920E+07
LA-142	7.600E+05	7.600E+05	7.600E+05	7.600E+05	7.600E+05	7.600E+05	9.120E+05	7.600E+05
CE-141	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.540E+07	1.370E+07
CE-143	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.630E+06	2.310E+06
CE-144	6.950E+07	6.950E+07	6.950E+07	6.950E+07	6.950E+07	6.950E+07	8.040E+07	6.950E+07
PR-143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR-144	1.830E+03	1.830E+03	1.830E+03	1.830E+03	1.830E+03	1.830E+03	2.110E+03	1.830E+03
ND-147	8.390E+06	8.390E+06	8.390E+06	8.390E+06	8.390E+06	8.390E+06	1.010E+07	8.390E+06
W-187	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.730E+06	2.350E+06
NP-239	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.980E+06	1.710E+06

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	2.380E+03	2.380E+03	2.380E+03	2.380E+03	2.380E+03	0.000E+00	2.380E+03
C-14	2.000E+05	4.270E+04	4.270E+04	4.270E+04	4.270E+04	4.270E+04	0.000E+00	4.270E+04
NA-24	1.540E+07	1.540E+07	1.540E+07	1.540E+07	1.540E+07	1.540E+07	0.000E+00	1.540E+07
P-32	1.600E+11	9.430E+09	0.000E+00	0.000E+00	0.000E+00	2.170E+09	0.000E+00	6.210E+09
CR-51	0.000E+00	0.000E+00	1.050E+05	2.300E+04	2.050E+05	4.700E+06	0.000E+00	1.610E+05
MN-54	0.000E+00	3.900E+07	0.000E+00	8.640E+06	0.000E+00	1.430E+07	0.000E+00	8.840E+06
MN-56	0.000E+00	3.100E-02	0.000E+00	2.660E-02	0.000E+00	2.810E+00	0.000E+00	5.340E-03
FE-55	1.350E+08	8.730E+07	0.000E+00	0.000E+00	4.270E+07	1.110E+07	0.000E+00	2.330E+07
FE-59	2.240E+08	3.920E+08	0.000E+00	0.000E+00	1.160E+08	1.870E+08	0.000E+00	1.540E+08
CO-58	0.000E+00	2.420E+07	0.000E+00	0.000E+00	0.000E+00	6.040E+07	0.000E+00	6.050E+07
CO-60	0.000E+00	8.820E+07	0.000E+00	0.000E+00	0.000E+00	2.100E+08	0.000E+00	2.080E+08
NI-63	3.490E+10	2.160E+09	0.000E+00	0.000E+00	0.000E+00	1.070E+08	0.000E+00	1.210E+09
NI-65	3.510E+00	3.970E-01	0.000E+00	0.000E+00	0.000E+00	3.020E+01	0.000E+00	1.800E-01
CU-64	0.000E+00	1.850E+05	0.000E+00	3.140E+05	0.000E+00	3.810E+06	0.000E+00	8.590E+04
ZN-65	5.550E+09	1.900E+10	0.000E+00	9.230E+09	0.000E+00	1.610E+10	0.000E+00	8.780E+09
ZN-69	2.020E-11	3.630E-11	0.000E+00	1.510E-11	0.000E+00	2.960E-09	0.000E+00	2.700E-12
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.340E-01
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.260E-22
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	2.230E+10	0.000E+00	0.000E+00	0.000E+00	5.690E+08	0.000E+00	1.100E+10
RB-88	0.000E+00	1.880E-44	0.000E+00	0.000E+00	0.000E+00	1.830E-44	0.000E+00	1.030E-44
RB-89	0.000E+00	3.290E-52	0.000E+00	0.000E+00	0.000E+00	1.120E-52	0.000E+00	2.260E-52
SR-89	1.260E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.590E+08	0.000E+00	3.610E+08
SR-90	1.220E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.520E+09	0.000E+00	3.100E+10
SR-91	2.720E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.220E+05	0.000E+00	9.830E+03

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	4.640E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.000E+01	0.000E+00	1.720E-01
Y-90	6.810E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.410E+05	0.000E+00	1.830E+01
Y-91	7.330E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.250E+06	0.000E+00	1.950E+03
Y-91M	5.670E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.890E-15	0.000E+00	1.930E-20
Y-92	5.380E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.030E+01	0.000E+00	1.510E-05
Y-93	2.160E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.700E+04	0.000E+00	5.870E-02
ZR-95	6.800E+03	1.660E+03	0.000E+00	1.790E+03	0.000E+00	8.260E+05	0.000E+00	1.180E+03
ZR-97	4.060E+00	6.970E-01	0.000E+00	7.030E-01	0.000E+00	4.450E+04	0.000E+00	3.180E-01
NB-95	5.930E+05	2.440E+05	0.000E+00	1.750E+05	0.000E+00	2.060E+08	0.000E+00	1.410E+05
MO-99	0.000E+00	2.080E+08	0.000E+00	3.110E+08	0.000E+00	6.850E+07	0.000E+00	4.060E+07
TC-99M	2.750E+01	5.670E+01	0.000E+00	6.100E+02	2.960E+01	1.650E+04	0.000E+00	7.300E+02
TC-101	2.470E-59	3.110E-59	0.000E+00	3.700E-58	1.700E-59	5.280E-57	0.000E+00	3.080E-58
RU-103	8.670E+03	0.000E+00	0.000E+00	1.800E+04	0.000E+00	1.050E+05	0.000E+00	2.900E+03
RU-105	8.050E-03	0.000E+00	0.000E+00	5.920E-02	0.000E+00	3.200E+00	0.000E+00	2.710E-03
RU-106	1.900E+05	0.000E+00	0.000E+00	2.250E+05	0.000E+00	1.440E+06	0.000E+00	2.380E+04
AG-110M	3.860E+08	2.820E+08	0.000E+00	4.030E+08	0.000E+00	1.460E+10	0.000E+00	1.860E+08
TE-125M	1.510E+08	5.040E+07	5.070E+07	0.000E+00	0.000E+00	7.180E+07	0.000E+00	2.040E+07
TE-127	6.320E+03	2.120E+03	5.140E+03	1.540E+04	0.000E+00	1.330E+05	0.000E+00	1.360E+03
TE-127M	4.210E+08	1.400E+08	1.220E+08	1.040E+09	0.000E+00	1.700E+08	0.000E+00	5.100E+07
TE-129	2.720E-09	9.380E-10	2.280E-09	6.770E-09	0.000E+00	2.170E-07	0.000E+00	6.350E-10
TE-129M	5.570E+08	1.910E+08	2.140E+08	1.390E+09	0.000E+00	3.330E+08	0.000E+00	8.580E+07
TE-131	3.430E-32	1.270E-32	3.060E-32	8.760E-32	0.000E+00	1.380E-30	0.000E+00	9.610E-33
TE-131M	3.380E+06	1.360E+06	2.750E+06	9.350E+06	0.000E+00	2.290E+07	0.000E+00	1.120E+06
TE-132	2.110E+07	1.040E+07	1.540E+07	6.530E+07	0.000E+00	3.870E+07	0.000E+00	9.750E+06
I-130	3.550E+06	7.810E+06	8.750E+08	8.580E+06	0.000E+00	1.670E+06	0.000E+00	3.130E+06

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Grs/Cow/Milk (CMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	2.720E+09	3.200E+09	1.050E+12	3.740E+09	0.000E+00	1.140E+08	0.000E+00	1.410E+09
I-132	1.430E+00	2.900E+00	1.360E+02	3.240E+00	0.000E+00	2.350E+00	0.000E+00	1.030E+00
I-133	3.630E+07	5.280E+07	9.600E+09	6.210E+07	0.000E+00	8.930E+06	0.000E+00	1.550E+07
I-134	1.760E-11	3.600E-11	8.400E-10	4.030E-11	0.000E+00	3.720E-11	0.000E+00	1.280E-11
I-135	1.120E+05	2.230E+05	2.000E+07	2.490E+05	0.000E+00	8.080E+04	0.000E+00	8.140E+04
CS-134	3.650E+10	6.800E+10	0.000E+00	1.750E+10	7.180E+09	1.850E+08	0.000E+00	6.870E+09
CS-136	1.980E+09	5.810E+09	0.000E+00	2.320E+09	4.740E+08	8.820E+07	0.000E+00	2.170E+09
CS-137	5.150E+10	6.020E+10	0.000E+00	1.620E+10	6.550E+09	1.880E+08	0.000E+00	4.270E+09
CS-138	8.390E-23	1.360E-22	0.000E+00	6.800E-23	1.060E-23	2.180E-22	0.000E+00	6.610E-23
BA-139	4.270E-07	2.830E-10	0.000E+00	1.700E-10	1.720E-10	2.710E-05	0.000E+00	1.240E-08
BA-140	2.410E+08	2.410E+05	0.000E+00	5.720E+04	1.480E+05	5.920E+07	0.000E+00	1.240E+07
BA-141	3.930E-45	2.690E-48	0.000E+00	1.620E-48	1.640E-48	4.800E-44	0.000E+00	1.240E-46
BA-142	2.430E-79	2.020E-82	0.000E+00	1.160E-82	1.220E-82	1.000E-78	0.000E+00	1.200E-80
LA-140	4.050E+01	1.600E+01	0.000E+00	0.000E+00	0.000E+00	1.880E+05	0.000E+00	4.110E+00
LA-142	1.700E-10	6.250E-11	0.000E+00	0.000E+00	0.000E+00	1.060E-05	0.000E+00	1.500E-11
CE-141	4.340E+04	2.640E+04	0.000E+00	8.150E+03	0.000E+00	1.370E+07	0.000E+00	3.110E+03
CE-143	3.970E+02	2.630E+05	0.000E+00	7.670E+01	0.000E+00	1.540E+06	0.000E+00	3.000E+01
CE-144	2.330E+06	9.520E+05	0.000E+00	3.850E+05	0.000E+00	1.330E+08	0.000E+00	1.300E+05
PR-143	1.490E+03	5.550E+02	0.000E+00	2.060E+02	0.000E+00	7.840E+05	0.000E+00	7.360E+01
PR-144	5.690E-53	2.200E-53	0.000E+00	7.980E-54	0.000E+00	1.020E-48	0.000E+00	2.870E-54
ND-147	8.810E+02	9.050E+02	0.000E+00	3.490E+02	0.000E+00	5.740E+05	0.000E+00	5.550E+01
W-187	6.080E+04	4.230E+04	0.000E+00	0.000E+00	0.000E+00	2.480E+06	0.000E+00	1.460E+04
NP-239	3.650E+01	3.260E+00	0.000E+00	6.510E+00	0.000E+00	9.430E+04	0.000E+00	1.840E+00

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	4.860E+03	4.860E+03	4.860E+03	4.860E+03	4.860E+03	0.000E+00	4.860E+03
C-14	2.000E+05	4.270E+04	4.270E+04	4.270E+04	4.270E+04	4.270E+04	0.000E+00	4.270E+04
NA-24	1.850E+06	1.850E+06	1.850E+06	1.850E+06	1.850E+06	1.850E+06	0.000E+00	1.850E+06
P-32	1.920E+11	1.130E+10	0.000E+00	0.000E+00	0.000E+00	2.600E+09	0.000E+00	7.460E+09
CR-51	0.000E+00	0.000E+00	1.260E+04	2.760E+03	2.460E+04	5.640E+05	0.000E+00	1.940E+04
MN-54	0.000E+00	4.680E+06	0.000E+00	1.040E+06	0.000E+00	1.720E+06	0.000E+00	1.060E+06
MN-56	0.000E+00	3.720E-03	0.000E+00	3.190E-03	0.000E+00	3.380E-01	0.000E+00	6.410E-04
FE-55	1.760E+06	1.130E+06	0.000E+00	0.000E+00	5.550E+05	1.440E+05	0.000E+00	3.030E+05
FE-59	2.920E+06	5.100E+06	0.000E+00	0.000E+00	1.510E+06	2.430E+06	0.000E+00	2.010E+06
CO-58	0.000E+00	2.910E+06	0.000E+00	0.000E+00	0.000E+00	7.250E+06	0.000E+00	7.260E+06
CO-60	0.000E+00	1.060E+07	0.000E+00	0.000E+00	0.000E+00	2.520E+07	0.000E+00	2.500E+07
NI-63	4.190E+09	2.590E+08	0.000E+00	0.000E+00	0.000E+00	1.290E+07	0.000E+00	1.450E+08
NI-65	4.210E-01	4.760E-02	0.000E+00	0.000E+00	0.000E+00	3.620E+00	0.000E+00	2.170E-02
CU-64	0.000E+00	2.070E+04	0.000E+00	3.500E+04	0.000E+00	4.240E+05	0.000E+00	9.570E+03
ZN-65	6.660E+08	2.280E+09	0.000E+00	1.110E+09	0.000E+00	1.930E+09	0.000E+00	1.050E+09
ZN-69	2.420E-12	4.360E-12	0.000E+00	1.810E-12	0.000E+00	3.550E-10	0.000E+00	3.240E-13
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.120E-01
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.510E-23
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	0.000E+00	2.670E+09	0.000E+00	0.000E+00	0.000E+00	6.830E+07	0.000E+00	1.320E+09
RB-88	0.000E+00	2.250E-45	0.000E+00	0.000E+00	0.000E+00	2.190E-45	0.000E+00	1.230E-45
RB-89	0.000E+00	3.940E-53	0.000E+00	0.000E+00	0.000E+00	1.340E-53	0.000E+00	2.720E-53
SR-89	2.640E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.430E+08	0.000E+00	7.580E+08
SR-90	2.550E+11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.190E+09	0.000E+00	6.500E+10
SR-91	5.700E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.750E+05	0.000E+00	2.060E+04

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	9.750E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.050E+02	0.000E+00	3.620E-01
Y-90	8.170E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.130E+05	0.000E+00	2.190E+00
Y-91	8.790E+03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.300E+05	0.000E+00	2.340E+02
Y-91M	6.810E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.270E-16	0.000E+00	2.320E-21
Y-92	6.450E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.230E+00	0.000E+00	1.810E-06
Y-93	2.590E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.040E+03	0.000E+00	7.050E-03
ZR-95	8.170E+02	1.990E+02	0.000E+00	2.140E+02	0.000E+00	9.910E+04	0.000E+00	1.410E+02
ZR-97	4.870E-01	8.360E-02	0.000E+00	8.430E-02	0.000E+00	5.340E+03	0.000E+00	3.820E-02
NB-95	7.120E+04	2.930E+04	0.000E+00	2.100E+04	0.000E+00	2.480E+07	0.000E+00	1.700E+04
MO-99	0.000E+00	2.500E+07	0.000E+00	3.730E+07	0.000E+00	8.220E+06	0.000E+00	4.870E+06
TC-99M	3.300E+00	6.800E+00	0.000E+00	7.320E+01	3.550E+00	1.970E+03	0.000E+00	8.760E+01
TC-101	2.960E-60	3.730E-60	0.000E+00	4.440E-59	2.030E-60	6.340E-58	0.000E+00	3.690E-59
RU-103	1.040E+03	0.000E+00	0.000E+00	2.170E+03	0.000E+00	1.270E+04	0.000E+00	3.480E+02
RU-105	9.660E-04	0.000E+00	0.000E+00	7.110E-03	0.000E+00	3.840E-01	0.000E+00	3.250E-04
RU-106	2.280E+04	0.000E+00	0.000E+00	2.700E+04	0.000E+00	1.730E+05	0.000E+00	2.850E+03
AG-110M	4.630E+07	3.380E+07	0.000E+00	4.830E+07	0.000E+00	1.750E+09	0.000E+00	2.240E+07
TE-125M	1.810E+07	6.050E+06	6.090E+06	0.000E+00	0.000E+00	8.620E+06	0.000E+00	2.450E+06
TE-127	7.580E+02	2.540E+02	6.170E+02	1.850E+03	0.000E+00	1.590E+04	0.000E+00	1.630E+02
TE-127M	5.050E+07	1.680E+07	1.460E+07	1.240E+08	0.000E+00	2.040E+07	0.000E+00	6.120E+06
TE-129	3.260E-10	1.130E-10	2.740E-10	8.130E-10	0.000E+00	2.610E-08	0.000E+00	7.620E-11
TE-129M	6.690E+07	2.290E+07	2.570E+07	1.670E+08	0.000E+00	3.990E+07	0.000E+00	1.030E+07
TE-131	4.110E-33	1.520E-33	3.670E-33	1.050E-32	0.000E+00	1.660E-31	0.000E+00	1.150E-33
TE-131M	4.050E+05	1.630E+05	3.310E+05	1.120E+06	0.000E+00	2.750E+06	0.000E+00	1.350E+05
TE-132	2.530E+06	1.250E+06	1.850E+06	7.840E+06	0.000E+00	4.640E+06	0.000E+00	1.170E+06
I-130	4.260E+06	9.370E+06	1.050E+09	1.030E+07	0.000E+00	2.010E+06	0.000E+00	3.760E+06

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Grs/Goat/Milk (GMILK)			Units:	m ² ·mrem/yr / μCi/sec; mrem/yr / μCi/m ³ (H-3, C-14)	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	3.260E+09	3.850E+09	1.260E+12	4.490E+09	0.000E+00	1.370E+08	0.000E+00	1.690E+09
I-132	1.720E+00	3.480E+00	1.630E+02	3.890E+00	0.000E+00	2.820E+00	0.000E+00	1.240E+00
I-133	4.350E+07	6.340E+07	1.150E+10	7.450E+07	0.000E+00	1.070E+07	0.000E+00	1.860E+07
I-134	2.110E-11	4.320E-11	1.010E-09	4.830E-11	0.000E+00	4.470E-11	0.000E+00	1.540E-11
I-135	1.350E+05	2.680E+05	2.400E+07	2.990E+05	0.000E+00	9.700E+04	0.000E+00	9.770E+04
CS-134	1.090E+11	2.040E+11	0.000E+00	5.250E+10	2.150E+10	5.540E+08	0.000E+00	2.060E+10
CS-136	5.930E+09	1.740E+10	0.000E+00	6.950E+09	1.420E+09	2.650E+08	0.000E+00	6.510E+09
CS-137	1.540E+11	1.810E+11	0.000E+00	4.850E+10	1.960E+10	5.650E+08	0.000E+00	1.280E+10
CS-138	2.520E-22	4.090E-22	0.000E+00	2.040E-22	3.190E-23	6.540E-22	0.000E+00	1.980E-22
BA-139	5.130E-08	3.400E-11	0.000E+00	2.040E-11	2.060E-11	3.250E-06	0.000E+00	1.480E-09
BA-140	2.890E+07	2.890E+04	0.000E+00	6.870E+03	1.780E+04	7.100E+06	0.000E+00	1.490E+06
BA-141	4.720E-46	3.230E-49	0.000E+00	1.940E-49	1.960E-49	5.760E-45	0.000E+00	1.490E-47
BA-142	2.920E-80	2.430E-83	0.000E+00	1.400E-83	1.470E-83	1.200E-79	0.000E+00	1.440E-81
LA-140	4.860E+00	1.920E+00	0.000E+00	0.000E+00	0.000E+00	2.250E+04	0.000E+00	4.930E-01
LA-142	2.040E-11	7.500E-12	0.000E+00	0.000E+00	0.000E+00	1.270E-06	0.000E+00	1.790E-12
CE-141	5.200E+03	3.170E+03	0.000E+00	9.790E+02	0.000E+00	1.640E+06	0.000E+00	3.740E+02
CE-143	4.760E+01	3.160E+04	0.000E+00	9.200E+00	0.000E+00	1.840E+05	0.000E+00	3.600E+00
CE-144	2.790E+05	1.140E+05	0.000E+00	4.620E+04	0.000E+00	1.600E+07	0.000E+00	1.560E+04
PR-143	1.780E+02	6.670E+01	0.000E+00	2.480E+01	0.000E+00	9.410E+04	0.000E+00	8.840E+00
PR-144	6.830E-54	2.640E-54	0.000E+00	9.570E-55	0.000E+00	1.230E-49	0.000E+00	3.440E-55
ND-147	1.060E+02	1.090E+02	0.000E+00	4.190E+01	0.000E+00	6.880E+04	0.000E+00	6.650E+00
W-187	7.300E+03	5.070E+03	0.000E+00	0.000E+00	0.000E+00	2.980E+05	0.000E+00	1.750E+03
NP-239	4.380E+00	3.910E-01	0.000E+00	7.810E-01	0.000E+00	1.130E+04	0.000E+00	2.210E-01

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	6.470E+02	6.470E+02	6.470E+02	6.470E+02	6.470E+02	0.000E+00	6.470E+02
C-14	2.650E+04	5.310E+03	5.310E+03	5.310E+03	5.310E+03	5.310E+03	0.000E+00	5.310E+03
NA-24	1.060E+04	1.060E+04	1.060E+04	1.060E+04	1.060E+04	1.060E+04	0.000E+00	1.060E+04
P-32	2.030E+06	1.120E+05	0.000E+00	0.000E+00	0.000E+00	1.610E+04	0.000E+00	7.740E+04
CR-51	0.000E+00	0.000E+00	5.750E+01	1.320E+01	1.280E+04	3.570E+02	0.000E+00	8.950E+01
MN-54	0.000E+00	2.530E+04	0.000E+00	4.980E+03	1.000E+06	7.060E+03	0.000E+00	4.980E+03
MN-56	0.000E+00	1.540E+00	0.000E+00	1.100E+00	1.250E+04	7.170E+04	0.000E+00	2.210E-01
FE-55	1.970E+04	1.170E+04	0.000E+00	0.000E+00	8.690E+04	1.090E+03	0.000E+00	3.330E+03
FE-59	1.360E+04	2.350E+04	0.000E+00	0.000E+00	1.010E+06	2.480E+04	0.000E+00	9.480E+03
CO-58	0.000E+00	1.220E+03	0.000E+00	0.000E+00	7.770E+05	1.110E+04	0.000E+00	1.820E+03
CO-60	0.000E+00	8.020E+03	0.000E+00	0.000E+00	4.510E+06	3.190E+04	0.000E+00	1.180E+04
NI-63	3.390E+05	2.040E+04	0.000E+00	0.000E+00	2.090E+05	2.420E+03	0.000E+00	1.160E+04
NI-65	2.390E+00	2.840E-01	0.000E+00	0.000E+00	8.120E+03	5.010E+04	0.000E+00	1.230E-01
CU-64	0.000E+00	1.880E+00	0.000E+00	3.980E+00	9.300E+03	1.500E+04	0.000E+00	7.740E-01
ZN-65	1.930E+04	6.260E+04	0.000E+00	3.250E+04	6.470E+05	5.140E+04	0.000E+00	3.110E+04
ZN-69	5.390E-02	9.670E-02	0.000E+00	4.020E-02	1.470E+03	1.320E+04	0.000E+00	7.180E-03
BR-83	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.810E+02
BR-84	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.000E+02
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.040E+01
RB-86	0.000E+00	1.900E+05	0.000E+00	0.000E+00	0.000E+00	3.040E+03	0.000E+00	8.820E+04
RB-88	0.000E+00	5.570E+02	0.000E+00	0.000E+00	0.000E+00	3.390E+02	0.000E+00	2.870E+02
RB-89	0.000E+00	3.210E+02	0.000E+00	0.000E+00	0.000E+00	6.820E+01	0.000E+00	2.060E+02
SR-89	3.980E+05	0.000E+00	0.000E+00	0.000E+00	2.030E+06	6.400E+04	0.000E+00	1.140E+04
SR-90	4.090E+07	0.000E+00	0.000E+00	0.000E+00	1.120E+07	1.310E+05	0.000E+00	2.590E+06
SR-91	9.560E+01	0.000E+00	0.000E+00	0.000E+00	5.260E+04	7.340E+04	0.000E+00	3.460E+00

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	1.050E+01	0.000E+00	0.000E+00	0.000E+00	2.380E+04	1.400E+05	0.000E+00	3.910E-01
Y-90	3.290E+03	0.000E+00	0.000E+00	0.000E+00	2.690E+05	1.040E+05	0.000E+00	8.820E+01
Y-91	5.880E+05	0.000E+00	0.000E+00	0.000E+00	2.450E+06	7.030E+04	0.000E+00	1.570E+04
Y-91M	4.070E-01	0.000E+00	0.000E+00	0.000E+00	2.790E+03	2.350E+03	0.000E+00	1.390E-02
Y-92	1.640E+01	0.000E+00	0.000E+00	0.000E+00	2.450E+04	1.270E+05	0.000E+00	4.610E-01
Y-93	1.500E+02	0.000E+00	0.000E+00	0.000E+00	7.640E+04	1.670E+05	0.000E+00	4.070E+00
ZR-95	1.150E+05	2.790E+04	0.000E+00	3.110E+04	1.750E+06	2.170E+04	0.000E+00	2.030E+04
ZR-97	1.500E+02	2.560E+01	0.000E+00	2.590E+01	1.100E+05	1.400E+05	0.000E+00	1.170E+01
NB-95	1.570E+04	6.430E+03	0.000E+00	4.720E+03	4.790E+05	1.270E+04	0.000E+00	3.780E+03
MO-99	0.000E+00	1.650E+02	0.000E+00	2.650E+02	1.350E+05	4.870E+04	0.000E+00	3.230E+01
TC-99M	1.400E-03	2.880E-03	0.000E+00	3.110E-02	8.110E+02	2.030E+03	0.000E+00	3.720E-02
TC-101	6.510E-05	8.230E-05	0.000E+00	9.790E-04	5.840E+02	8.440E+02	0.000E+00	8.120E-04
RU-103	2.020E+03	0.000E+00	0.000E+00	4.240E+03	5.520E+05	1.610E+04	0.000E+00	6.790E+02
RU-105	1.220E+00	0.000E+00	0.000E+00	8.990E-01	1.570E+04	4.840E+04	0.000E+00	4.100E-01
RU-106	8.680E+04	0.000E+00	0.000E+00	1.070E+05	1.160E+07	1.640E+05	0.000E+00	1.090E+04
AG-110M	9.980E+03	7.220E+03	0.000E+00	1.090E+04	3.670E+06	3.300E+04	0.000E+00	5.000E+03
TE-125M	4.760E+03	1.990E+03	1.620E+03	0.000E+00	4.470E+05	1.290E+04	0.000E+00	6.580E+02
TE-127	2.230E+00	9.530E-01	1.850E+00	4.860E+00	1.030E+04	2.440E+04	0.000E+00	4.890E-01
TE-127M	1.670E+04	6.900E+03	4.870E+03	3.750E+04	1.310E+06	2.730E+04	0.000E+00	2.070E+03
TE-129	7.880E-02	3.470E-02	6.750E-02	1.750E-01	3.000E+03	2.630E+04	0.000E+00	1.880E-02
TE-129M	1.410E+04	6.090E+03	5.470E+03	3.180E+04	1.680E+06	6.900E+04	0.000E+00	2.230E+03
TE-131	1.740E-02	8.220E-03	1.580E-02	3.990E-02	2.060E+03	8.220E+03	0.000E+00	5.000E-03
TE-131M	1.070E+02	5.500E+01	8.930E+01	2.650E+02	1.990E+05	1.190E+05	0.000E+00	3.630E+01
TE-132	3.720E+02	2.370E+02	2.790E+02	1.030E+03	3.400E+05	4.410E+04	0.000E+00	1.760E+02
I-130	6.360E+03	1.390E+04	1.600E+06	1.530E+04	0.000E+00	1.990E+03	0.000E+00	5.570E+03

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Inhalation (INHL)			Units:	mrem/yr / $\mu\text{Ci}/\text{m}^3$	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	3.790E+04	4.440E+04	1.480E+07	5.180E+04	0.000E+00	1.060E+03	0.000E+00	1.960E+04
I-132	1.690E+03	3.540E+03	1.690E+05	3.950E+03	0.000E+00	1.900E+03	0.000E+00	1.260E+03
I-133	1.320E+04	1.920E+04	3.560E+06	2.240E+04	0.000E+00	2.160E+03	0.000E+00	5.600E+03
I-134	9.210E+02	1.880E+03	4.450E+04	2.090E+03	0.000E+00	1.290E+03	0.000E+00	6.650E+02
I-135	3.860E+03	7.600E+03	6.960E+05	8.470E+03	0.000E+00	1.830E+03	0.000E+00	2.770E+03
CS-134	3.960E+05	7.030E+05	0.000E+00	1.900E+05	7.970E+04	1.330E+03	0.000E+00	7.450E+04
CS-136	4.830E+04	1.350E+05	0.000E+00	5.640E+04	1.180E+04	1.430E+03	0.000E+00	5.290E+04
CS-137	5.490E+05	6.120E+05	0.000E+00	1.720E+05	7.130E+04	1.330E+03	0.000E+00	4.550E+04
CS-138	5.050E+02	7.810E+02	0.000E+00	4.100E+02	6.540E+01	8.760E+02	0.000E+00	3.980E+02
BA-139	1.480E+00	9.840E-04	0.000E+00	5.920E-04	5.950E+03	5.100E+04	0.000E+00	4.300E-02
BA-140	5.600E+04	5.600E+01	0.000E+00	1.340E+01	1.600E+06	3.840E+04	0.000E+00	2.900E+03
BA-141	1.570E-01	1.080E-04	0.000E+00	6.500E-05	2.970E+03	4.750E+03	0.000E+00	4.970E-03
BA-142	3.980E-02	3.300E-05	0.000E+00	1.900E-05	1.550E+03	6.930E+02	0.000E+00	1.960E-03
LA-140	5.050E+02	2.000E+02	0.000E+00	0.000E+00	1.680E+05	8.480E+04	0.000E+00	5.150E+01
LA-142	1.030E+00	3.770E-01	0.000E+00	0.000E+00	8.220E+03	5.950E+04	0.000E+00	9.040E-02
CE-141	2.770E+04	1.670E+04	0.000E+00	5.250E+03	5.170E+05	2.160E+04	0.000E+00	1.990E+03
CE-143	2.930E+02	1.930E+02	0.000E+00	5.640E+01	1.160E+05	4.970E+04	0.000E+00	2.210E+01
CE-144	3.190E+06	1.210E+06	0.000E+00	5.380E+05	9.840E+06	1.480E+05	0.000E+00	1.760E+05
PR-143	1.400E+04	5.240E+03	0.000E+00	1.970E+03	4.330E+05	3.720E+04	0.000E+00	6.990E+02
PR-144	4.790E-02	1.850E-02	0.000E+00	6.720E-03	1.610E+03	4.280E+03	0.000E+00	2.410E-03
ND-147	7.940E+03	8.130E+03	0.000E+00	3.150E+03	3.220E+05	3.120E+04	0.000E+00	5.000E+02
W-187	1.300E+01	9.020E+00	0.000E+00	0.000E+00	3.960E+04	3.560E+04	0.000E+00	3.120E+00
NP-239	3.710E+02	3.320E+01	0.000E+00	6.620E+01	5.950E+04	2.490E+04	0.000E+00	1.880E+01

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
H-3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NA-24	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.190E+07	1.390E+07	1.190E+07
P-32	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CR-51	4.660E+06	4.660E+06	4.660E+06	4.660E+06	4.660E+06	4.660E+06	5.510E+06	4.660E+06
MN-54	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.390E+09	1.630E+09	1.390E+09
MN-56	9.020E+05	9.020E+05	9.020E+05	9.020E+05	9.020E+05	9.020E+05	1.070E+06	9.020E+05
FE-55	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
FE-59	2.730E+08	2.730E+08	2.730E+08	2.730E+08	2.730E+08	2.730E+08	3.210E+08	2.730E+08
CO-58	3.790E+08	3.790E+08	3.790E+08	3.790E+08	3.790E+08	3.790E+08	4.440E+08	3.790E+08
CO-60	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.150E+10	2.530E+10	2.150E+10
NI-63	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NI-65	2.970E+05	2.970E+05	2.970E+05	2.970E+05	2.970E+05	2.970E+05	3.450E+05	2.970E+05
CU-64	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.070E+05	6.880E+05	6.070E+05
ZN-65	7.470E+08	7.470E+08	7.470E+08	7.470E+08	7.470E+08	7.470E+08	8.590E+08	7.470E+08
ZN-69	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	4.870E+03	4.870E+03	4.870E+03	4.870E+03	4.870E+03	4.870E+03	7.080E+03	4.870E+03
BR-84	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.030E+05	2.360E+05	2.030E+05
BR-85	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	8.990E+06	8.990E+06	8.990E+06	8.990E+06	8.990E+06	8.990E+06	1.030E+07	8.990E+06
RB-88	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.310E+04	3.780E+04	3.310E+04
RB-89	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.230E+05	1.480E+05	1.230E+05
SR-89	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.160E+04	2.510E+04	2.160E+04
SR-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-91	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.150E+06	2.510E+06	2.150E+06

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
SR-92	7.770E+05	7.770E+05	7.770E+05	7.770E+05	7.770E+05	7.770E+05	8.630E+05	7.770E+05
Y-90	4.490E+03	4.490E+03	4.490E+03	4.490E+03	4.490E+03	4.490E+03	5.310E+03	4.490E+03
Y-91	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.070E+06	1.210E+06	1.070E+06
Y-91M	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.160E+05	1.000E+05
Y-92	1.800E+05	1.800E+05	1.800E+05	1.800E+05	1.800E+05	1.800E+05	2.140E+05	1.800E+05
Y-93	1.830E+05	1.830E+05	1.830E+05	1.830E+05	1.830E+05	1.830E+05	2.510E+05	1.830E+05
ZR-95	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.450E+08	2.840E+08	2.450E+08
ZR-97	2.960E+06	2.960E+06	2.960E+06	2.960E+06	2.960E+06	2.960E+06	3.440E+06	2.960E+06
NB-95	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.370E+08	1.610E+08	1.370E+08
MO-99	3.990E+06	3.990E+06	3.990E+06	3.990E+06	3.990E+06	3.990E+06	4.630E+06	3.990E+06
TC-99M	1.840E+05	1.840E+05	1.840E+05	1.840E+05	1.840E+05	1.840E+05	2.110E+05	1.840E+05
TC-101	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.040E+04	2.260E+04	2.040E+04
RU-103	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.080E+08	1.260E+08	1.080E+08
RU-105	6.360E+05	6.360E+05	6.360E+05	6.360E+05	6.360E+05	6.360E+05	7.210E+05	6.360E+05
RU-106	4.220E+08	4.220E+08	4.220E+08	4.220E+08	4.220E+08	4.220E+08	5.070E+08	4.220E+08
AG-110M	3.440E+09	3.440E+09	3.440E+09	3.440E+09	3.440E+09	3.440E+09	4.010E+09	3.440E+09
TE-125M	1.550E+06	1.550E+06	1.550E+06	1.550E+06	1.550E+06	1.550E+06	2.130E+06	1.550E+06
TE-127	2.980E+03	2.980E+03	2.980E+03	2.980E+03	2.980E+03	2.980E+03	3.280E+03	2.980E+03
TE-127M	9.160E+04	9.160E+04	9.160E+04	9.160E+04	9.160E+04	9.160E+04	1.080E+05	9.160E+04
TE-129	2.620E+04	2.620E+04	2.620E+04	2.620E+04	2.620E+04	2.620E+04	3.100E+04	2.620E+04
TE-129M	1.980E+07	1.980E+07	1.980E+07	1.980E+07	1.980E+07	1.980E+07	2.310E+07	1.980E+07
TE-131	2.920E+04	2.920E+04	2.920E+04	2.920E+04	2.920E+04	2.920E+04	3.450E+07	2.920E+04
TE-131M	8.030E+06	8.030E+06	8.030E+06	8.030E+06	8.030E+06	8.030E+06	9.460E+06	8.030E+06
TE-132	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.230E+06	4.980E+06	4.230E+06
I-130	5.510E+06	5.510E+06	5.510E+06	5.510E+06	5.510E+06	5.510E+06	6.690E+06	5.510E+06

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Ground Plane Deposition (GPD)			Units:	m ² ·mrem/yr / μCi/sec	
Nuclide	Bone	Liver	Thyroid	Kidney	Lung	Gilli	Skin	Total Body
I-131	1.720E+07	1.720E+07	1.720E+07	1.720E+07	1.720E+07	1.720E+07	2.090E+07	1.720E+07
I-132	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.250E+06	1.470E+06	1.250E+06
I-133	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.450E+06	2.980E+06	2.450E+06
I-134	4.470E+05	4.470E+05	4.470E+05	4.470E+05	4.470E+05	4.470E+05	5.300E+05	4.470E+05
I-135	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.530E+06	2.950E+06	2.530E+06
CS-134	6.860E+09	6.860E+09	6.860E+09	6.860E+09	6.860E+09	6.860E+09	8.000E+09	6.860E+09
CS-136	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.510E+08	1.710E+08	1.510E+08
CS-137	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.030E+10	1.200E+10	1.030E+10
CS-138	3.590E+05	3.590E+05	3.590E+05	3.590E+05	3.590E+05	3.590E+05	4.100E+05	3.590E+05
BA-139	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.060E+05	1.190E+05	1.060E+05
BA-140	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.050E+07	2.350E+07	2.050E+07
BA-141	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.170E+04	4.750E+04	4.170E+04
BA-142	4.490E+04	4.490E+04	4.490E+04	4.490E+04	4.490E+04	4.490E+04	5.110E+04	4.490E+04
LA-140	1.920E+07	1.920E+07	1.920E+07	1.920E+07	1.920E+07	1.920E+07	2.180E+07	1.920E+07
LA-142	7.600E+05	7.600E+05	7.600E+05	7.600E+05	7.600E+05	7.600E+05	9.120E+05	7.600E+05
CE-141	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.370E+07	1.540E+07	1.370E+07
CE-143	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.310E+06	2.630E+06	2.310E+06
CE-144	6.950E+07	6.950E+07	6.950E+07	6.950E+07	6.950E+07	6.950E+07	8.040E+07	6.950E+07
PR-143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR-144	1.830E+03	1.830E+03	1.830E+03	1.830E+03	1.830E+03	1.830E+03	2.110E+03	1.830E+03
ND-147	8.390E+06	8.390E+06	8.390E+06	8.390E+06	8.390E+06	8.390E+06	1.010E+07	8.390E+06
W-187	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.350E+06	2.730E+06	2.350E+06
NP-239	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.710E+06	1.980E+06	1.710E+06

LIST OF EFFECTIVE SECTIONS

<u>SECTION</u>	<u>REVISION NUMBER</u>	<u>REVISION DATE</u>
TABLE OF CONTENTS	15	05/10/16
16.1	1	08/27/08
16.2	2	08/21/09
16.3	1	08/21/09
16.5-1	5	09/03/19
16.5-2	Deleted	
16.5-3	2	09/19/19
16.5-4	0	10/09/02
16.5-5	1	01/28/10
16.5-6	1	08/21/09
16.5-7	2	02/06/15
16.5-8	Deleted	
16.5-9	2	11/06/18
16.5-10	Deleted	
16.6-1	0	10/09/02
16.6-2	Deleted	
16.6-3	1	08/21/09
16.6-4	2	11/21/19
16.6-5	2	01/09/13
16.7-1	1	08/21/09
16.7-2	4	02/03/11
16.7-3	5	11/21/19
16.7-4	2	08/21/09
16.7-5	2	08/21/09

LIST OF EFFECTIVE SECTIONS

<u>SECTION</u>	<u>REVISION NUMBER</u>	<u>REVISION DATE</u>
16.7-6	3	06/10/16
16.7-7	1	08/21/09
16.7-8	2	08/21/09
16.7-9	11	07/18/18
16.7-10	8	06/12/19
16.7-11	1	08/21/09
16.7-12	1	08/21/09
16.7-13	3	06/10/16
16.7-14	1	08/21/09
16.7-15	1	08/21/09
16.7-16	0	06/08/09
16.7-17	0	02/10/15
16.7-18	0	05/10/16
16.8-1	6	12/10/15
16.8-2	3	12/18/19
16.8-3	1	10/24/06
16.8-4	2	11/05/07
16.8-5	3	08/21/09
16.9-1	10	01/29/19
16.9-2	6	08/03/17
16.9-3	5	07/03/18
16.9-4	5	09/11/17
16.9-5	11	10/08/19
16.9-6	12	07/03/18

LIST OF EFFECTIVE SECTIONS

<u>SECTION</u>	<u>REVISION NUMBER</u>	<u>REVISION DATE</u>
16.9-7	4	08/21/09
16.9-8	5	08/21/09
16.9-9	3	08/21/09
16.9-10	5	08/21/09
16.9-11	3	08/21/09
16.9-12	3	02/10/15
16.9-13	4	09/27/16
16.9-14	1	09/25/06
16.9-15	2	08/21/09
16.9-16	2	08/21/09
16.9-17	0	10/09/02
16.9-18	Deleted	
16.9-19	3	02/20/12
16.9-20	0	10/09/02
16.9-21	1	10/13/16
16.9-22	1	08/21/09
16.9-23	5	08/03/17
16.9-24	2	10/24/06
16.9-25	2	08/21/09
16.9-26	1	11/15/18
16.10-1	1	08/21/09
16.10-2	1	10/24/06
16.10-3	1	08/21/09
16.11-1	1	07/27/13

LIST OF EFFECTIVE SECTIONS

<u>SECTION</u>	<u>REVISION NUMBER</u>	<u>REVISION DATE</u>
16.11-2	4	02/10/15
16.11-3	0	10/09/02
16.11-4	1	08/21/09
16.11-5	0	10/09/02
16.11-6	3	08/03/15
16.11-7	10	11/29/17
16.11-8	0	10/09/02
16.11-9	0	10/09/02
16.11-10	1	08/21/09
16.11-11	1	03/20/03
16.11-12	0	10/09/02
16.11-13	1	07/27/13
16.11-14	0	10/09/02
16.11-15	0	10/09/02
16.11-16	1	10/24/11
16.11-17	0	10/09/02
16.11-18	1	08/21/09
16.11-19	0	10/09/02
16.11-20	3	11/21/19
16.11-21	0	10/09/02
16.12-1	0	10/09/02
16.13-1	1	08/03/17
16.13-2	Deleted	
16.13-3	Deleted	

LIST OF EFFECTIVE SECTIONS

<u>SECTION</u>	<u>REVISION NUMBER</u>	<u>REVISION DATE</u>
16.13-4	2	03/11/18

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-1 Liquid Effluents

COMMITMENT: The concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS (see Figure 16.11-16-1 in SLC 16.11-16) shall be limited to:

- a. For radionuclides other than dissolved or entrained noble gases, 10 times the effluent concentrations specified in 10 CFR Part 20, Appendix B, Table 2, Column 2, and
- b. For dissolved or entrained noble gases, the concentration shall be limited to 2×10^{-4} microCurie/ml total activity.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS not within limits.	A.1 Restore the concentration to within limits.	Immediately

TESTING REQUIREMENTS

TEST	FREQUENCY
<p>TR 16.11-1-1 -----NOTE----- The results of the radioactivity analyses shall be used in accordance with the methodology and parameters in the ODCM to assure that the concentrations at the point of release are maintained within the limits. ----- Sample and analyze radioactive liquid wastes according to Table 16.11-1-1.</p>	According to Table 16.11-1-1

Table 16.11-1-1

Radioactive Liquid Waste Sampling and Analysis Program (page 1 of 3)

LIQUID RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS	LOWER LIMIT OF DETECTION (LLD) ⁽¹⁾ (μCi/ml)			
1. Batch Waste Release Tanks ⁽²⁾ Any tank which discharges liquid wastes by either liquid effluent monitor, EMF-49 or EMF-57	Prior to each release Each Batch	Prior to each release Each Batch	Principal Gamma Emitters ⁽³⁾	5×10^{-7}			
			I-131	1×10^{-6}			
	Prior to each release One Batch/31 days	31 days	Dissolved and Entrained Gases (Gamma Emitters)		1×10^{-5}		
				Prior to each release Each Batch	31 days Composite ⁽⁴⁾	H-3	1×10^{-5}
						Gross Alpha	1×10^{-7}
Prior to each release Each Batch	92 days Composite ⁽⁴⁾	Sr-89, Sr-90	5×10^{-8}				
2. Continuous Releases ⁽⁵⁾ Conventional Waste Water Treatment Line	Continuous ⁽⁶⁾	7 days Composite ⁽⁶⁾	Principal Gamma Emitters ⁽³⁾	5×10^{-7}			
			I-131	1×10^{-6}			
	31 days Grab Sample	31 days	Dissolved and Entrained Gases (Gamma Emitters)	1×10^{-5}			
	Continuous ⁽⁶⁾	31 days Composite ⁽⁶⁾	H-3	1×10^{-5}			
			Gross Alpha	1×10^{-7}			
	Continuous ⁽⁶⁾	92 days Composite ⁽⁶⁾	Sr-89, Sr-90	5×10^{-8}			

Table 16.11-1-1

Radioactive Liquid Waste Sampling and Analysis Program (page 2 of 3)

NOTES:

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

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

$$LLD = \frac{(2.71/T) + 4.65 s_b}{E \cdot V \cdot 2.22 \times 10^6 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

Where:

LLD = the "a priori" lower limit of detection (microCurie per unit mass or volume),

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),

E = the counting efficiency (counts per disintegration),

V = the sample size (units of mass or volume),

2.22×10^6 = the number of disintegrations per minute per microCurie,

Y = the fractional radiochemical yield, when applicable,

λ = the radioactive decay constant for the particular radionuclide (sec^{-1}),

Δt = the elapsed time between midpoint of sample collection and time of counting (sec), and

T = the sample counting time (min).

Typical values of E, V, Y and Δt shall be used in the calculation.

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

- (2) A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated, and then thoroughly mixed to assure representative sampling.

Table 16.11-1-1

Radioactive Liquid Waste Sampling and Analysis Program (page 3 of 3)

- (3) The principal gamma emitters for which the LLD specification applies include the following radionuclides:

Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, and Ce-141. The LLD for Ce-144 is 5×10^{-6} $\mu\text{Ci/ml}$. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Radioactive Effluent Release Report pursuant to Technical Specification 5.6.3 in the format outlined in Regulatory Guide 1.21, Appendix B, Revision 1, June 1974.

- (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 that is representative of the liquids released.
- (5) A continuous release is the discharge of liquid wastes of a non-discrete volume, e.g., from a volume of a system that has an input flow during the continuous release.
- (6) To be representative of the quantities and concentrations of radioactive materials in liquid effluents, samples shall be collected continuously in proportion to the rate of flow of the effluent stream. Prior to analyses, all samples taken for the composite shall be thoroughly mixed in order for the composite sample to be representative of the effluent release.

BASES

The basic requirements for SLCs concerning effluents from nuclear power reactors are stated in 10 CFR 50.36a. These requirements indicate that compliance with effluent SLCs will keep average annual releases of radioactive material in effluents to small percentages of the limits specified in the old 10 CFR 20.106 (new 10 CFR 20.1302). These requirements further indicate that operational flexibility is allowed, compatible with considerations of health and safety, which may temporarily result in releases higher than such small percentages, but still within the limits specified in the old 10 CFR 20.106 which references Appendix B, Table II concentrations (MPCs). These referenced concentrations are specific values which relate to an annual dose of 500 mrem. It is further indicated in 10 CFR 50.36a that when using operational flexibility, best efforts shall be exerted to keep levels of radioactive materials in effluents as low as is reasonably achievable (ALARA) as set forth in 10 CFR 50, Appendix I.

As stated in the Introduction to Appendix B of the new 10 CFR 20, the liquid effluent concentration (EC) limits given in Appendix B, Table 2, Column 2, are based on an annual dose of 50 mrem. Since a release concentration corresponding to a limiting dose rate of 500 mrem/year has been acceptable as a SLC limit for liquid effluents, which applies at all times as an assurance that the limits of 10 CFR 50, Appendix I are not likely to be exceeded, it should not be necessary to reduce this limit by a factor of 10.

Operational history at Catawba has demonstrated that the use of the concentration values associated with the old 10 CFR 20.106 as SLC limits has resulted in calculated maximum individual doses to a MEMBER OF THE PUBLIC that are small percentages of the limits of 10 CFR 50, Appendix I. Therefore, the use of concentration values which correspond to an annual dose of 500 mrem (ten times the concentration values stated in the new 10 CFR 20, Appendix B, Table 2, Column 2) should not have a negative impact on the ability to continue to operate within the limits of 10 CFR 50, Appendix I and 40 CFR 190.

Having sufficient operational flexibility is especially important in establishing a basis for effluent monitor setpoint calculations. As discussed above, the concentrations stated in the new 10 CFR 20, Appendix B, Table 2, Column 2, relate to a dose of 50 mrem in a year. When applied on an instantaneous basis, this corresponds to a dose rate of 50 mrem/year. This low value is impractical upon which to base effluent monitor setpoint calculations for many liquid effluent release situations when monitor background, monitor sensitivity, and monitor performance must be taken into account.

Therefore, to accommodate operational flexibility needed for effluent releases, the limits associated with SLC 16.11-1 are based on ten times the concentrations stated in the new 10 CFR 20, Appendix B, Table 2, Column 2, to apply at all times. The multiplier of ten is proposed because the annual dose of 500 mrem, upon which the concentrations in the old 10 CFR 20, Appendix B, Table II, Column 2, are based, is a factor of 10 higher than annual dose of 50 mrem, upon which the concentrations in the new 10 CFR

BASES (continued)

20, Appendix B, Table 2, Column 2, are based. Compliance with the limits of the new 10 CFR 20.1301 will be demonstrated by operating within the limits of 10 CFR 50, Appendix I and 40 CFR 190. The concentration limit for dissolved or entrained noble gases is based upon the assumption that Xe-135 is the controlling radioisotope and its MPC in air (submersion) was converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection (ICRP) Publication 2.

This commitment applies to the release of radioactive materials in liquid effluents from all units at the site.

The required detection capabilities for radioactive materials in liquid waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD, and other detection limits can be found in HASL Procedures Manual, HASL-300 (revised annually), Currie, L. A., "Limits for Qualitative Detection and Quantitative Determination – Application to Radiochemistry," Annal. 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).

REFERENCES

1. Catawba Offsite Dose Calculation Manual.
2. 10 CFR Part 20, Appendix B.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-2 Radioactive Liquid Effluent Monitoring Instrumentation

COMMITMENT The Radioactive Liquid Effluent Monitoring Instrumentation channels shown in Table 16.11-2-1 shall be FUNCTIONAL with their Alarm/Trip Setpoints set to ensure that the limits of SLC 16.11-1 are not exceeded.

AND

The Alarm/Trip Setpoints of these channels shall be determined and adjusted in accordance with the methodology and parameters in the OFFSITE DOSE CALCULATION MANUAL (ODCM).

APPLICABILITY: At all times, except when the effluent pathway is mechanically isolated; thus, a release to the environment is not possible.

REMEDIAL ACTIONS

-----NOTE-----
Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more Radioactive Liquid Effluent Monitoring Instrumentation channel(s) Alarm/Trip Setpoint less conservative than required.	A.1 Suspend the release of radioactive liquid effluents monitored by the affected channel(s).	Immediately
	<u>OR</u>	
	A.2 Declare the channel(s) non-functional.	Immediately
B. One or more Radioactive Liquid Effluent Monitoring Instrumentation channel(s) non-functional.	B.1 Enter the applicable Conditions and Required Actions specified in Table 16.11-2-1 for the channel(s).	Immediately

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
C. One channel non-functional.	C.1.1 Analyze two independent samples per Testing Requirement 16.11-1-1. <u>AND</u>	Prior to initiating a release
	C.1.2 Perform independent verification of the discharge line valving. <u>AND</u>	Prior to initiating a release
	C.1.3.1 Perform independent verification of manual portion of the computer input for release rate calculations performed by computer. <u>OR</u>	Prior to initiating a release
	C.1.3.2 Perform independent verification of entire calculations for release rate calculations performed manually. <u>AND</u>	Prior to initiating a release
	C.1.4 Restore channel to FUNCTIONAL status. <u>OR</u>	14 days
	C.2 Suspend release of radioactive effluents via this pathway.	Immediately

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
D. One flow rate measurement device channel non-functional.	D.1 -----NOTE----- Pump performance curves generated in place may be used to estimate flow. ----- Estimate the flow rate of the release.	Once per 4 hours during releases
	<u>AND</u> D.2 Restore channel to FUNCTIONAL status.	30 days
E. One channel non-functional.	E.1 Perform an analysis of grab samples for radioactivity at a lower limit of detection of 10^{-7} microCurie/ml.	Once per 12 hours during releases when secondary specific activity is > 0.01 microCurie/gm DOSE EQUIVALENT I-131
	<u>AND</u> E.2 Restore channel to FUNCTIONAL status.	<u>AND</u> Once per 24 hours during releases when secondary specific activity is \leq 0.01 microCurie/gm DOSE EQUIVALENT I-131 30 days

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
F. One channel non-functional.	F.1 Collect and analyze grab samples for principal gamma emitters (listed in Table 16.11-1-1, NOTE 3) at a lower limit of detection of no more than 5×10^{-7} microCurie/ml.	Once per 12 hours
	<u>AND</u> F.2 Restore non-functional channel to FUNCTIONAL status.	30 days
G. Required Action and associated Completion Time of Condition C, D, E, or F not met.	G.1 Explain why the non-functionality was not corrected within the specified Completion Time.	In the next scheduled Radioactive Effluent Release Report pursuant to Technical Specification 5.6.3

TESTING REQUIREMENTS

-----NOTE-----

Refer to Table 16.11-2-1 to determine which TRs apply for each Radioactive Liquid Effluent Monitoring Instrumentation channel.

TEST	FREQUENCY
TR 16.11-2-1 Perform CHANNEL CHECK.	24 hours
TR 16.11-2-2 -----NOTE----- The CHANNEL CHECK shall consist of verifying indication of flow. ----- Perform CHANNEL CHECK.	24 hours during periods of release
TR 16.11-2-3 Perform SOURCE CHECK.	Prior to each release
TR 16.11-2-4 Perform SOURCE CHECK.	31 days
TR 16.11-2-5 Perform COT.	92 days
TR 16.11-2-6 -----NOTE----- For Instrument 1, the COT shall also demonstrate that automatic isolation of this pathway and control room alarm annunciation (for EMF-57, alarm annunciation is in the Monitor Tank Building control room and on the Monitor Tank Building control panel remote annunciator panel) occur if any of the following conditions exist: a. Instrument indicates measured levels above the Alarm/Trip Setpoint, or b. Circuit failure/instrument downscale failure (alarm only) ----- Perform COT.	9 months

(continued)

TESTING REQUIREMENTS (continued)

TEST	FREQUENCY
<p>TR 16.11-2-7 -----NOTE----- For Instrument 1, the initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Bureau of Standards (NBS) or using standards that have been obtained from suppliers that participate in measurement assurance activities with NBS. These standards shall permit calibrating the system over its intended range of energy and measurement range. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used. ----- Perform CHANNEL CALIBRATION.</p>	<p>18 months</p>

Table 16.11-2-1

Radioactive Liquid Effluent Monitoring Instrumentation

INSTRUMENT	REQUIRED CHANNELS	CONDITIONS	TESTING REQUIREMENTS
1. Radioactivity Monitors Providing Alarm and Automatic Termination of Release			
1.a Waste Liquid Discharge Monitor (EMF-49 – Low Range)	1 per station	A, C, G	TR 16.11-2-1 TR 16.11-2-3 TR 16.11-2-6 TR 16.11-2-7
1.b Turbine Building Sump Monitor (EMF-31)	1	A, E, G	TR 16.11-2-1 TR 16.11-2-4 TR 16.11-2-6 TR 16.11-2-7
1.c Monitor Tank Building Liquid Discharge Monitor (EMF-57 – Low Range)	1 per station	A, C, G	TR 16.11-2-1 TR 16.11-2-3 TR 16.11-2-6 TR 16.11-2-7
2. Continuous Composite Samplers and Sampler Flow Monitor			
2.a Conventional Waste Water Treatment Line (no alarm/trip function)	1 per station	E, G	TR 16.11-2-2 TR 16.11-2-7
3. Flow Rate Measurement Devices			
3.a Waste Liquid Effluent Line (no alarm/trip function)	1 per station	D, G	TR 16.11-2-2 TR 16.11-2-7
3.b Conventional Waste Water Treatment Line (no alarm/trip function)	1 per station	D, G	TR 16.11-2-2 TR 16.11-2-7
3.c Low Pressure Service Water Minimum Flow Interlock	1 per station	D, G	TR 16.11-2-2 TR 16.11-2-5 TR 16.11-2-7
3.d Monitor Tank Building Waste Liquid Effluent Line (no alarm/trip function)	1 per station	D, G	TR 16.11-2-2 TR 16.11-2-7
4. Radioactivity Monitors Providing Alarm			
4.a Service Water Monitor on Containment Spray Heat Exchanger (EMF-45 A & B – Low Range)	1 per heat exchanger	A, F, G	TR 16.11-2-1 TR 16.11-2-4 TR 16.11-2-6 TR 16.11-2-7

BASES The Radioactive Liquid Effluent Monitoring 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 and adjusted in accordance with the methodology and parameters in the ODCM to ensure that the Alarm/Trip will occur prior to exceeding the limits of 10 CFR Part 20. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

Regarding the COMMITMENT APPLICABILITY, isolation of the effluent pathway is to be by mechanical means (e.g., valve closure). Electrical or pneumatic isolation is not required, unless the isolation is designed to receive an automatic signal to open.

- REFERENCES**
1. Catawba Offsite Dose Calculation Manual.
 2. 10 CFR Part 20.
 3. 10 CFR Part 50, Appendix A.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-3 Dose

COMMITMENT The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released, from each unit, to UNRESTRICTED AREAS (see Figure 16.11-16-1 in SLC 16.11-16) shall be limited:

- a. During any calendar quarter to ≤ 1.5 mrem to the whole body and to ≤ 5 mrem to any organ, and
- b. During any calendar year to ≤ 3 mrem to the whole body and to ≤ 10 mrem to any organ.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Calculated dose from release of radioactive materials in liquid effluents exceeding above limits.</p>	<p>A.1 -----NOTE----- If drinking water supply is taken from receiving water body within 3 miles downstream of plant discharge, the Special Report shall also include the results of radiological analyses of the drinking water source and the radiological impact on finished drinking water supplies with regard to 40 CFR 141, Safe Drinking Water Act. ----- Prepare and submit a Special Report to the NRC which identifies the causes for exceeding the limits, corrective actions taken to reduce releases, and actions taken to ensure that subsequent releases are within limits.</p>	<p>30 days</p>

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11-3-1 Determine cumulative dose contributions from liquid effluents for current calendar quarter and current calendar year in accordance with the methodology and parameters in the ODCM.	31 days

BASES This SLC is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR Part 50. The COMMITMENT implements the guides set forth in Section II.A of Appendix I. The REMEDIAL ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents to UNRESTRICTED AREAS will be kept “as low as is reasonably achievable”. Also, for fresh water sites with drinking water supplies that can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR Part 141. The dose calculation methodology and parameters in the ODCM implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I,” Revision 1, October 1977 and Regulatory Guide 1.113, “Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I,” April 1977.

This SLC applies to the release of radioactive materials in liquid effluents from each unit at the site. When shared radwaste treatment systems are used by more than one unit on a site, the wastes from all units are mixed for shared treatment; by such mixing, the effluent releases cannot accurately be ascribed to a specific unit. An estimate should be made of the contributions from each unit based on input conditions, e.g., flow rates and radioactivity concentrations, or, if not practicable, the treated effluent releases may be allocated equally to each of the radioactive waste producing units sharing the radwaste treatment system. For determining conformance to COMMITMENTS, these allocations from shared radwaste treatment systems are to be added to the releases specifically attributed to each unit to obtain the total releases per unit.

- REFERENCES
1. Catawba Offsite Dose Calculation Manual.
 2. 40 CFR Part 141.
 3. 10 CFR Part 50, Appendix I.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-4 Liquid Radwaste Treatment System

COMMITMENT The Liquid Radwaste Treatment System shall be FUNCTIONAL and appropriate portions of the system shall be used to reduce releases of radioactivity when the projected doses due to the liquid effluent, from each unit, to UNRESTRICTED AREAS (see Figure 16.11-16-1 in SLC 16.11-16) would exceed 0.06 mrem to the whole body or 0.2 mrem to any organ in a 31-day period.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Radioactive liquid waste being discharged without treatment and in excess of above limits.</p> <p><u>AND</u></p> <p>Any portion of Liquid Radwaste Treatment System not in operation.</p>	<p>A.1 Prepare and submit a Special Report to the NRC which identifies the reasons liquid radwaste was discharged without treatment, identification of non-functional equipment and reasons for non-functionality, corrective actions taken to restore the equipment to FUNCTIONAL status, and actions taken to prevent recurrence.</p>	<p>30 days</p>

TESTING REQUIREMENTS

-----NOTE-----

The Liquid Radwaste Treatment System shall be demonstrated FUNCTIONAL by meeting SLC 16.11-1 and SLC 16.11-3.

TEST	FREQUENCY
TR 16.11-4-1 Project liquid release doses from each unit to UNRESTRICTED AREAS, in accordance with the methodology and parameters in the ODCM, when the Liquid Radwaste Treatment System is not being fully utilized.	31 days

BASES

The FUNCTIONALITY of the Liquid Radwaste Treatment System ensures that this system will be available for use whenever liquid effluents require treatment prior to release to the environment. 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 COMMITMENT implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objective given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the Liquid Radwaste Treatment System were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50, for liquid effluents.

This SLC applies to the release of radioactive materials in liquid effluents from each unit at the site. When shared radwaste treatment systems are used by more than one unit on a site, the wastes from all units are mixed for shared treatment; by such mixing, the effluent releases cannot accurately be ascribed to a specific unit. An estimate should be made of the contributions from each unit based on input conditions, e.g., flow rates and radioactivity concentrations, or, if not practicable, the treated effluent releases may be allocated equally to each of the radioactive waste producing units sharing the radwaste treatment system. For determining conformance to COMMITMENTS, these allocations from shared radwaste treatment systems are to be added to the releases specifically attributed to each unit to obtain the total releases per unit.

REFERENCES

1. Catawba Offsite Dose Calculation Manual.
2. 10 CFR Part 50, Appendix A.

REFERENCES (continued)

3. 10 CFR Part 50, Appendix I.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-5 Chemical Treatment Ponds

COMMITMENT The quantity of radioactive material contained in each Chemical Treatment Pond (CTP) shall be limited by the following expression:

$$\frac{264}{V} \cdot \sum_j \frac{A_j}{(C_j \times 10)} < 1.0$$

excluding tritium and dissolved or entrained noble gases,

where:

A_j = CTP inventory limit for single radionuclide “j”, in Curies;

C_j = 10 CFR 20, Appendix B, Table 2, Column 2, concentration for single radionuclide “j”, microCuries/milliliter;

V = design volume of liquid and slurry in the CTP, in gallons;
and

264 = conversion unit, microCuries/Curie per milliliter/gallon.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Quantity of radioactive material in any CTP exceeding above limit.</p>	<p>A.1 Suspend all additions of radioactive material to the CTP.</p>	<p>Immediately</p>
	<p><u>AND</u></p> <p>A.2 Initiate corrective action to reduce the CTP contents to within limits.</p>	<p>Immediately</p>

TESTING REQUIREMENTS

TEST	FREQUENCY
<p>TR 16.11-5-1 Verify that the quantity of radioactive material contained in each batch of resin/water slurry to be transferred to the CTPs is within limits by analyzing a representative sample of the batch to be transferred. Each batch to be transferred to the CTPs shall be limited by:</p> $\sum_j \frac{c_j}{(C_j \times 10)} < 0.006,$ <p>where:</p> <p>c_j = radioactive resin/water slurry concentration for radionuclide "j" entering the UNRESTRICTED AREA CTPs, in microCuries/milliliter; and</p> <p>C_j = 10 CFR 20, Appendix B, Table 2, Column 2, concentration for single radionuclide "j", in microCuries/milliliter.</p>	<p>Prior to each transfer</p>

BASES The inventory limits of the CTPs are based on limiting the consequences of an uncontrolled release of the pond inventory. The expression in this SLC assumes the pond inventory is uniformly mixed, that the pond is located in an uncontrolled area as defined in 10 CFR Part 20, and that the concentration limit in Note 1 to Appendix B of 10 CFR Part 20 applies.

The batch limits of resin/water slurry transferred to the CTP assure that radioactive material transferred to the CTP are "as low as is reasonably achievable" in accordance with 10 CFR 50.36a. The expression in SLC 16.11-5 assures no batch will be transferred to the CTP unless the sum of the ratios of the activity of the radionuclides to their respective concentration limitation is less than the ratio of the 10 CFR Part 50, Appendix I, Section II.A, total body dose level to the instantaneous whole body dose rate limitation, or that:

$$\sum_j \frac{c_j}{(C_j \times 10)} < \frac{3 \text{ mrem / yr}}{500 \text{ mrem / yr}} = 0.006,$$

where:

BASES (continued)

c_j = radioactive resin/water slurry concentration for radionuclide "j" entering the UNRESTRICTED AREA CTP, in microCuries/milliliter; and,

C_j = 10 CFR Part 20, Appendix B, Table 2, Column 2, concentration for single radionuclide "j", in microCuries/milliliter.

The filter/demineralizers using powdered resin and the blowdown demineralizer are backwashed or sluiced to a holding tank. The tank will be agitated to obtain a representative sample of the resin inventory in the tank. A known weight of the wet, drained resin (moisture content approximately 55 to 60%, bulk density of about 58 pounds per cubic foot) will then be counted. The concentration of the resin slurry to be pumped to the CTPs will then be determined by the formula:

$$c_j = \frac{Q_j W_R}{V_T},$$

where:

Q_j = concentration of radioactive materials in wet, drained resin for radionuclide "j", excluding tritium, dissolved or entrained noble gases, and radionuclides with less than an 8-day half-life. The analysis shall include at least Ce-144, Cs-134, Cs-137, Co-58, and Co-60, in microCuries/gram. Estimates of the Sr-89 and Sr-90 batch concentration shall be included based on the most recent monthly composite analysis (within 3 months);

W_R = total weight of resin in the storage tank in grams (determined from chemistry logs procedures); and,

V_T = total volume of resin water mixture in storage tank to be transferred to the CTPs in milliliters.

The batch limits provide assurance that activity input to the CTP will be minimized, and a means of identifying radioactive material in the inventory limitation of this SLC.

- REFERENCES
1. Catawba Offsite Dose Calculation Manual.
 2. 10 CFR Part 20, Appendix B.
 3. 10 CFR Part 50, Appendix I.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-6 Gaseous Effluents

COMMITMENT The dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY (see Figure 16.11-16-1 in SLC 16.11-16) shall be limited to the following:

- a. For noble gases: ≤ 500 mrem/yr to the whole body and ≤ 3000 mrem/yr to the skin; and,
- b. For Iodine-131, for Iodine-133, for tritium, and for all radionuclides in particulate form with half-lives > 8 days: ≤ 1500 mrem/yr to any organ.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Dose rate not within limit.	A.1 Restore the release rate to within limits.	Immediately

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11-6-1 Verify that the dose rate due to noble gases in gaseous effluents is within limits in accordance with the methodology and parameters in the ODCM.	In accordance with the methodology and parameters in the ODCM
TR 16.11-6-2 Verify that the dose rate due to Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives > 8 days in gaseous effluents is within limits in accordance with the methodology and parameters in the ODCM by obtaining representative samples and performing analyses according to Table 16.11-6-1.	According to Table 16.11-6-1

Table 16.11-6-1

Radioactive Gaseous Waste Sampling and Analysis Program (page 1 of 4)

GASEOUS RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS	LOWER LIMIT OF DETECTION (LLD) ⁽¹⁾ (μCi/ml)
1. Waste Gas Storage Tank	Prior to each release Each Tank Grab Sample	Prior to each release Each Tank	Principal Gamma Emitters ⁽²⁾	1x10 ⁻⁴
2. Containment Purge	Prior to each release Each PURGE ⁽³⁾ Grab Sample	Prior to each release Each PURGE ⁽³⁾	Principal Gamma Emitters ⁽²⁾	1x10 ⁻⁴
3. Unit Vent	7 days ⁽³⁾⁽⁴⁾ Grab Sample	31 days	H-3 (oxide)	1x10 ⁻⁶
		7 days ⁽³⁾	Principal Gamma Emitters ⁽²⁾	1x10 ⁻⁴
4. Containment Air Release and Addition System	24 hours ⁽³⁾⁽⁵⁾ Grab Sample	24 hours ⁽³⁾⁽⁵⁾	Principal Gamma Emitters ⁽²⁾	1x10 ⁻⁴
		31 days	H-3 (oxide)	1x10 ⁻⁶
5. All Release Types as Listed in 3. Above	Continuous ⁽⁶⁾	7 days ⁽⁷⁾ Charcoal Sample	I-131	1x10 ⁻¹²
		7 days ⁽⁷⁾ Particulate Sample	I-133	1x10 ⁻¹⁰
		31 days Composite Particulate Sample	Principal Gamma Emitters ⁽²⁾	1x10 ⁻¹¹
		92 days Composite Particulate Sample	Gross Alpha ⁽⁸⁾	1x10 ⁻¹¹
			Sr-89, Sr-90	1x10 ⁻¹¹

(continued)

Table 16.11-6-1
Radioactive Gaseous Waste Sampling and Analysis Program (page 2 of 4)

GASEOUS RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS	LOWER LIMIT OF DETECTION (LLD) ⁽¹⁾ (μCi/ml)
6. Waste Monitor Tank Building Ventilation Exhaust	7 days Grab Sample	7 days	Principal Gamma Emitters ⁽²⁾	1x10 ⁻⁴
	Continuous ⁽⁶⁾	7 days ⁽⁹⁾ Charcoal Sample	H-3 (oxide)	1x10 ⁻⁶
	Continuous ⁽⁶⁾	7 days ⁽⁹⁾ Particulate Sample	I-131	1x10 ⁻¹²
	Continuous ⁽⁶⁾	7 days ⁽⁹⁾ Particulate Sample	I-133	1x10 ⁻¹⁰
	Continuous ⁽⁶⁾	31 days Composite Particulate Sample	Principal Gamma Emitters ⁽²⁾	1x10 ⁻¹¹
	Continuous ⁽⁶⁾	92 days Composite Particulate Sample	Gross Alpha Sr-89, Sr-90	1x10 ⁻¹¹

Table 16.11-6-1

Radioactive Gaseous Waste Sampling and Analysis Program (page 3 of 4)

NOTES:

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

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

$$LLD = \frac{(2.71/T) + 4.65 s_b}{E \cdot V \cdot 2.22 \times 10^6 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

Where:

LLD = the "a priori" lower limit of detection (microCurie per unit mass or volume);

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute);

E = the counting efficiency (counts per disintegration);

V = the sample size (units of mass or volume);

2.22×10^6 = the number of disintegrations per minute per microCurie;

Y = the fractional radiochemical yield, when applicable;

λ = the radioactive decay constant for the particular radionuclide (sec^{-1});

Δt = the elapsed time between midpoint of sample collection and time of counting (sec); and

T = the sample counting time (min).

Typical values of E, V, Y and Δt shall be used in the calculation.

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

Table 16.11-6-1

Radioactive Gaseous Waste Sampling and Analysis Program (page 4 of 4)

- (2) The principal gamma emitters for which the LLD specification applies include the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 in noble gas releases based on grab samples and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, I-131, Cs-134, Cs-137, and Ce-141 in iodine and particulate releases based on continuous samples. The LLD for Ce-144 is 5×10^{-9} $\mu\text{Ci/ml}$ and is based on continuous samples. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Radioactive Effluent Release Report, pursuant to Technical Specification 5.6.3 in the format outlined in Regulatory Guide 1.21, Appendix B, Revision 1, June 1974.
- (3) Sampling and analysis shall also be performed following shutdown, startup, or a THERMAL POWER stabilization (power level constant at desired power level) after a THERMAL POWER change exceeding 15% of RATED THERMAL POWER within a 1-hour period, for at least one of the three gaseous release types with this notation.
- (4) Tritium grab samples shall be taken at least once per 24 hours when the refueling canal is flooded.
- (5) Required sampling and analysis frequency during effluent release via this pathway.
- (6) The ratio of the sample flow volume to the sampled stream flow volume shall be known for the time period covered by each dose or dose rate calculation made in accordance with SLCs 16.11-6, 16.11-8, and 16.11-9.
- (7) Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing, or after removal from sampler. Sampling 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 does not apply if: (1) analysis shows that the DOSE EQUIVALENT I-131 concentration in the reactor coolant has not increased more than a factor of 3; and (2) the noble gas monitor shows that effluent activity has not increased more than a factor of 3.
- (8) The composite filter(s) will be analyzed for alpha activity by analyzing one filter per week to ensure that at least four filters are analyzed per collection period.
- (9) Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours to meet LLDs after changing, or after removal from sampler. If the particulate and charcoal sample frequency is changed to a 24-hour frequency, the corresponding LLDs may be increased by a factor of 10 (e.g., LLD for I-131 from 1×10^{-12} to 1×10^{-11} $\mu\text{Ci/ml}$).

BASES

The basic requirements for SLCs concerning effluents from nuclear power reactors are stated in 10 CFR 50.36a. These requirements indicate that compliance with effluent SLCs will keep average annual releases of radioactive material in effluents to small percentages of the limits specified in the old 10 CFR 20.106 (new 10 CFR 20.1301). These requirements further indicate that operational flexibility is allowed, compatible with considerations of health and safety, which may temporarily result in releases higher than such small percentages, but still within the limits specified in the old 10 CFR 20.106 which references Appendix B, Table II concentrations (MPCs). These referenced concentrations are specific values which relate to an annual dose of 500 mrem. It is further indicated in 10 CFR 50.36a that when using operational flexibility, best efforts shall be exerted to keep levels of radioactive materials in effluents as low as is reasonably achievable (ALARA) as set forth in 10 CFR 50, Appendix I.

As stated in the Introduction to Appendix B of the new 10 CFR 20, the gaseous effluent concentration (EC) limits given in Appendix B, Table 2, Column 1, are based on an annual dose of 50 mrem for isotopes for which inhalation or ingestion is limiting or 100 mrem for isotopes for which submersion (noble gases) is limiting. Since release concentrations corresponding to limiting dose rates less than or equal to 500 mrem/year to the whole body, 3000 mrem/year to the skin from noble gases, and 1500 mrem/year to any organ from Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days at the site boundary has been acceptable as a SLC limit for gaseous effluents to assure that the limits of 10 CFR 50, Appendix I and 40 CFR 190 are not likely to be exceeded, it should not be necessary to restrict the operational flexibility by incorporating the dose rate associated with the EC value for isotopes based on inhalation/ingestion (50 mrem/year) or the dose rate associated with the EC value for isotopes based on submersion (100 mrem/year).

Having sufficient operational flexibility is especially important in establishing a basis for effluent monitor setpoint calculations. As discussed above, the concentrations stated in the new 10 CFR 20, Appendix B, Table 2, Column 1, relate to a dose of 50 or 100 mrem in a year. When applied on an instantaneous basis, this corresponds to a dose rate of 50 or 100 mrem/year.

These low values are impractical upon which to base effluent monitor setpoint calculations for many gaseous effluent release situations when monitor background, monitor sensitivity, and monitor performance must be taken into account.

Therefore, to accommodate operational flexibility needed for effluent releases, the limits associated with gaseous release rate SLCs will be maintained at the current instantaneous dose rate limit for noble gases of 500 mrem/year to the whole body and 3000 mrem/year to the skin; and for Iodine-131, for Iodine-133, for tritium, and for all radionuclides in particulate

BASES (continued)

form with half-lives greater than 8 days, an instantaneous dose rate limit of 1500 mrems/year to any organ.

Compliance with the limits of the new 10 CFR 20.1301 will be demonstrated by operating within the limits of 10 CFR 50, Appendix I and 40 CFR 190. Operational history at Catawba has demonstrated that the use of the dose rate values listed above (i.e., 500 mrems/year, 3000 mrems/year, and 1500 mrems/year) as SLC limits has resulted in calculated maximum individual doses to MEMBERS OF THE PUBLIC that are small percentages of the limits of 10 CFR 50, Appendix I and 40 CFR 190.

The specified release rate limits restrict, at all times, the corresponding gamma and beta dose rates above background to a MEMBER OF THE PUBLIC at or beyond the SITE BOUNDARY to less than or equal to 500 mrem/year to the whole body and to less than or equal to 3000 mrem/year to the skin from noble gases, and to less than or equal to 1500 mrem/year to any organ from Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than eight days.

This commitment applies to the release of radioactive materials in gaseous effluents from all units at the site.

The required detection capabilities for radioactive material in gaseous waste samples are tabulated in terms of the lower limits of detection (LLDs). Based on NUREG-1301 and Regulatory Guide 1.21, the LLD value of 1×10^{-4} $\mu\text{Ci/ml}$ for grab samples is only applicable to noble gases grab samples and the LLD values for particulate and iodine radionuclides are applicable to continuous charcoal and particulate samples. The Table 16.11-6-1 Gaseous Release Type Number 5 (All Release Types as Listed in 3. Above) and Type Number 6 (Waste Monitor Tank Building Ventilation Exhaust) LLDs are based on weekly samples per NUREG-1301. There are two isotopes with associated LLDs that do not agree directly with NUREG-1301: Ce-144, LLD of 5×10^{-9} $\mu\text{Ci/ml}$, which has historically been applied and achieved for analytical results, and I-133, LLD of 1×10^{-10} $\mu\text{Ci/ml}$, which again has been historically listed, as 1×10^{-9} $\mu\text{Ci/ml}$, for Radioactive Gaseous Waste Sampling but changed to be in agreement with I-131 for weekly (7-day) samples and is not specified in NUREG-1301. 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).

REFERENCES 1. Catawba Offsite Dose Calculation Manual.

REFERENCES (continued)

2. 10 CFR Part 20, Appendix B.
3. 10 CFR Part 20.
4. 10 CFR Part 50.
5. 40 CFR Part 190.
6. NUREG-1301.
7. Regulatory Guide 1.21.

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
C. One channel non-functional.	C.1 Verify that EMF-36 (Low Range) is FUNCTIONAL.	Prior to initiating a release
	<u>OR</u>	
	C.2.1 Analyze two independent samples of the tank's contents.	Prior to initiating a release
	<u>AND</u>	
	C.2.2 Perform independent verification of the discharge line valving.	Prior to initiating a release
	<u>AND</u>	
	C.2.3.1 Perform independent verification of manual portion of the computer input for release rate calculations performed by computer.	Prior to initiating a release
<u>OR</u>		
C.2.3.2 Perform independent verification of entire calculations for release rate calculations performed manually.	Prior to initiating a release	
<u>AND</u>		
C.2.4 Restore channel to FUNCTIONAL status.	14 days	
<u>OR</u>		
C.3 Suspend release of radioactive effluents via this pathway.	Immediately	

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
D. One or more flow rate measurement device channel(s) non-functional.	D.1 Estimate the flow rate of the release.	Once per 4 hours during releases
	<u>AND</u>	
	D.2 Restore channel to FUNCTIONAL status.	30 days
E. One or more Noble Gas Activity Monitor channel(s) non-functional.	E.1 Obtain grab samples from effluent pathway.	Once per 12 hours during releases
	<u>AND</u>	
	E.2 Perform an analysis of grab samples for radioactivity.	Within 24 hours of obtaining the sample
	<u>AND</u>	
E.3 Restore channel to FUNCTIONAL status.	30 days	

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>F. Noble Gas Activity Monitor (EMF-39 – Low Range) providing automatic termination of release via the Containment Purge Exhaust System (CPES) non-functional.</p>	<p>F.1 -----NOTE----- In order to utilize Required Action F.1, the following conditions must be satisfied:</p> <ol style="list-style-type: none"> 1. The affected unit is in MODES 5 or 6. 2. EMF-36 is FUNCTIONAL and in service for the affected unit. 3. The Reactor Coolant System for the affected unit has been vented. 4. Either the reactor vessel head is in place (bolts are not required), or if it is not in place, the lifting of heavy loads over the reactor vessel and the movement of irradiated fuel assemblies within containment have been suspended. <p>-----</p> <p>Restore the non-functional channel to FUNCTIONAL status.</p>	<p>12 hours</p>
<p>G. Required Action and associated Completion Time of Condition F not met.</p> <p><u>OR</u></p> <p>Required Action F.1 not utilized.</p>	<p>G.1 Suspend PURGING of radioactive effluents via this pathway.</p>	<p>Immediately</p>

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
H. One or more sampler channel(s) non-functional.	H.1 Perform sampling with auxiliary sampling equipment as required by Table 16.11-6-1.	Continuously
	<u>AND</u> H.2 Restore channel to FUNCTIONAL status.	30 days
I. One Condenser Evacuation System Noble Gas Activity Monitor (EMF-33) channel non-functional.	I.1 -----NOTE----- Applicable to effluent releases via the Condenser Steam Air Ejector (ZJ) System. ----- Obtain grab samples from effluent pathway.	Once per 12 hours during releases
	<u>AND</u> I.2 -----NOTE----- Applicable to effluent releases via the Condenser Steam Air Ejector (ZJ) System. ----- Perform an analysis of grab samples for radioactivity.	Within 24 hours of obtaining the sample

(continued)

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>I. (continued)</p>	<p>I.3 -----NOTE----- Applicable to effluent releases via the Steam Generator Blowdown (BB) System atmospheric vent valve (BB-27) in the off-normal mode. ----- Perform an analysis of grab samples for radioactivity at a lower limit of detection of 10^{-7} microCurie/ml.</p> <p><u>AND</u></p> <p>I.4 Restore channel to FUNCTIONAL status.</p>	<p>Once per 12 hours during releases when secondary specific activity is > 0.01 microCurie/gm DOSE EQUIVALENT I-131</p> <p><u>AND</u></p> <p>Once per 24 hours during releases when secondary specific activity is \leq 0.01 microCurie/gm DOSE EQUIVALENT I-131</p> <p>30 days</p>
<p>J. Noble Gas Activity Monitor (EMF-39 – Low Range) providing automatic termination of release via the Containment Air Release and Addition System non-functional.</p>	<p>J.1 Verify that EMF-36 is FUNCTIONAL.</p> <p><u>OR</u></p> <p>J.2.1 Analyze two independent samples of the containment atmosphere.</p> <p><u>AND</u></p>	<p>Prior to initiating a release</p> <p>Prior to initiating a release</p> <p>(continued)</p>

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
K. Required Action and associated Completion Time of Condition C, D, E, F, H, I, or J not met.	K.1 Explain why the non-functionality was not corrected within the specified Completion Time.	In the next scheduled Radioactive Effluent Release Report pursuant to Technical Specification 5.6.3

TESTING REQUIREMENTS

-----NOTE-----
Refer to Table 16.11-7-1 to determine which TRs apply for each Radioactive Gaseous Effluent Monitoring Instrumentation channel.

TEST	FREQUENCY
TR 16.11-7-1 Perform CHANNEL CHECK.	Prior to each release
TR 16.11-7-2 -----NOTE----- For Instruments 1a, 4, and 5, a SOURCE CHECK for these channels shall be the qualitative assessment of channel response when the channel sensor is exposed to a light-emitting diode. ----- Perform SOURCE CHECK.	Prior to each release
TR 16.11-7-3 Perform CHANNEL CHECK.	12 hours
TR 16.11-7-4 Perform CHANNEL CHECK.	24 hours
TR 16.11-7-5 Perform CHANNEL CHECK.	7 days

(continued)

TESTING REQUIREMENTS (continued)

TEST	FREQUENCY
<p>TR 16.11-7-6 -----NOTE----- For Instruments 2 and 3a, a SOURCE CHECK for these channels shall be the qualitative assessment of channel response when the channel sensor is exposed to a light-emitting diode. ----- Perform SOURCE CHECK.</p>	31 days
<p>TR 16.11-7-7 -----NOTE----- For Instruments 1a, 3a, 3c, 5, and 6a, the COT shall also demonstrate, as applicable, that automatic isolation of this pathway and control room alarm annunciation (for EMF-58, alarm annunciation is in the Monitor Tank Building control room and on the Monitor Tank Building control panel remote annunciator panel) occur if any of the following conditions exist:</p> <ul style="list-style-type: none"> a. Instrument indicates measured levels above the Alarm/Trip Setpoint, or b. Circuit failure/instrument downscale failure (alarm only) <p>----- Perform COT.</p>	9 months
<p>TR 16.11-7-8 -----NOTE----- For Instruments 2 and 4, the COT shall also demonstrate that automatic isolation of this pathway and control room alarm annunciation occur if any of the following conditions exist:</p> <ul style="list-style-type: none"> a. Instrument indicates measured levels above the Alarm/Trip Setpoint, or b. Circuit failure/instrument downscale failure (alarm only) <p>----- Perform COT.</p>	18 months

(continued)

TESTING REQUIREMENTS (continued)

TEST	FREQUENCY
<p>TR 16.11-7-9 -----NOTE----- For Instruments 1a, 2, 3a, 3c, 4, 5, and 6a, the initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Bureau of Standards (NBS) or using standards that have been obtained from suppliers that participate in measurement assurance activities with NBS. These standards shall permit calibrating the system over its intended range of energy and measurement range. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used. ----- Perform CHANNEL CALIBRATION.</p>	18 months

Table 16.11-7-1

Radioactive Gaseous Effluent Monitoring Instrumentation (page 1 of 2)

INSTRUMENT	REQUIRED CHANNELS	CONDITIONS	APPLICABLE MODES	TESTING REQUIREMENTS
1. Waste Gas Holdup System				
1.a Noble Gas Activity Monitor – Providing Alarm and Automatic Termination of Release (EMF-50 – Low Range)	1 per station	A, C, K	At all times except when the isolation valve is closed and locked	TR 16.11-7-1 TR 16.11-7-2 TR 16.11-7-7 TR 16.11-7-9
1.b Effluent System Flow Rate Measuring Device	1 per station	D, K	At all times except when the isolation valve is closed and locked	TR 16.11-7-1 TR 16.11-7-9
2. Condenser Evacuation System Noble Gas Activity Monitor (EMF-33) (BB-27 is only isolation function required) (Note 1)	1	A, I, K	When air ejectors are in operation (Apply Required Action I.3 when air ejectors are not in operation)	TR 16.11-7-3 TR 16.11-7-6 TR 16.11-7-8 TR 16.11-7-9
3. Vent System				
3.a Noble Gas Activity Monitor (EMF-36 – Low Range)	1	A, E, K	At all times	TR 16.11-7-4 TR 16.11-7-6 TR 16.11-7-7 TR 16.11-7-9
3.b Deleted.				
3.c Particulate Sampler (EMF-35)	1	A, H, K	At all times (Note 2)	TR 16.11-7-4 TR 16.11-7-6 TR 16.11-7-7 TR 16.11-7-9
3.d Unit Vent Stack Flow Rate Meter (no alarm/trip function)	1	D, K	At all times (Note 2)	TR 16.11-7-4 TR 16.11-7-9
3.e Unit Vent Radiation Monitor Flow Meter	1	E, K	At all times (Note 2)	TR 16.11-7-4 TR 16.11-7-9
4. Containment Purge System Noble Gas Activity Monitor – Providing Alarm and Automatic Termination of Release (EMF-39 – Low Range)	1	A, F, G, K	5, 6	TR 16.11-7-2 TR 16.11-7-3 TR 16.11-7-8 TR 16.11-7-9

(continued)

Table 16.11-7-1

Radioactive Gaseous Effluent Monitoring Instrumentation (page 2 of 2)

INSTRUMENT	REQUIRED CHANNELS	CONDITIONS	APPLICABLE MODES	TESTING REQUIREMENTS
5. Containment Air Release and Addition System Noble Gas Activity Monitor – Providing Alarm and Automatic Termination of Release (EMF-39 – Low Range)	1	A, J, K	1, 2, 3, 4, 5, 6	TR 16.11-7-2 TR 16.11-7-3 TR 16.11-7-7 TR 16.11-7-9
6. Monitor Tank Building HVAC				
6.a Noble Gas Activity Monitor – Providing Alarm (EMF-58 – Low Range)	1 per station	A, E, K	At all times (Note 2)	TR 16.11-7-4 TR 16.11-7-6 TR 16.11-7-7 TR 16.11-7-9
6.b Effluent Flow Rate Measuring Device	1 per station	D, K	At all times (Note 2)	TR 16.11-7-4 TR 16.11-7-9

Note 1: The setpoint is as required by the primary to secondary leak rate monitoring program.

Note 2: Except when the effluent pathway is mechanically isolated; thus, a release to the environment is not possible.

BASES

The Radioactive Gaseous Effluent Monitoring 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 and adjusted in accordance with the methodology and parameters in the ODCM to ensure that the Alarm/Trip will occur prior to exceeding the limits of 10 CFR Part 20. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50. The sensitivity of any noble gas activity monitor used to show compliance with the gaseous effluent release requirements of SLC 16.11-8 shall be such that concentrations as low as 1×10^{-6} $\mu\text{Ci/cc}$ are measurable.

Regarding Note 2 of Table 16.11-7-1, isolation of the effluent pathway is to be by mechanical means (e.g., valve closure). Electrical or pneumatic isolation is not required, unless the isolation is designed to receive an automatic signal to open.

In MODES 5 and 6, initiation of the Containment Purge Exhaust System (CPES) with EMF-39 non-functional is not permissible. The basis for Required Action F.1 is to allow the continued operation of the CPES with EMF-39 initially FUNCTIONAL. Continued operation of the CPES is contingent upon the ability of the affected unit to meet the requirements as noted in Required Action F.1.

TR 16.11-7-7 requires the performance of a COT on the applicable Radioactive Gaseous Effluent Radiation Monitors. The test ensures that a signal from the control room module can generate the appropriate alarm and actuations. The required actuations/isolations for a High Radiation condition (i.e., radiation level above its Trip 2 setpoint) are listed below for each monitor.

0EMF-50 - Waste Gas Discharge Monitor

1WG160 closes when EMF-50 detects radiation level above its setpoint.

1/2EMF-36 - Unit Vent Noble Gas Monitor

The following actuations occur when EMF-36 detects radiation level above its setpoint:

1. Containment Air Release and Addition System fans discharge to unit vent valve VQ10 closes.
2. Auxiliary Building unfiltered ventilation exhaust fans A and B stop.
3. Fuel Handling Ventilation Exhaust System (FHVES) exhaust trains align to the filter units.
4. (For 1EMF-36 only) 1WG160 closes.

1/2EMF-35 - Unit Vent Particulate Monitor (Sampler)

The following actuations occur when EMF-35 detects radiation level above its setpoint:

1. Containment Air Release and Addition System fans discharge to unit vent valve VQ10 closes.
2. Auxiliary Building unfiltered ventilation exhaust fans A and B stop.
3. Fuel Handling Ventilation Exhaust System (FHVES) exhaust trains align to the filter units.
4. ((For 1EMF-35 only) 1WG160 closes.

BASES (continued)

1/2EMF-39 - Containment Noble Gas Monitor

The following actuations occur when EMF-39 detects radiation level above its setpoint:

1. Signals are provided to both trains of the Solid State Protection System (SSPS) to initiate a CPES isolation. This is verified by observing that Relays K615 in the SSPS A output cabinet and the SSPS B output cabinet are latched.
2. EMF-39 isolates the CPES without going through the SSPS by stopping CPES supply fans A and B, CPES exhaust fans A and B, and by closing the appropriate valves and dampers.
3. Containment Evacuation Alarm, unless the source range trip is blocked.

0EMF-58

This monitor provides no control function.

TR 16.11-7-8 requires the performance of a COT on the Condensate Steam Air Ejector Exhaust Monitor, 1/2EMF-33 and Containment Noble Gas Monitor, 1/2EMF-39. The test ensures that a signal from the control room module can generate the appropriate alarm and actuations. The required actuations/isolations for a High Radiation condition (i.e., radiation level above its Trip 2 setpoint) are listed below.

1/2EMF-33 - Condensate Steam Air Ejector Exhaust Monitor

The following actuations occur when EMF-33 detects radiation level above its setpoint:

1. Closure of BB27 is required in order to isolate the Blowdown Tank from the environment. Because of plant limitations/restrictions:
 - a. Opening the valve (in order to verify it goes closed on a High Radiation signal) is only possible during outages due to the negative effects on the Blowdown System with the unit at power.
 - b. Testing during innages will be by verification of relay contacts opening in the valve circuit.
2. Closure of BB24, BB65, BB69, and BB73 is required to minimize the amount of potentially contaminated material being delivered to the Blowdown Tank.
3. Closure of NM269, NM270, NM271, and NM272 is required to minimize the amount of potentially contaminated material being delivered to the
4. Conventional Sampling System. Closure of NM267 is required to minimize the amount of potentially contaminated material being delivered to the Condensate Storage Tank by isolating flow through EMF-34.
5. Closure of BB48 is required to minimize the amount of potentially contaminated material being delivered from the Blowdown System discharge to the Turbine Building sump.

1/2EMF-39 - Containment Noble Gas Monitor

The following actuations occur when EMF-39 detects radiation level above its setpoint:

BASES (continued)

1. Signals are provided to both trains of the Solid State Protection System (SSPS) to initiate a Containment Air Release and Addition System isolation. This is verified by observing that relays K615 in the SSPS Train A output cabinet and the SSPS Train B output cabinet are latched.
2. Containment Evacuation Alarm, unless the source range trip is blocked.

REFERENCES

1. Catawba Offsite Dose Calculation Manual.
2. 10 CFR Part 20.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-8 Dose - Noble Gases

COMMITMENT The air dose due to noble gases released in gaseous effluents, from each unit, to areas at and beyond the SITE BOUNDARY (see Figure 16.11-16-1 in SLC 16.11-16) shall be limited to the following:

- a. During any calendar quarter: ≤ 5 mrad for gamma radiation and ≤ 10 mrad for beta radiation, and
- b. During any calendar year: ≤ 10 mrad for gamma radiation and ≤ 20 mrad for beta radiation.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Calculated air dose from radioactive noble gases in gaseous effluents exceeding any of above limits.	A.1 Prepare and submit a Special Report to the NRC which identifies the causes for exceeding the limits, corrective actions taken to reduce releases, and actions taken to ensure that subsequent releases are within limits.	30 days

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11-8-1 Determine cumulative dose contributions from noble gases in gaseous effluents for current calendar quarter and current calendar year in accordance with the methodology and parameters in the ODCM.	31 days

BASES

This SLC is provided to implement the requirements of Sections II.B, III.A and IV.A of Appendix I, 10 CFR Part 50. The COMMITMENT implements the guides set forth in Section II.B of Appendix I. The REMEDIAL ACTION statement provides the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable". The TESTING REQUIREMENTS implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The dose calculation methodology and parameters 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, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors," Revision 1, July 1977. The ODCM equations provided for determining the air doses at and beyond the SITE BOUNDARY are based upon the historical average atmospheric conditions.

This commitment applies to the release of radioactive materials in gaseous effluents from each unit at the site. When shared radwaste treatment systems are used by more than one unit on a site, the wastes from all units are mixed for shared treatment; by such mixing, the effluent releases cannot accurately be ascribed to a specific unit. An estimate should be made of the contributions from each unit based on input conditions, e.g., flow rates and radioactivity concentrations, or, if not practicable, the treated effluent releases may be allocated equally to each of the radioactives waste producing units sharing the radwaste treatment system. For determining conformance to COMMITMENTS, these allocations from shared radwaste treatment systems are to be added to the releases specifically attributed to each unit to obtain the total releases per unit.

REFERENCES

1. Catawba Offsite Dose Calculation Manual.
2. 10 CFR Part 50, Appendix I.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-9 Dose - Iodine-131, Iodine-133, Tritium, and Radioactive Material in Particulate Form

COMMITMENT The dose to a MEMBER OF THE PUBLIC from Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives > 8 days in gaseous effluents released, from each unit, to areas at and beyond the SITE BOUNDARY (see Figure 16.11-16-1 in SLC 16.11-16) shall be limited to the following:

- a. During any calendar quarter: ≤ 7.5 mrem to any organ, and
- b. During any calendar year: ≤ 15 mrem to any organ.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Calculated dose from the release of Iodine-131, Iodine-133, tritium, and radioactive material in particulate form with half-lives > 8 days in gaseous effluents exceeding any of above limits.	A.1 Prepare and submit a Special Report to the NRC which identifies the causes for exceeding the limits, corrective actions taken to reduce releases, and actions taken to ensure that subsequent releases are within limits.	30 days

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11-9-1 Determine cumulative dose contributions from Iodine-131, Iodine-133, tritium, and radioactive material in particulate form with half-lives > 8 days in gaseous effluents for current calendar quarter and current calendar year in accordance with the methodology and parameters in the ODCM.	31 days

BASES

This SLC is provided to implement the requirements of Sections II.C, III.A and IV.A of Appendix I, 10 CFR Part 50, and are the guides set forth in Section II.C of Appendix I. The REMEDIAL ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents to UNRESTRICTED AREAS will be kept “as low as is reasonably achievable”. The ODCM calculational methods specified in the TESTING REQUIREMENTS implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The ODCM calculational methodology and parameters for calculating the doses due to the actual release rates of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I,” Revision 1, October 1977 and Regulatory Guide 1.111, “Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors,” Revision 1, July 1977. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate COMMITMENTS for Iodine-131, Iodine-133, tritium, and radionuclides in particulate form with half-lives greater than 8 days are dependent upon the existing radionuclide pathways to man in the areas at and beyond the SITE BOUNDARY. The pathways that were examined in the development of the calculations were: (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.

This commitment applies to the release of radioactive materials in gaseous effluents from each unit at the site. When shared radwaste treatment systems are used by more than one unit on a site, the wastes from all units are mixed for shared treatment; by such mixing, the effluent releases cannot accurately be ascribed to a specific unit. An estimate should be made of the contributions from each unit based on input conditions, e.g., flow rates and radioactivity concentrations, or, if not practicable, the treated effluent releases may be allocated equally to each of the radioactive waste producing units sharing the radwaste treatment system. For determining conformance to COMMITMENTS, these allocations from shared radwaste treatment systems are to be added to the releases specifically attributed to each unit to obtain the total releases per unit.

REFERENCES

1. Catawba Offsite Dose Calculation Manual.
2. 10 CFR Part 50, Appendix I.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-10 Gaseous Radwaste Treatment System

COMMITMENT The VENTILATION EXHAUST TREATMENT SYSTEM and the WASTE GAS HOLDUP SYSTEM shall be FUNCTIONAL and appropriate portions of these systems shall be used to reduce releases of radioactivity when the projected doses in 31 days due to gaseous effluent releases, from each unit, to areas at and beyond the SITE BOUNDARY (see Figure 16.11-16-1 in SLC 16.11-16) would exceed either:

- a. 0.2 mrad to air from gamma radiation, or
- b. 0.4 mrad to air from beta radiation, or
- c. 0.3 mrem to any organ of a MEMBER OF THE PUBLIC.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Radioactive gaseous waste being discharged without treatment and in excess of above limits.	A.1 Prepare and submit a Special Report to the NRC which identifies non-functional equipment and reasons for non-functionality, actions taken to restore the equipment to FUNCTIONAL status, and actions taken to prevent recurrence.	30 days

TESTING REQUIREMENTS

-----NOTE-----

The installed VENTILATION EXHAUST TREATMENT SYSTEM and WASTE GAS HOLDUP SYSTEM shall be demonstrated FUNCTIONAL by meeting SLC 16.11-6, SLC 16.11-8, and SLC 16.11-9.

TEST	FREQUENCY
TR 16.11-10-1 Project gaseous release doses from each unit to areas at and beyond the SITE BOUNDARY, in accordance with the methodology and parameters in the ODCM, when Gaseous Radwaste Treatment Systems are not being fully utilized.	31 days

BASES

The FUNCTIONALITY of the WASTE GAS HOLDUP SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM ensures that the systems will be available for use whenever gaseous effluents require treatment prior to release to the environment. 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 COMMITMENT implements the requirements of 10 CFR 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objectives given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the systems were specified as a suitable fraction of the dose design objectives set forth in Sections II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

This SLC applies to the release of radioactive materials in gaseous effluents from each unit at the site. When shared radwaste treatment systems are used by more than one unit on a site, the wastes from all units are mixed for shared treatment; by such mixing, the effluent releases cannot accurately be ascribed to a specific unit. An estimate should be made of the contributions from each unit based on input conditions, e.g., flow rates and radioactivity concentrations, or, if not practicable, the treated effluent releases may be allocated equally to each of the radioactive waste producing units sharing the radwaste treatment system. For determining conformance to COMMITMENTS, these allocations from shared radwaste treatment systems are to be added to the releases specifically attributed to each unit to obtain the total releases per unit.

- REFERENCES
1. Catawba Offsite Dose Calculation Manual.
 2. 10 CFR Part 50, Appendix I.

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
D. Solid waste equipment incapable of supporting COMMITMENT.	D.1 Restore the equipment to a status capable of supporting COMMITMENT. OR D.2 Provide for alternative capability to process wastes as necessary to satisfy all applicable transportation and disposal requirements.	In a time frame supporting COMMITMENT In a time frame supporting COMMITMENT

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11-11-1 Verify, using the PROCESS CONTROL PROGRAM, the solidification of at least one representative test specimen from at least every tenth batch of each type of radioactive waste to be solidified for disposal at a 10 CFR Part 61 disposal site.	Every tenth batch of each type of radioactive waste to be solidified

BASES This SLC implements the requirements of 10 CFR Part 50.36a and General Design Criterion 60 of Appendix A to 10 CFR Part 50 and requirements to use a PROCESS CONTROL PROGRAM to meet applicable 10 CFR Part 61 waste form criteria for solidified and dewatered radioactive wastes.

- The PROCESS CONTROL PROGRAM describes administrative and operational controls used for the solidification of liquid or wet solid radioactive wastes in order to meet applicable 10 CFR Part 61 waste form requirements.
- The PROCESS CONTROL PROGRAM describes the administrative and operational controls used for the dewatering of wet radioactive wastes to meet 10 CFR Part 61 free-standing water requirements.
- The process parameters used in establishing the PROCESS CONTROL PROGRAM shall be based on demonstrated processing of actual or simulated liquid or wet solid wastes and must adequately verify that the final product of solidification or dewatering meets all applicable federal, state, and disposal site requirements.

REFERENCES

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."
2. 10 CFR Part 50, Appendix A.
3. 10 CFR Part 20, "Standards for Protection Against Radiation."
4. 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste."
5. 10 CFR Part 71, "Packaging and Transportation of Radioactive Materials."
6. PROCESS CONTROL PROGRAM Manual.
7. Generic Letter 84-12, "Compliance with 10 CFR Part 61 and Implementation of the Radiological Effluent Technical Specifications (RETS) and Attendant Process Control Program (PCP)."
8. Generic Letter 89-01, "Implementation of Programmatic Controls for Radiological 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."

TESTING REQUIREMENTS

-----NOTE-----

Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with SLC 16.11-3, SLC 16.11-8, and SLC 16.11-9, and in accordance with the methodology and parameters specified in the ODCM.

TEST	FREQUENCY
TR 16.11-12-1 Determine cumulative dose contributions from direct radiation from the units and from radwaste storage tanks in accordance with the methodology and parameters specified in the ODCM.	When calculated doses from effluent releases exceed twice the limits of SLC 16.11-3, SLC 16.11-8, or SLC 16.11-9

BASES

This SLC is provided to meet the dose limitations of 40 CFR Part 190 that have been incorporated into 10 CFR Part 20 by 46 FR 18525. The SLC requires the preparation and submittal of a Special Report whenever the calculated doses due to releases of radioactivity and to radiation from uranium fuel cycle sources exceed 25 mrem to the whole body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem. For sites containing up to four reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR Part 190 if the individual reactors remain within twice the dose design objectives of Appendix I, and if direct radiation doses from the units and from outside storage tanks are kept small.

This Special Report, as defined in 10 CFR 20.2203(a)(4), shall include an analysis that estimates the radiation exposure (dose) to a MEMBER OF THE PUBLIC from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s) covered by this report. It shall also describe levels of radiation and concentrations of radioactive material involved, and the cause of the exposure levels or concentrations. The Special Report will describe a course of action that should result in the limitation of the annual dose to a MEMBER OF THE PUBLIC to within the 40 CFR Part 190 limits. For the purposes of the Special Report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible, with the exception that dose contributions from other nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered.

BASES (continued)

If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40 CFR Part 190, the Special Report with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in accordance with the provisions of 40 CFR 190.11 and 10 CFR 20.2203(a)(4), is considered to be a timely request and fulfills the requirements of 40 CFR Part 190 and a variance is granted until NRC staff action is completed. The variance only relates to the limits of 40 CFR Part 190, and does not apply in any way to the other requirements for dose limitation of 10 CFR Part 20, as addressed in SLC 16.11-1 and SLC 16.11-6.

An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation that is part of the nuclear fuel cycle.

- REFERENCES
1. Catawba Offsite Dose Calculation Manual.
 2. 10 CFR Part 20.
 3. 40 CFR Part 190.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-13 Monitoring Program

COMMITMENT The Radiological Environmental Monitoring Program shall be conducted as specified in Table 16.11-13-1.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Radiological Environmental Monitoring Program not being conducted as specified in Table 16.11-13-1.</p>	<p>A.1 Identify the reasons for not conducting the program as required and the plans for preventing a recurrence in the Annual Radiological Environmental Operating Report.</p>	<p>In the next scheduled Annual Radiological Environmental Operating Report pursuant to Technical Specification 5.6.2</p>
<p>B. Radioactivity level resulting from plant effluents of environmental sampling medium at a specified location in excess of reporting limits of Table 16.11-13-2 when averaged over any calendar quarter.</p>	<p>B.1 Prepare and submit a Special Report that identifies the cause(s) for exceeding the limits 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 SLC 16.11-3, SLC 16.11-8, and SLC 16.11-9.</p>	<p>30 days</p>

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>C. Milk or fresh leafy vegetation samples unavailable from one or more sample location(s) required by Table 16.11-13-1.</p>	<p>C.1 -----NOTE----- Specific location(s) from which samples were unavailable may be deleted from the program. -----</p> <p>Revise the Radiological Environmental Monitoring Program to identify location(s) for obtaining replacement samples.</p> <p><u>AND</u></p> <p>C.2 Identify the cause of the unavailability of samples and identify and justify new location(s) for obtaining replacement samples in the Annual Radioactive Effluent Release Report and also include in the report a revised figure(s) and table for the ODCM reflecting the new location(s).</p>	<p>30 days</p> <p>In the next scheduled Annual Radioactive Effluent Release Report pursuant to Technical Specification 5.5.1</p>

TESTING REQUIREMENTS

TEST	FREQUENCY
<p>TR 16.11-13-1-----NOTE----- The maximum values for the lower limits of detection shall be as specified in Table 16.11-13-3. -----</p> <p>Collect and analyze radiological environmental monitoring samples pursuant to Table 16.11-13-1 from the specific locations given in the table and figure(s) in the ODCM.</p>	<p>In accordance with Table 16.11-13-1</p>

Table 16.11-13-1
Radiological Environmental Monitoring Program (page 1 of 7)

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
1. Direct Radiation ⁽²⁾	<p>Forty routine monitoring stations either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, placed as follows:</p> <p>An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY;</p> <p>An outer ring of stations, one in each meteorological sector in the 6- to 8-km range from the site; and</p> <p>The balance of the stations to be placed in special interest areas such as population centers, nearby residences, schools, and in one or two areas to serve as control stations.</p>	Quarterly	Gamma dose quarterly

(continued)

Table 16.11-13-1
Radiological Environmental Monitoring Program (page 2 of 7)

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
<p>2. Airborne Radioiodine and Particulates</p>	<p>Samples from five locations.</p> <p>Three samples from close to the three SITE BOUNDARY locations, in different sectors, of the highest calculated annual average ground-level D/Q;</p> <p>One sample from the vicinity of a community having the highest calculated annual average ground-level D/Q; and</p> <p>One sample from a control location, as for example 15 to 30 km distant and in the least prevalent wind direction.</p>	<p>Continuous sampler operation with sample collection weekly, or more frequently if required by dust loading.</p>	<p><u>Radioiodine Canister:</u> I-131 analysis weekly.</p> <p><u>Particulate Sampler:</u> Gross beta radioactivity analysis following filter change; ⁽³⁾ and gamma isotopic analysis ⁽⁴⁾ of composite (by location) quarterly.</p>

(continued)

Table 16.11-13-1
Radiological Environmental Monitoring Program (page 3 of 7)

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
<p>3. Waterborne</p> <p>a. Surface⁽⁶⁾</p> <p>b. Ground</p> <p>c. Drinking</p> <p>d. Sediment from Shoreline</p>	<p>One sample upstream. One sample downstream.</p> <p>Samples from one or two sources only if likely to be affected⁽⁷⁾.</p> <p>One sample of each of one to three of the nearest water supplies that could be affected by its discharge.</p> <p>One sample from a control location.</p> <p>One sample from downstream area with existing or potential recreational value.</p>	<p>Composite sample over 1-month period⁽⁶⁾.</p> <p>Quarterly</p> <p>Composite sample over 2-week period⁽⁶⁾ when I-131 analysis is performed; monthly composite otherwise.</p> <p>Semiannually</p>	<p>Gamma isotopic analysis⁽⁴⁾ monthly. Composite for tritium analysis quarterly.</p> <p>Gamma isotopic⁽⁴⁾ and tritium analysis quarterly.</p> <p>I-131 analysis on each composite when the dose calculated for the consumption of the water is greater than 1 mrem per year⁽⁶⁾. Composite for gross beta and gamma isotopic analyses⁽⁴⁾ monthly. Composite for tritium analysis quarterly.</p> <p>Gamma isotopic analysis⁽⁴⁾ semiannually.</p>

(continued)

Table 16.11-13-1
Radiological Environmental Monitoring Program (page 4 of 7)

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
<p>4. Ingestion</p> <p>a. Milk</p> <p>b. Fish and Invertebrates</p>	<p>Samples from milking animals in three locations within 5-km distance having the highest dose potential. If there are none, then one sample from milking animals in each of three areas between 5 to 8 km distant where doses are calculated to be greater than 1 mrem per year⁽⁶⁾. One sample from milking animals at a control location 15 to 30 km distant and in the least prevalent wind direction.</p> <p>One sample each of a predatory species, a bottom feeder and a forage species in vicinity of plant discharge area.</p> <p>One sample each of a predatory species, a bottom feeder and a forage species in areas not influenced by plant discharge.</p>	<p>Semimonthly when animals are on pasture; monthly at other times.</p> <p>Sample in season, or semiannually if they are not seasonal.</p>	<p>Gamma isotopic⁽⁴⁾ and I-131 analysis semi-monthly when animals are on pasture; monthly at other times.</p> <p>Gamma isotopic analysis⁽⁴⁾ on edible portions.</p>

(continued)

Table 16.11-13-1
Radiological Environmental Monitoring Program (page 5 of 7)

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
<p>4. Ingestion (Continued)</p> <p>c. Food Products</p>	<p>One sample of each principal class of food products from any area that is irrigated by water in which liquid plant wastes have been discharged.</p> <p>Samples of three different kinds of broad leaf vegetation grown nearest each of two different offsite locations of highest predicted annual average ground level D/Q if milk sampling is not performed.</p> <p>One sample of each of the similar broad leaf vegetation grown 15 to 30 km distant in the least prevalent wind direction if milk sampling is not performed.</p>	<p>At time of harvest⁽⁹⁾.</p> <p>Monthly, when available.</p> <p>Monthly, when available.</p>	<p>Gamma isotopic analyses⁽⁴⁾ on edible portion.</p> <p>Gamma isotopic⁽⁴⁾ and I-131 analysis.</p> <p>Gamma isotopic⁽⁴⁾ and I-131 analysis.</p>

Table 16.11-13-1

Radiological Environmental Monitoring Program (page 6 of 7)

NOTES:

- (1) Specific parameters of distance and direction sector from the centerline of the station, and additional description where pertinent, shall be provided for each and every sample location in Table 16.11-13-1 in a table and figure(s) in the ODCM. Refer to NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978, and to Radiological Assessment Branch Technical Position, Revision 1, November 1979. Deviations are permitted from the required sampling schedule if specimens are unobtainable due to circumstances such as hazardous conditions, seasonal unavailability, and malfunction of automatic sampling equipment. If specimens are unobtainable due to sampling equipment malfunction, effort 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 Technical Specification 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. In lieu of any Licensee Event Report required by 10 CFR 50.73 and pursuant to Technical Specification 5.6.3, identify the cause of the unavailability of samples for that pathway and identify the new location(s) for obtaining replacement samples in the next Radioactive Effluent Release Report and also include in the report a revised figure(s) and table for the ODCM reflecting the new location(s).
- (2) One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dosimeters. For the purposes of this table, a thermoluminescent dosimeter (TLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation. (The 40 stations is not an absolute number. The number of direct radiation monitoring stations may be reduced according to geographical limitations; e.g., at an ocean site, some sectors will be over water so that the number of dosimeters may be reduced accordingly. The frequency of analysis or readout for TLD systems will depend upon the characteristics of the specific system used and should be selected to obtain optimum dose information within minimal fading.)
- (3) Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for 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.

Table 16.11-13-1

Radiological Environmental Monitoring Program (page 7 of 7)

- (4) Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.
- (5) The “upstream sample” shall be taken at a distance beyond significant influence of the discharge. The “downstream” sample shall be taken in an area beyond but near the mixing zone. “Upstream” samples in an estuary must be taken far enough upstream to be beyond the plant influence. Salt water shall be sampled only when the receiving water is utilized for recreational activities.
- (6) A composite sample is one in which the rate at which the liquid sampled is uniform and in which the method of sampling employed results in a specimen that is representative of the time-averaged concentration at the location being sampled. In this program composite sample aliquots shall be collected at time intervals that are very short (e.g., hourly) relative to the compositing period (e.g., monthly) in order to assure obtaining a representative sample.
- (7) Groundwater samples shall be taken when this source is tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination.
- (8) The dose shall be calculated for the maximum organ and age group, using the methodology and parameters in the ODCM.
- (9) If harvest occurs more than once a year, sampling shall be performed during each discrete harvest. If harvest occurs continuously, sampling shall be monthly. Attention shall be paid to including samples of tuberous and root food products.

Table 16.11-13-2
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	20,000 ⁽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-Nb-95	400				
I-131	2	0.9		3	100
Cs-134	30	10	1,000	60	1,000
Cs-137	50	20	2,000	70	2,000
Ba-La-140	200			300	

(1) For drinking water samples. This is 40 CFR Part 141 value. If no drinking water pathway exists, a value of 30,000 pCi/l may be used.

Table 16.11-13-3
Lower Limit of Detection (LLD)⁽³⁾ (page 1 of 3)

ANALYSIS	WATER (pCi/l)	AIRBORNE PARTICULATE OR GASES (pCi/m ³)	FISH (pCi/kg, wet)	MILK (pCi/l)	FOOD PRODUCTS (pCi/kg, wet)	SEDIMENT (pCi/kg, dry)
Gross Beta	4	0.01				
H-3	2000 ⁽⁵⁾					
Mn-54	15		130			
Fe-59	30		260			
Co-58, 60	15		130			
Zn-65	30		260			
Zr-Nb-95	15					
I-131	1 ⁽⁴⁾	0.07		1	60	
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-La-140	15			15		

Table 16.11-13-3

Lower Limit of Detection (LLD)⁽³⁾ (page 2 of 3)

NOTES:

- (1) This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report pursuant to Technical Specification 5.6.2.
- (2) Required detection capabilities for thermoluminescent dosimeters used for environmental measurements shall be in accordance with the recommendations of Regulatory Guide 4.13.
- (3) The LLD is defined, for purposes of these commitments, as the smallest concentrations of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

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

$$LLD = \frac{(2.71/T) + 4.65s_b}{E \cdot V \cdot 2.22 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

Where:

LLD = the "a priori" lower limit of detection (picoCuries per unit mass or volume);

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute);

E = the counting efficiency (counts per disintegration);

V = the sample size (units of mass or volume);

2.22 = the number of disintegrations per minute per picoCurie;

Y = the fractional radiochemical yield, when applicable;

λ = the radioactive decay constant for the particular radionuclide (sec^{-1});

Δt = the elapsed time between environmental collection, or end of the sample collection period, and time of counting (sec); and

T = the sample counting time (min).

Table 16.11-13-3

Lower Limit of Detection (LLD)⁽³⁾ (page 3 of 3)

Typical values of E, V, Y and Δt shall be used in the calculation.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement. Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report pursuant to Technical Specification 5.6.2.

- (4) LLD for drinking water samples. If no drinking water pathway exists, the LLD of gamma isotopic analysis may be used.
- (5) If no drinking water pathway exists, a value of 3000 pCi/l may be used.

BASES

The Radiological Environmental Monitoring Program required by this SLC provides representative measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposures of MEMBERS OF THE PUBLIC resulting from the plant operation. This Monitoring Program implements Section IV.B.2 of Appendix I to 10 CFR Part 50 and thereby supplements the Radiological Effluent Monitoring Program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the modeling of the environmental exposure pathways. Guidance for this Monitoring Program is provided by the Radiological Assessment Branch Technical Position on Environmental Monitoring. The initially specified Monitoring Program will be effective for at least the first 3 years of commercial operation. Following this period, program changes may be initiated based on operational experience.

The required detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLDs). The LLDs required by Table 16.11-13-3 are 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.

With the level of radioactivity in an environmental sampling medium at a specified location exceeding the reporting levels of Table 16.11-13-2 when averaged over any calendar quarter, in lieu of a Licensee Event Report, prepare and submit to the Commission within 30 days a Special Report that 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 SLC 16.11-3, SLC 16.11-8, and SLC 16.11-9. When more than one of the radionuclides in Table 16.11-13-2 are detected in the sampling medium, this report shall be submitted if:

$$\frac{\text{concentration (1)}}{\text{reporting level (1)}} + \frac{\text{concentration (2)}}{\text{reporting level (2)}} + \dots \geq 1.0$$

When radionuclides other than those in Table 16.11-13-2 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 from all radionuclides is equal to or greater than the calendar year limits of SLC 16.11-3, SLC 16.11-8, and SLC 16.11-9. 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 Operating Report required by Technical Specification 5.6.2. The methodology and parameters used to estimate the potential annual dose to a MEMBER OF THE PUBLIC shall be indicated in the 30-day Special Report.

BASES (continued)

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).

- REFERENCES
1. Catawba Offsite Dose Calculation Manual.
 2. 10 CFR Part 50, Appendix I.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. (continued)	B.2 Identify the new location(s), revised figure(s) and table(s) for the ODCM, and information supporting the change in sampling location(s) in the Annual Radioactive Effluent Release Report.	In the next scheduled Annual Radioactive Effluent Release Report pursuant to Technical Specification 5.5.1

TESTING REQUIREMENTS

TEST	FREQUENCY
<p>TR 16.11-14-1-----NOTE-----</p> <p>The results of the Land Use Census shall be included in the Annual Radiological Environmental Operating Report pursuant to Technical Specification 5.6.2.</p> <p>-----</p> <p>Conduct a Land Use Census during the growing season using the information which will provide the best results such as a door-to-door survey, aerial survey, or consultation with local agricultural authorities.</p>	12 months

BASES This SLC 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 given in the ODCM are made if required by the results of this census. The best information from the door-to-door survey, from aerial survey, or from consulting with local agricultural authorities shall be used. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the census to gardens of greater than 50 m² 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/m².

BASES (continued)

With a Land Use Census identifying a location(s) which yield a calculated dose or dose commitment (via the same exposure pathway) 20% greater than at a location from which samples are currently being obtained in accordance with SLC 16.11-13, add the new location(s) within 30 days to the Radiological Environmental Monitoring Program given in the ODCM. The sampling location(s), excluding the control station location, having the lowest calculated dose or dose commitment, 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.

- REFERENCES
1. Catawba Offsite Dose Calculation Manual.
 2. 10 CFR Part 50, Appendix I.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-15 Interlaboratory Comparison Program

COMMITMENT Analyses shall be performed on all radioactive materials, supplied as part of an Interlaboratory Comparison Program, that correspond to samples required by SLC 16.11-13.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Analyses not being performed as required.	A.1 Report corrective actions taken to prevent recurrence in the Annual Radiological Environmental Operating Report.	In the next scheduled Annual Radiological Environmental Operating Report pursuant to Technical Specification 5.6.2

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11-15-1 Report a summary of the results of the Interlaboratory Comparison Program in the Annual Radiological Environmental Operating Report.	In the Annual Radiological Environmental Operating Report pursuant to Technical Specification 5.6.2

BASES The requirement for participation in an Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring in order to demonstrate that the results are valid for the purposes of Section IV.B.2 of Appendix I to 10 CFR Part 50.

BASES (continued)

The Interlaboratory Comparison Program shall be described in the Annual Radiological Environmental Operating Report.

REFERENCES 1. 10 CFR Part 50, Appendix I.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-16 Annual Radiological Environmental Operating Report and Radioactive Effluent Release Report

COMMITMENT Annual Radiological Environmental Operating Report

Routine Annual Radiological Environmental Operating Reports covering the operation of the unit during the previous calendar year shall be submitted prior to May 15 of each year.

The Annual Radiological Environmental Operating Reports shall include summaries, interpretations, and an analysis of trends of the results of the radiological environmental surveillance activities for the report period, including a comparison with preoperational studies, with operational controls as appropriate, and with previous environmental surveillance reports, and an assessment of the observed impacts of the plant operation on the environment. The reports shall also include the results of the Land Use Census.

The Annual Radiological Environmental Operating Reports shall include the results of analysis of all radiological environmental samples and of all environmental radiation measurements taken during the period pursuant to the locations specified in the table and figures in the ODCM, as well as summarized and tabulated results of these analyses and measurements in the format of the table in the Radiological Assessment Branch Technical Position, Revision 1, November 1979. In the event that some individual results are not available for inclusion with the report, the report shall be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted as soon as possible in a supplementary report.

The reports shall also include the following: a summary description of the Radiological Environmental Monitoring Program; at least two legible maps (one map shall cover stations near the SITE BOUNDARY, and a second map shall include the more distant stations) covering all sampling locations keyed to a table giving distances and directions from the centerline of one reactor; the results of licensee participation in the Interlaboratory Comparison Program, required by SLC 16.11-15; discussion of all deviations from the sampling schedule of Table 16.11-13-1; and discussion of all analyses in which the LLD required by Table 16.11-13-3 was not achievable.

A single submittal may be made for the station.

(continued)

COMMITMENT (continued)

Radioactive Effluent Release Report

The Radioactive Effluent Release Report covering the operation of the unit during the previous calendar year shall be submitted before May 1 of each year. The Radioactive Effluent Release Reports shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the unit.

The Radioactive Effluent Release Report shall include an annual summary of hourly meteorological data collected over the previous year. This annual summary may be either in the form of an hour-by-hour listing on magnetic tape of wind speed, wind direction, atmospheric stability, and precipitation (if measured), or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability. (In lieu of submission with the Radioactive Effluent Release Report, the licensee has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.) This same report shall include an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the unit or station during the previous calendar year. A five-year average of representative onsite meteorological data shall be used in the gaseous effluent dose pathway calculations. Dispersion factors (X/Qs) and deposition factors (D/Qs) shall be generated using the computer code XOQDOQ (NUREG/CR-2919) which implements NRC Regulatory Guide 1.111. The meteorological conditions concurrent with the time of release shall be reviewed annually to determine if the five-year average values should be revised. The assessment of radiation doses shall be performed in accordance with the methodology and parameters in the ODCM.

The Radioactive Effluent Release Report shall also include an assessment of radiation doses to the likely most exposed MEMBER OF THE PUBLIC from reactor releases and other nearby uranium fuel cycle sources, including doses from primary effluent pathways and direct radiation, for the previous calendar year to show conformance with 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operation." Acceptable methods for calculating the dose contribution from liquid and gaseous effluents are given in Regulatory Guide 1.109, Rev. 1, October 1977.

The Radioactive Effluent Release Reports shall include the following information for each type of solid waste shipped offsite during the report period:

(continued)

COMMITMENT (continued)

- a. Total container volume, in cubic meters,
- b. Total Curie quantity (determined by measurement or estimate),
- c. Principal radionuclides (determined by measurement or estimate),
- d. Type of waste (e.g., dewatered spent resin, compacted dry waste, evaporator bottoms),
- e. Number of shipments, and
- f. Solidification agent or absorbent (e.g., cement or other approved agents (media)).

The Radioactive Effluent Release Reports shall include a list and description of unplanned releases from the site to UNRESTRICTED AREAS of radioactive materials in gaseous and liquid effluents made during the reporting period.

The Radioactive Effluent Release Reports shall include any changes made during the reporting period to the PROCESS CONTROL PROGRAM (PCP) and to the ODCM, as well as a listing of new locations for dose calculations and/or environmental monitoring identified by the Land Use Census pursuant to SLC 16.11-14.

A single submittal may be made for the station. The submittal should combine those sections that are common to both units.

APPLICABILITY: At all times.

REMEDIAL ACTIONS None

TESTING REQUIREMENTS None

BASES None

REFERENCES None

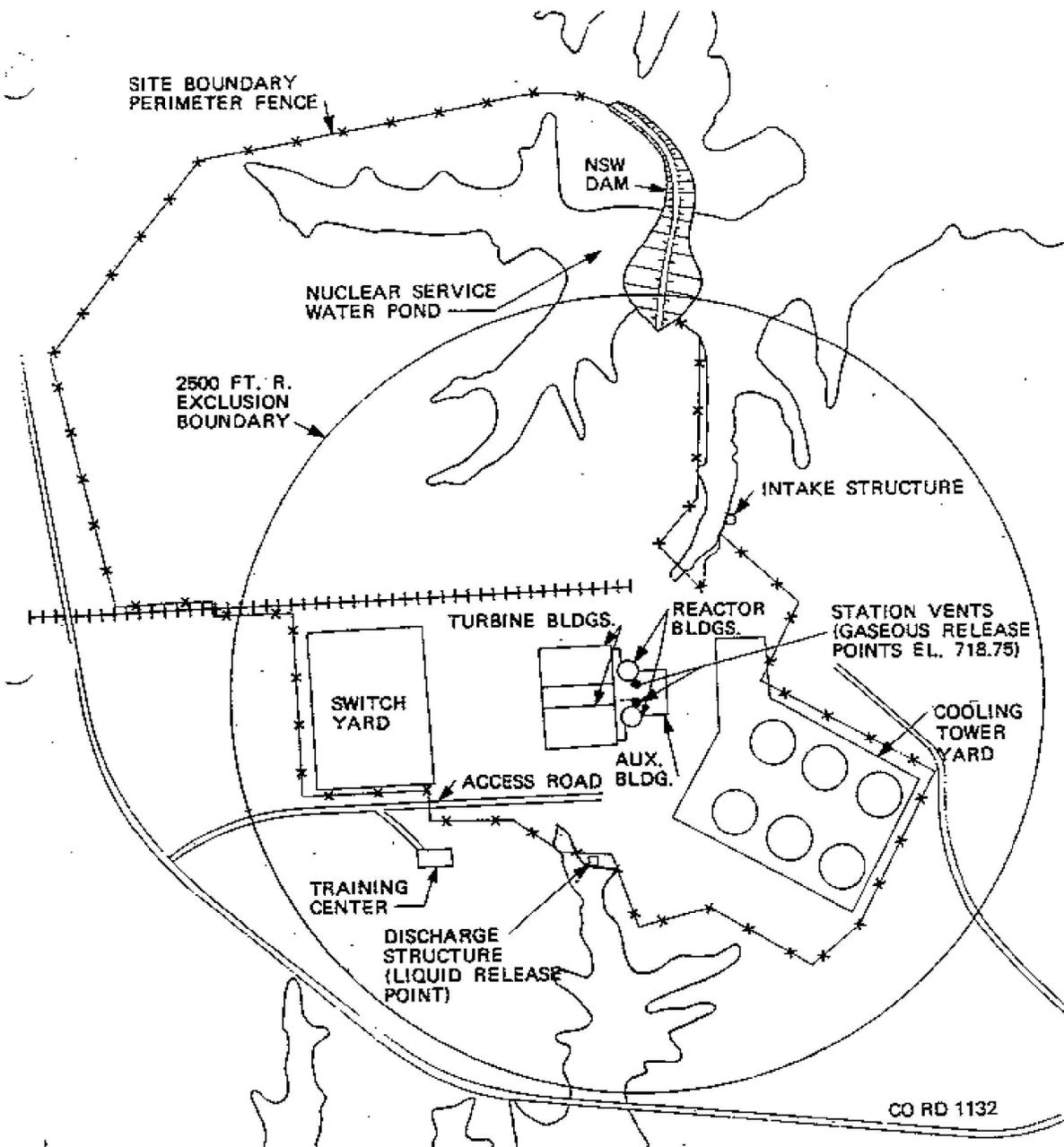


Figure 16.11-16-1

UNRESTRICTED AREA and SITE BOUNDARY for Radioactive Effluents

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-17 Liquid Holdup Tanks

COMMITMENT The quantity of radioactive material contained in each temporary unprotected outdoor tank shall be limited to ≤ 10 Curies, excluding tritium and dissolved or entrained noble gases.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Quantity of radioactive material in tank(s) exceeding limit.	A.1 Suspend all additions of radioactive material to the tank(s).	Immediately
	<u>AND</u>	
	A.2 Reduce tank(s) contents to within limit.	48 hours
	<u>AND</u>	
	A.3 Describe the events leading to this condition in the Radioactive Effluent Release Report.	In the next scheduled Radioactive Effluent Release Report pursuant to Technical Specification 5.6.3

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11-17-1 Verify that the quantity of radioactive material contained in each tank is within limits by analyzing a representative sample of the tank(s) contents when radioactive materials are being added to the tank(s).	7 days

BASES The tanks included in this SLC are all those outdoor radwaste tanks that are not surrounded by liners, dikes, or walls capable of holding the tank contents and that do not have tank overflows and surrounding area drains connected to the liquid radwaste treatment system.

Restricting the quantity of radioactive material contained in the specified tanks provides assurance that in the event of an uncontrolled release of the tank's contents, the resulting concentrations would be less than the limits of 10 CFR Part 20, Appendix B, Table II, Column 2, at the nearest potable water supply and the nearest surface water supply in an UNRESTRICTED AREA.

- REFERENCES**
1. Letter from NRC to Gary R. Peterson, Duke, Issuance of Improved Technical Specifications Amendments for Catawba, September 30, 1998.

 2. Technical Specification 5.5.12, Explosive Gas and Storage Tank Radioactivity Monitoring Program.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-18 Explosive Gas Mixture

COMMITMENT The concentration of oxygen in the WASTE GAS HOLDUP SYSTEM shall be limited to $\leq 2\%$ by volume whenever the hydrogen concentration is $> 4\%$ by volume.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Concentration of oxygen in the WASTE GAS HOLDUP SYSTEM $> 2\%$ but $\leq 4\%$ by volume and hydrogen concentration $> 4\%$ by volume.	A.1 Reduce oxygen concentration to within limits.	48 hours
B. Concentration of oxygen in the WASTE GAS HOLDUP SYSTEM $> 4\%$ by volume and hydrogen concentration $> 4\%$ by volume.	B.1 Suspend all additions of waste gases to the system.	Immediately
	<u>AND</u>	
	B.2 Reduce the concentration of oxygen to $\leq 4\%$ by volume.	Immediately
	<u>AND</u>	
	B.3 Reduce oxygen concentration to within limits.	48 hours

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11-18-1 Verify that the concentrations of hydrogen and oxygen in the WASTE GAS HOLDUP SYSTEM are within limits by continuously monitoring the waste gases in the WASTE GAS HOLDUP SYSTEM with the hydrogen and oxygen monitors required FUNCTIONAL by SLC 16.11-20.	During WASTE GAS HOLDUP SYSTEM operation

BASES This SLC is provided to ensure that the concentration of potentially explosive gas mixtures contained in the WASTE GAS HOLDUP SYSTEM is maintained below the flammability limits of hydrogen and oxygen. Automatic control features are included in the system to prevent the hydrogen and oxygen concentrations from reaching these flammability limits. These automatic control features include isolation of the source of hydrogen and/or oxygen, automatic diversion to recombiners, or injection of dilutants to reduce the concentration below the flammability limits. Maintaining the concentration of hydrogen and oxygen below their flammability limits provides assurance that the releases of radioactive materials will be controlled in conformance with the requirements of General Design Criterion 60 of Appendix A to 10 CFR Part 50.

- REFERENCES**
1. Letter from NRC to Gary R. Peterson, Duke, Issuance of Improved Technical Specifications Amendments for Catawba, September 30, 1998.
 2. Technical Specification 5.5.12, Explosive Gas and Storage Tank Radioactivity Monitoring Program.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-19 Gas Storage Tanks

COMMITMENT The quantity of radioactivity contained in each gas storage tank shall be limited to $\leq 97,000$ Curies of noble gases (considered as Xe-133 equivalent).

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Quantity of radioactive material in tank(s) exceeding limit.	A.1 Suspend all additions of radioactive material to the tank(s).	Immediately
	<u>AND</u>	
	A.2 Reduce tank(s) contents to within limit.	48 hours
	<u>AND</u>	
	A.3 Describe the events leading to this condition in the Radioactive Effluent Release Report.	In the next scheduled Radioactive Effluent Release Report pursuant to Technical Specification 5.6.3

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11-19-1 Verify that the quantity of radioactive material contained in each tank is within limits when radioactive materials are being added to the tank(s).	24 hours

BASES The tanks included in this SLC are those tanks for which the quantity of radioactivity contained is not limited directly or indirectly by another SLC. Restricting the quantity of radioactivity contained in each gas storage tank provides assurance that in the event of an uncontrolled release of the tank's contents, the resulting whole body exposure to a MEMBER OF THE PUBLIC at the nearest SITE BOUNDARY will not exceed 0.5 rem. This is consistent with Standard Review Plan 11.3, Branch Technical Position ETSB 11-5, "Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure," in NUREG-0800, July 1981.

- REFERENCES**
1. Letter from NRC to Gary R. Peterson, Duke, Issuance of Improved Technical Specifications Amendments for Catawba, September 30, 1998.

 2. Technical Specification 5.5.12, Explosive Gas and Storage Tank Radioactivity Monitoring Program.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-20 Explosive Gas Monitoring Instrumentation

COMMITMENT The Explosive Gas Monitoring Instrumentation channels shown in Table 16.11-20-1 shall be FUNCTIONAL with their Alarm/Trip Setpoints set to ensure that the limits of SLC 16.11-18 are not exceeded.

APPLICABILITY: During WASTE GAS HOLDUP SYSTEM operation.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more required Explosive Gas Monitoring Instrumentation channel(s) Alarm/Trip Setpoint less conservative than required.	A.1 Declare the channel(s) non-functional.	Immediately
B. One required hydrogen monitor channel non-functional.	B.1 Suspend oxygen supply to the recombiner.	Immediately
	<u>AND</u> B.2 Restore channel to FUNCTIONAL status.	30 days
C. One required oxygen monitor channel non-functional.	C.1 Obtain and analyze grab samples.	24 hours
	<u>AND</u> C.2 Restore channel to FUNCTIONAL status.	30 days

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
D. Two required oxygen monitor channels non-functional.	D.1 Obtain and analyze grab samples.	Once per 4 hours during degassing operations <u>AND</u> Once per 24 hours during other operations
	<u>AND</u> D.2 Restore channels to FUNCTIONAL status.	30 days
E. Required Action and associated Completion Time of Condition B, C, or D not met.	E.1 Prepare and submit a Special Report to the NRC to explain why the non-functionality was not corrected within the time specified.	30 days

TESTING REQUIREMENTS

-----NOTE-----
Refer to Table 16.11-20-1 to determine which TRs apply for each Explosive Gas Monitoring Instrumentation channel.

TEST	FREQUENCY
TR 16.11-20-1 Perform CHANNEL CHECK.	24 hours
TR 16.11-20-2 Perform COT.	31 days

(continued)

TESTING REQUIREMENTS (continued)

TEST	FREQUENCY
<p>TR 16.11-20-3-----NOTE-----</p> <p>The CHANNEL CALIBRATION shall include the use of standard gas samples in accordance with the manufacturer's recommendations. In addition, a standard gas sample of nominal four volume percent hydrogen (for the hydrogen monitors), nominal four volume percent oxygen (for the oxygen monitors 0WGMT6540, 0WGMT6560, 0WGMT6160, and 0WGMT6161), and nominal three volume percent oxygen (for the oxygen monitors 0WGMT6550 and 0WGMT6570) with the balance nitrogen, shall be used in the calibration and/or to check linearity of the analyzers.</p> <p>-----</p> <p>Perform CHANNEL CALIBRATION.</p>	<p>92 days</p>

Table 16.11-20-1

Explosive Gas Monitoring Instrumentation

INSTRUMENT	REQUIRED CHANNELS	TESTING REQUIREMENTS
WASTE GAS HOLDUP SYSTEM Explosive Gas Monitoring Instrumentation		
1. Hydrogen Monitors	1/in-service train per station	TR 16.11-20-1 TR 16.11-20-2 TR 16.11-20-3
2. Oxygen Monitors	2/in-service train per station	TR 16.11-20-1 TR 16.11-20-2 TR 16.11-20-3

BASES The Explosive Gas Monitoring Instrumentation is provided for monitoring and controlling the concentrations of potentially explosive gas mixtures in the WASTE GAS HOLDUP SYSTEM.

If an instrument has alarm and trip capability, then both the alarm and the trip setpoints are required to be verified for the instrument to remain FUNCTIONAL. For instruments with alarm-only capability, the alarm setpoint must be verified for the instrument to remain FUNCTIONAL.

OWGMT6540, OWGMT6550, OWGMT6560, and OWGMT6570 provide both an alarm and a trip function. OWGMT6160 and OWGMT6161 provide an alarm-only function. The oxygen monitors for waste gas analyzers OWGMT6550 or OWGMT6570 can only be credited if oxygen concentration is <3.7% and if NO oxygen sources are present.

REFERENCES 1. Letter from NRC to Gary R. Peterson, Duke, Issuance of Improved Technical Specifications Amendments for Catawba, September 30, 1998.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-21 Major Changes to Liquid, Gaseous, and Solid Radwaste Treatment Systems

COMMITMENT Licensee-initiated major changes to the Radwaste Treatment Systems (liquid, gaseous, and solid):

1. Shall be reported to the NRC in the Radioactive Effluent Release Report for the period in which the evaluation was reviewed by the Station Manager. Licensees may choose to submit the information called for in this SLC as part of the periodic Updated Final Safety Analysis Report update. The discussion of each change shall contain:
 - a. A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR 50.59;
 - b. Sufficient detailed information to totally support the reason for the change without benefit of additional or supplemental information;
 - c. A detailed description of the equipment, components, and processes involved and the interfaces with other plant systems;
 - d. An evaluation of the change, which shows the predicted releases of radioactive materials in liquid and gaseous effluents and/or quantity of solid waste that differ from those previously predicted in the license application and amendments thereto;
 - e. An evaluation of the change, which shows the expected maximum exposures to a MEMBER OF THE PUBLIC in the UNRESTRICTED AREA and to the general population that differ from those previously estimated in the license application and amendments thereto;
 - f. A comparison of the predicted releases of radioactive materials, in liquid and gaseous effluents and in solid waste, to the actual releases for the period prior to when the changes are to be made;
 - g. An estimate of the exposure to plant operating personnel as a result of the change; and

(continued)

COMMITMENT (continued)

- h. Documentation of the fact that the change was reviewed and found acceptable by the Station Manager or the Chemistry Manager.
2. Shall become effective upon review and acceptance by a qualified individual/organization.

APPLICABILITY: At all times.

REMEDIAL ACTIONS None

TESTING REQUIREMENTS None

BASES None

- REFERENCES
1. Letter from NRC to Gary R. Peterson, Duke, Issuance of Improved Technical Specifications Amendments for Catawba, September 30, 1998.

Attachment 10
Summary of Changes to the Process Control Program

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 10

Summary of Changes to the Process Control Program

This attachment includes a summary of changes to the PCP.

Attachment 10
Summary of Changes to the Process Control Program

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

No revision of the Catawba Nuclear Station PCP was published in 2019.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 11

Summary of Major Modifications to the Radioactive Waste Treatment Systems

This attachment includes a description of major modifications to the radioactive waste treatment systems that are anticipated to affect effluent releases.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

No major modifications to the Catawba Nuclear Station liquid, solid, or mobile radioactive waste treatment systems that are anticipated to affect effluent releases occurred in 2019.

There was one modification to the Catawba Nuclear Station radioactive gaseous waste system completed in 2019. Engineering Change (EC) 415235 replaced the obsolete model 3623 Hach Orbisphere analyzers with a model 511FK Hach analyzer for components 0WGMT6540, 0WGMT6550, 0WGMT6560, and 0WGMT6570. The EC also replaced the Hach model 31120 O₂ sensors with Hach model K1200 O₂ sensors. This explosive gas instrumentation is provided for monitoring and controlling the concentrations of potentially explosive gas mixtures in the Waste Gas System.

Attachment 12
Errata to a Previous Year's ARERR

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 12

Errata to a Previous Year's ARERR

This attachment includes any amended pages from a previous year's ARERR.

Attachment 12
Errata to a Previous Year's ARERR

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

There is one (1) amendment to a previous year's ARERR.

The following contains amended pages to the Catawba Nuclear Station 2018 ARERR. The Amended pages are identified with "Amendment #" on page. Specific changes are identified with change bars in the right margin.

Catawba Nuclear Station 2018 ARERR Amendment #1 requires the following changes to Attachment 1 (Reference NCR 02282078) and Attachment 6.

Catawba Nuclear Station 2018 ARERR Attachment 1, Page 1-2 as submitted:

Gaseous Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
1. Total Release	Ci	1.25E+00	1.25E+00	1.57E+00	1.31E+00	5.37E+00
2. Avg. Release Rate	µCi/sec	1.61E-01	1.58E-01	1.98E-01	1.64E-01	1.70E-01
B. Iodine-131						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	µCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life ≥ 8 days						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	µCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
1. Total Release	Ci	4.67E+01	4.89E+01	4.20E+01	5.82E+01	1.96E+02
2. Avg. Release Rate	µCi/sec	6.01E+00	6.22E+00	5.29E+00	7.32E+00	6.21E+00
E. Carbon-14						
1. Total Release	Ci	4.94E+00	5.01E+00	5.47E+00	4.37E+00	2.01E+01
2. Avg. Release Rate	µCi/sec	6.36E-01	6.37E-01	6.88E-01	5.95E-01	6.39E-01
F. Gross Alpha						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	µCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Attachment 12
Errata to a Previous Year's ARERR**

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Catawba Nuclear Station 2018 ARERR Attachment 1, Page 1-2 as amended (Amendment #1):

Gaseous Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
1. Total Release	Ci	1.25E+00	1.25E+00	1.57E+00	1.30E+00	5.37E+00
2. Avg. Release Rate	µCi/sec	1.61E-01	1.58E-01	1.98E-01	1.64E-01	1.70E-01
B. Iodine-131						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	µCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life ≥ 8 days						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	µCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
1. Total Release	Ci	4.67E+01	4.89E+01	4.20E+01	5.82E+01	1.96E+02
2. Avg. Release Rate	µCi/sec	6.01E+00	6.22E+00	5.29E+00	7.32E+00	6.21E+00
E. Carbon-14						
1. Total Release	Ci	4.94E+00	5.01E+00	5.47E+00	4.37E+00	2.01E+01
2. Avg. Release Rate	µCi/sec	6.36E-01	6.37E-01	6.88E-01	5.95E-01	6.39E-01
F. Gross Alpha						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	µCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Attachment 12
Errata to a Previous Year's ARERR**

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Catawba Nuclear Station 2018 ARERR Attachment 6, Page 6-2 as submitted:

Gaseous Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Noble Gases						
1. Maximum Gamma Air	mRAD	1.27E-02	1.17E-02	1.59E-02	1.31E-02	5.33E-02
(a) Limit	mRAD	1.27E-01	1.17E-01	1.59E-01	1.31E-01	2.67E-01
(b) % of Limit						
2. Maximum Beta Air	mRAD	4.50E-03	4.36E-03	5.63E-03	4.66E-03	1.92E-02
(a) Limit	mRAD	2.25E-02	2.18E-02	2.82E-02	2.33E-02	4.79E-02
(b) % of Limit						
<u>Receptor Location</u>	0.5 miles	NNE	NNE	NNE	NNE	NNE
B. Iodine, H-3, & Particulates						
1. Maximum Organ Dose	mREM	1.16E+00	1.18E+00	1.28E+00	1.11E+00	4.73E+00
(a) Limit	mREM	7.73E+00	7.83E+00	8.55E+00	7.40E+00	1.58E+01
(b) % of Limit						
<u>Receptor Location</u>	0.5 miles	NE	NE	NE	NE	NE
<u>Critical Age</u>		CHILD	CHILD	CHILD	CHILD	CHILD
<u>Critical Organ</u>		BONE	BONE	BONE	BONE	BONE
<u>Critical Pathway</u>		VEGETA- TION	VEGETA- TION	VEGETA- TION	VEGETA- TION	VEGETA- TION

**Attachment 12
Errata to a Previous Year's ARERR**

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Catawba Nuclear Station 2018 ARERR Attachment 6, Page 6-2 as amended (Amendment #1):

Gaseous Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
C. Noble Gases						
1. Maximum Gamma Air	mRAD	1.27E-02	1.17E-02	1.59E-02	1.30E-02	5.33E-02
(c) Limit	mRAD	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(d) % of Limit		1.27E-01	1.17E-01	1.59E-01	1.30E-01	2.67E-01
2. Maximum Beta Air	mRAD	4.50E-03	4.36E-03	5.63E-03	4.65E-03	1.91E-02
(c) Limit	mRAD	2.00E+01	2.00E+01	2.00E+01	2.00E+01	4.00E+01
(d) % of Limit		2.25E-02	2.18E-02	2.82E-02	2.33E-02	4.79E-02
<u>Receptor Location</u>	0.5 miles	NNE	NNE	NNE	NNE	NNE
D. Iodine, H-3, & Particulates						
1. Maximum Organ Dose	mREM	1.16E+00	1.18E+00	1.28E+00	1.11E+00	4.73E+00
(c) Limit	mREM	1.50E+01	1.50E+01	1.50E+01	1.50E+01	3.00E+01
(d) % of Limit		7.73E+00	7.83E+00	8.55E+00	7.40E+00	1.58E+01
<u>Receptor Location</u>	0.5 miles	NE	NE	NE	NE	NE
<u>Critical Age</u>		CHILD	CHILD	CHILD	CHILD	CHILD
<u>Critical Organ</u>		BONE	BONE	BONE	BONE	BONE
<u>Critical Pathway</u>		VEGETA- TION	VEGETA- TION	VEGETA- TION	VEGETA- TION	VEGETA- TION

**Attachment 12
Errata to a Previous Year's ARERR**

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Catawba Nuclear Station 2018 ARERR Attachment 6, Page 6-3 as submitted:

Liquid Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Batch Mode						
1. Maximum Organ Dose	mREM	2.15E-02	3.84E-02	1.78E-02	4.08E-02	9.50E-02
(a) Limit	mREM	2.15E-01	3.84E-01	1.78E-01	4.08E-01	4.75E-01
(b) % of Limit						
2. Maximum Total Body Dose	mREM	2.08E-02	2.16E-02	1.43E-02	4.01E-02	9.24E-02
(a) Limit	mREM	6.93E-01	7.21E-01	4.76E-01	1.34E+00	1.54E+00
(b) % of Limit						
<u>Critical Age</u>		CHILD	CHILD	CHILD	CHILD	CHILD
<u>Critical Organ</u>		LIVER	BONE	BONE	GILLI	LIVER
<u>Critical Pathway</u>		POTABLE	FRESH	FRESH	POTABLE	POTABLE
		WATER	WATER	WATER	WATER	WATER
B. Continuous Mode						
1. Maximum Organ Dose	mREM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
(a) Limit	mREM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
(b) % of Limit						
2. Maximum Total Body Dose	mREM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
(a) Limit	mREM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
(b) % of Limit						
<u>Critical Age</u>		N/A	N/A	N/A	N/A	N/A
<u>Critical Organ</u>		N/A	N/A	N/A	N/A	N/A
<u>Critical Pathway</u>		N/A	N/A	N/A	N/A	N/A

**Attachment 12
Errata to a Previous Year's ARERR**

Catawba Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Catawba Nuclear Station 2018 ARERR Attachment 6, Page 6-3 as amended (Amendment #1):

Liquid Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
C. Batch Mode						
1. Maximum Organ Dose	mREM	2.15E-02	3.84E-02	1.78E-02	4.08E-02	9.50E-02
(c) Limit	mREM	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(d) % of Limit		2.15E-01	3.84E-01	1.78E-01	4.08E-01	4.75E-01
2. Maximum Total Body Dose	mREM	2.08E-02	2.16E-02	1.43E-02	4.01E-02	9.24E-02
(c) Limit	mREM	3.00E+00	3.00E+00	3.00E+00	3.00E+00	6.00E+00
(d) % of Limit		6.93E-01	7.21E-01	4.76E-01	1.34E+00	1.54E+00
<u>Critical Age</u>		CHILD	CHILD	CHILD	CHILD	CHILD
<u>Critical Organ</u>		LIVER	BONE	BONE	GILLI	LIVER
<u>Critical Pathway</u>		POTABLE WATER	FRESH WATER	FRESH WATER	POTABLE WATER	POTABLE WATER
D. Continuous Mode						
1. Maximum Organ Dose	mREM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
(c) Limit	mREM	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(d) % of Limit		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Maximum Total Body Dose	mREM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
(c) Limit	mREM	3.00E+00	3.00E+00	3.00E+00	3.00E+00	6.00E+00
(d) % of Limit		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
<u>Critical Age</u>		N/A	N/A	N/A	N/A	N/A
<u>Critical Organ</u>		N/A	N/A	N/A	N/A	N/A
<u>Critical Pathway</u>		N/A	N/A	N/A	N/A	N/A

Enclosure 3
RA-20-0078

ENCLOSURE 3: [HNP Annual Radioactive Effluent Release Report](#)



Shearon Harris Nuclear Power Plant Unit 1

Annual Radioactive Effluent Release Report

January 1, 2019 through December 31, 2019

Docket 50-400



Introduction

The Annual Radioactive Effluent Release Report is pursuant to Shearon Harris Nuclear Power Plant Technical Specification 6.9.1.4 and ODCM Section F.2. The below listed attachments to this report provide the required information. In addition, the ODCM is included pursuant to Shearon Harris Nuclear Power Plant Technical Specification 6.14.

- Attachment 1 Summary of Gaseous and Liquid Effluents
- Attachment 2 Supplemental Information
- Attachment 3 Solid Radioactive Waste Disposal
- Attachment 4 Meteorological Data
- Attachment 5 Unplanned Offsite Releases
- Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public
- Attachment 7 Information to Support the NEI Ground Water Protection Initiative
- Attachment 8 Inoperable Equipment
- Attachment 9 Summary of Changes to the Offsite Dose Calculation Manual
- Attachment 10 Summary of Changes to the Process Control Program
- Attachment 11 Summary of Major Modifications to the Radioactive Waste Treatment Systems
- Attachment 12 Errata to a Previous Year's ARERR

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 1

Summary of Gaseous and Liquid Effluents

This attachment includes a summary of the quantities of radioactive liquid and gaseous effluents as outlined in Regulatory Guide 1.21, Appendix A.

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	μCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Iodine-131						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	1.90E-07	1.90E-07
2. Avg. Release Rate	μCi/sec	0.00E+00	0.00E+00	0.00E+00	2.38E-08	2.38E-08
C. Particulates Half-Life ≥ 8 days						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	μCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
1. Total Release	Ci	1.87E+01	1.60E+01	1.52E+01	2.04E+01	7.03E+01
2. Avg. Release Rate	μCi/sec	2.41E+00	2.03E+00	1.91E+00	2.57E+00	2.23E+00
E. Gross Alpha						
1. Total Release	Ci	0.00+00	0.00+00	0.00+00	0.00+00	0.00E+00
2. Avg. Release Rate	μCi/sec	0.00+00	0.00+00	0.00+00	0.00+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Elevated Releases - Continuous Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life \geq 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Shearon Harris Nuclear Power Plant Unit 1 does not have elevated releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Elevated Releases - Batch Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life \geq 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Shearon Harris Nuclear Power Plant Unit 1 does not have elevated releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground Releases - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00+00	0.00+00	0.00E+00	0.00E+00	0.00E+00
B. Iodines						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00+00	0.00+00	0.00+00	0.00+00	0.00E+00
C. Particulates Half-Life \geq 8 days						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00+00	0.00+00	0.00+00	0.00+00	0.00E+00
D. Tritium						
H-3	Ci	1.87E+01	1.60E+01	1.52E+01	2.02E+01	7.01E+01
E. Gross Alpha						
Total for Period	Ci	0.00+00	0.00+00	0.00+00	0.00+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground Releases - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Iodines						
I-131	Ci	0.00+00	0.00E+00	0.00+00	1.90E-07	1.90E-07
Total for Period	Ci	0.00+00	0.00E+00	0.00+00	1.90E-07	1.90E-07
C. Particulates Half-Life ≥ 8 days						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00+00	0.00E+00	0.00+00	0.00+00	0.00E+00
D. Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	1.92E-01	1.92E-01
E. Gross Alpha						
Total for Period	Ci	0.00+00	0.00+00	0.00+00	0.00+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Mixed-Mode Releases - Continuous Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life \geq 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Shearon Harris Nuclear Power Plant Unit 1 does not have mixed-mode releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Mixed-Mode Releases - Batch Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life \geq 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* Shearon Harris Nuclear Power Plant Unit 1 does not have mixed-mode releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products *						
1. Total Release	Ci	3.78E-04	1.13E-03	1.45E-03	2.99E-03	5.95E-03
2. Avg. Diluted Conc.	µCi/ml	7.12E-11	2.02E-10	2.82E-10	4.98E-10	2.63E-10
B. Tritium						
1. Total Release	Ci	2.64E+01	1.04E+02	2.69E+02	2.13E+02	6.12E+02
2. Avg. Diluted Conc.	µCi/ml	4.97E-06	1.86E-05	5.23E-05	3.56E-05	2.79E-05
C. Dissolved & Entrained Gases						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Diluted Conc.	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Diluted Conc.	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E. Volume of Liquid Waste						
1. Batch Releases	liters	5.40E+05	4.68E+05	8.36E+05	8.79E+05	2.72E+06
2. Continuous Releases	liters	1.13E+07	1.53E+07	1.55E+07	1.27E+07	5.48E+07
F. Volume of Dilution Water						
1. Batch Releases	liters	5.31E+09	5.61E+09	5.15E+09	5.99E+09	2.21E+10
2. Continuous Releases	liters	5.31E+09	5.61E+09	5.15E+09	5.99E+09	2.21E+10

* Excludes tritium, dissolved and entrained noble gases, and gross alpha.

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Liquid Effluents - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Tritium						
H-3	Ci	6.10E-02	6.99E-02	1.65E-01	8.28E-02	3.78E-01
C. Dissolved & Entrained Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Liquid Effluents - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
Cr-51	Ci	0.00+00	0.00+00	0.00+00	1.90E-04	1.90E-04
Mr-54	Ci	0.00+00	2.97E-05	3.64E-05	1.54E-04	2.20E-04
Co-58	Ci	5.17E-06	0.00+00	0.00+00	1.90E-04	1.95E-04
Co-60	Ci	1.25E-04	4.85E-04	6.07E-04	1.56E-03	2.78E-03
Ni-63	Ci	1.56E-04	3.45E-04	2.17E-04	0.00+00	7.18E-04
Zr-95	Ci	0.00+00	0.00+00	0.00+00	3.25E-05	3.25E-05
Nb-95	Ci	0.00+00	3.45E-06	8.15E-06	9.53E-05	1.07E-04
Sb-124	Ci	0.00+00	2.19E-05	0.00+00	1.38E-04	1.60E-04
Sb-125	Ci	9.24E-05	2.49E-04	5.78E-04	6.17E-04	1.54E-03
Cs-134	Ci	0.00+00	0.00+00	0.00+00	1.22E-05	1.22E-05
Cs-137	Ci	0.00+00	0.00+00	7.39E-06	0.00+00	7.39E-06
Total for Period	Ci	3.78E-04	1.13E-03	1.45E-03	2.99E-03	5.96E-03
B. Tritium						
H-3	Ci	2.64E+01	1.04E+02	2.69E+02	2.13E+02	6.12E+02
C. Dissolved & Entrained Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Gross Alpha						
D. Total for Period	Ci	0.00+00	0.00+00	0.00+00	0.00+00	0.00E+00

**Attachment 2
Supplemental Information**

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 2

Supplemental Information

This attachment includes supplemental information to the gaseous and liquid effluents report.

**Attachment 2
Supplemental Information**

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

I. Regulatory Limits - Per Unit

A. Noble Gases - Air Dose

- | | | |
|--------------------------------|---|---------|
| 1. Calendar Quarter Gamma Dose | = | 5 mRAD |
| 2. Calendar Quarter Beta Dose | = | 10 mRAD |
| 3. Calendar Year Gamma Dose | = | 10 mRAD |
| 4. Calendar Year Beta Dose | = | 20 mRAD |

B. Liquid Effluents - Dose

- | | | |
|-------------------------------------|---|----------|
| 1. Calendar Quarter Total Body Dose | = | 1.5 mREM |
| 2. Calendar Quarter Organ Dose | = | 5 mREM |
| 3. Calendar Year Total Body Dose | = | 3 mREM |
| 4. Calendar Year Organ Dose | = | 10 mREM |

C. Gaseous Effluents - Iodine-131 & 133, Tritium, and Particulates with Half-lives > 8 days

- | | | |
|--------------------------------|---|----------|
| 1. Calendar Quarter Organ Dose | = | 7.5 mREM |
| 2. Calendar Year Organ Dose | = | 15 mREM |

II. Maximum Permissible Effluent Concentrations

A. Gaseous Effluents

1. Information found in Offsite Dose Calculation Manual

B. Liquid Effluents

1. Information found in 10 CFR Part 20, Appendix B, Table 2, Column 2

III. Average Energy

(not applicable)

IV. Measurements and Approximations of Total Radioactivity

Analyses of specific radionuclides in selected or composited samples as described in the ODCM are used to determine the radionuclide composition of the effluent. A summary description of the method used for estimating overall errors associated with radioactivity measurements is provided as part of this attachment.

**Attachment 2
Supplemental Information**

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

V. Batch Releases

A. Liquid Effluents

		Jan - Jun	Jul - Dec
1. Number of Batch Releases	=	13	23
2. Total Time Period for Batch Releases	=	1.11E+04 min	1.87E+04 min
3. Maximum Time Period for a Batch Release	=	1.04E+03 min	1.20E+03 min
4. Average Time Period for a Batch Release	=	8.50E+02 min	8.12E+02 min
5. Minimum Time Period for a Batch Release	=	7.52E+02 min	3.31E+02 min
6. Average Stream Flow During Release Periods	=	1.05E+04 gpm	1.10E+04 gpm

B. Gaseous Effluents

		Jan - Jun	Jul - Dec
1. Number of Batch Releases	=	0	12
2. Total Time Period for Batch Releases	=	0.00E+00 min	1.64E+04 min
3. Maximum Time Period for a Batch Release	=	0.00E+00 min	4.03E+03 min
4. Average Time Period for a Batch Release	=	0.00E+00 min	1.36E+03 min
5. Minimum Time Period for a Batch Release	=	0.00E+00 min	1.20E+02 min

VI. Abnormal Releases

See Attachment 5, Unplanned Offsite Releases.

Attachment 2 Supplemental Information

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Carbon-14

The Shearon Harris Nuclear Power Plant 2019 ARERR contains estimates of C-14 radioactivity released in 2019, and estimates of public dose resulting from the C-14 effluent. The concentration and offsite dose from C-14 has been estimated by using a calculation approach, assuming typical or maximum values for the various calculation parameters. Because the dose contribution of C-14 from liquid radioactive waste is much less than that contributed by gaseous radioactive waste, evaluation of C-14 in liquid radioactive waste is not required (Ref. Reg. Guide 1.21, Rev. 2).

The quantity of gaseous C-14 released to the environment can be estimated by use of a C-14 source term scaling factor based on power generation (Ref. Reg. Guide 1.21, Rev. 2). The Shearon Harris Nuclear Power Plant UFSAR Section 11.1.5 states the expected C-14 generation to be 7.3 Curies assuming 292 effective full power days (EFPD) in a calendar year. For the Shearon Harris Nuclear Power Plant 2019 ARERR, a source term scaling factor using actual EFPD of 315.015 days is assumed. Using the source term scaling factor from Shearon Harris Nuclear Power Plant in 2019 results in a site total C-14 gaseous release estimate to the environment of 7.85 Curies. Due to the reducing environment of a Pressured Water Reactor, only 30% of the C-14 is assumed to be released in the Carbon Dioxide (CO₂) form. Dose is not expected from other forms (methane, etc). 70% of the C-14 gaseous effluent is assumed to be from batch releases and the remaining 30% is assumed to be from continuous releases through the plant vent (ref. IAEA Technical Reports Series no. 421, "Management of Waste Containing Tritium and Carbon-14", 2004).

The resultant offsite doses were based upon this source term and the dose calculations described in NRC Regulatory Guide 1.109, Revision 1, and the Shearon Harris Nuclear Power Plant ODCM. The estimated C-14 dose impact on the maximum organ dose from airborne effluents released from Shearon Harris Nuclear Power Plant in 2019 is well below the 10CFR 50, Appendix I, ALARA design objective (i.e., 15 mrem/yr per unit). The Harris Nuclear Plant Land Use Census did not provide sufficient detail for age groups at the residences. Therefore, a Child was assumed to be at each residence for the C-14 dose calculation. The receptor location of 2.91 km NNE and the Critical Age of a Child was the most restrictive receptor and age group out of the sixteen sectors.

	<u>Units</u>	<u>1st Qtr</u>	<u>2nd Qtr</u>	<u>3rd Qtr</u>	<u>4th Qtr</u>	<u>Year</u>
1. EFPD	Days	89.918	90.932	91.555	42.61	315.015
2. C-14 Activity Released	Ci	2.22E+00	2.27E+00	2.29E+00	1.07E+00	7.85E+00
3. C-14 Total Body Dose	mREM	1.28E-02	1.31E-02	1.32E-02	6.13E-03	4.52E-02
4. C-14 Organ Dose	mREM	6.42E-02	6.58E-02	6.63E-02	3.08E-02	2.27E-01

Receptor Location **2.91 km NNE**
Critical Age **CHILD**
Critical Organ **BONE**

Attachment 2 Supplemental Information

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Dose from Returned/Re-used of Previously Discharge Plant Effluents

Cooling Tower Plume

Tritium in Cooling Tower plume creates an exposure pathway to a member of the public. Murray and Trettle, Inc. was contracted to perform an evaluation of the dose to a member of the public from exposure to tritium in the Cooling Tower plume. Results of the plume exposure are contained in report "*Impact of Tritium Release from the Cooling Tower at the Harris Nuclear Plant for 2019*". Using the methodology described in ODCM 2.3.2, the following is a summary of tritium activity released through the Cooling Tower plume and resulting dose for 2019.

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
1. H-3 Activity Released	Ci	2.69E-01	4.30E-01	6.24E-01	4.65E-01	1.79E+00
2. H-3 Dose	mREM	3.43E-04	5.53E-04	8.11E-04	6.05E-04	2.31E-03

Receptor Location **2.91 km NNE**
Critical Age **CHILD**
Critical Organ **N/A ***

Harris Lake Evaporation

Evaporation of water containing tritium in Harris Lake creates an exposure pathway to a member of the public. Murray and Trettle, Inc. was contracted to perform an evaluation of the dose to a member of the public from evaporation of tritium in Harris Lake. Results of the evaluation are contained in report "*Impact of Tritium Release from the Water Reservoir (Lake Harris) at the Harris Nuclear Plant for 2019*". Using the methodology described in ODCM 2.3.3, the following is a summary of tritium activity released through evaporation and resulting dose for 2019.

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
1. H-3 Activity Released	Ci	8.95E+00	1.32E+01	3.23E+01	2.53E+01	7.98E+01
2. H-3 Dose	mREM	5.87E-03	8.72E-03	2.11E-02	1.65E-02	5.22E-02

Receptor Location **6.65 km SSW**
Critical Age **CHILD**
Critical Organ **N/A ***

Drinking Water at Harris Plant and the Harris Energy and Environmental (HE&EC) Training Centers

Concentrations of radionuclides used in this specific drinking water pathway are determined by averaging the monthly concentrations detected in environmental location (REMP) DW-51. In 2019, no plant related gamma emitting radionuclides were detected. Tritium was detected each month, as expected. Using the methodology described in ODCM 2.3.1, the following is a summary of average concentration consumed and resulting dose for 2019.

	<u>Units</u>	<u>Year</u>
1. Avg. H-3 Concentration	µCi/L	2.68E+03
2. H-3 Dose	mREM	7.34E-02

Critical Age **ADULT**
Critical Organ **N/A ***

* The dose factor for H-3 is the same for all organs and Total Body (with the exception of Bone, which is 0.00E+00).

Attachment 2 Supplemental Information

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Tritium in Fish from Harris Lake

Concentrations of radionuclides used in this specific fish consumption pathway are determined by averaging the monthly concentrations detected in environmental location (REMP) SW-26. In 2019, no plant related gamma emitting radionuclides were detected. Tritium was detected each month, as expected. Since tritium is consistently detected in Harris Lake REMP samples, tritium concentration in the fish is assumed to be in equilibrium with Harris Lake. Using the methodology and data described in NRC Regulatory Guide 1.109, Rev.1, October 1977, Equation A-1, Table E-5, and Table E-11, the following is a summary of average concentration consumed and resulting dose for 2019.

	<u>Units</u>	<u>Year</u>
1. Avg. H-3 Concentration	pCi/L	4.17E+03
2. H-3 Dose	mREM	8.28E-03

Critical Age **ADULT**
Critical Organ **N/A** *

* The dose factor for H-3 is the same for all organs and Total Body (with the exception of Bone, which is 0.00E+00).

Attachment 2 Supplemental Information

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Overall Estimate of Error for Gaseous Effluent Radioactivity Release Reported

The estimated percentage of overall error for Noble Gases in Gaseous effluent release data at Shearon Harris Nuclear Power Plant has been determined to be $\pm 52.68\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

- | | | |
|--------------------------------------------------------|---|--------------|
| 1. Counting Standard (20000 counts/energy % error) | = | $\pm 0.1\%$ |
| 2. Calibration Standard | = | $\pm 5.0\%$ |
| 3. Acceptable Counting Statistic for Nuclide ID (R.E.) | = | $\pm 25.0\%$ |
| 4. Sample Volume Variability | = | $\pm 5.0\%$ |
| 5. Stack Flow Rates (Non-steady Release Rates) | = | $\pm 10.0\%$ |
| 6. Rad Monitor Calibration | = | $\pm 20.0\%$ |
| 7. Net Activity Determination from Rad Monitors | = | $\pm 40.0\%$ |

The estimated percentage of overall error for Air Particulates in Gaseous effluent release data at Shearon Harris Nuclear Power Plant has been determined to be $\pm 33.75\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

- | | | |
|--------------------------------------------------------|---|--------------|
| 1. Counting Standard (20000 counts/energy % error) | = | $\pm 0.1\%$ |
| 2. Calibration Standard | = | $\pm 5.0\%$ |
| 3. Acceptable Counting Statistic for Nuclide ID (R.E.) | = | $\pm 25.0\%$ |
| 4. Sample Flow (Sample Volume) | = | $\pm 10.0\%$ |
| 5. Potential Sample Line Losses | = | $\pm 8.0\%$ |
| 6. Stack Flow Rates (Non-steady Release Rates) | = | $\pm 10.0\%$ |
| 7. Chemical Yield Factors (Sr-89, 90) | = | $\pm 15.0\%$ |

The estimated percentage of overall error for Iodine on Charcoal Filters in Gaseous effluent release data at Shearon Harris Nuclear Power Plant has been determined to be $\pm 30.38\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

- | | | |
|--------------------------------------------------------|---|--------------|
| 1. Counting Standard (20000 counts/energy % error) | = | $\pm 0.1\%$ |
| 2. Calibration Standard | = | $\pm 5.0\%$ |
| 3. Acceptable Counting Statistic for Nuclide ID (R.E.) | = | $\pm 25.0\%$ |
| 4. Sample Flow (Sample Volume) | = | $\pm 10.0\%$ |
| 5. Potential Sample Line Losses | = | $\pm 8.0\%$ |
| 6. Stack Flow Rates (Non-steady Release Rates) | = | $\pm 10.0\%$ |
| 7. Collection Efficiency | = | $\pm 3.0\%$ |

The estimated percentage of overall error for Tritium in Gaseous effluent release data at Shearon Harris Nuclear Power Plant has been determined to be $\pm 52.20\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

- | | | |
|--------------------------------------------------------|---|--------------|
| 1. Counting Standard (20000 counts/energy % error) | = | $\pm 0.1\%$ |
| 2. Calibration Standard | = | $\pm 5.0\%$ |
| 3. Acceptable Counting Statistic for Nuclide ID (R.E.) | = | $\pm 50.0\%$ |
| 4. Stack Flow Rates (Non-steady Release Rates) | = | $\pm 10.0\%$ |
| 5. Collection Efficiency | = | $\pm 10.0\%$ |

Attachment 2 Supplemental Information

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Overall Estimate of Error for Liquid Effluent Radioactivity Release Reported

The estimated percentage of overall error for Fission and Activation Products in Liquid effluent release data at Shearon Harris Nuclear Power Plant has been determined to be $\pm 32.79\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

- | | | |
|--------------------------------------------------------|---|--------------|
| 1. Counting Standard (20000 counts/energy % error) | = | $\pm 0.1\%$ |
| 2. Calibration Standard | = | $\pm 5.0\%$ |
| 3. Acceptable Counting Statistic for Nuclide ID (R.E.) | = | $\pm 25.0\%$ |
| 4. Sample (sample volume between techs) | = | $\pm 5.0\%$ |
| 5. Volume Determinations (Tank Level) | = | $\pm 20.0\%$ |

The estimated percentage of overall error for Tritium in Liquid effluent release data at Shearon Harris Nuclear Power Plant has been determined to be $\pm 54.31\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

- | | | |
|--------------------------------------------------------|---|--------------|
| 1. Counting Standard (20000 counts/energy % error) | = | $\pm 0.1\%$ |
| 2. Calibration Standard | = | $\pm 5.0\%$ |
| 3. Acceptable Counting Statistic for Nuclide ID (R.E.) | = | $\pm 50.0\%$ |
| 4. Sample (sample volume between techs) | = | $\pm 5.0\%$ |
| 5. Volume Determinations (Tank Level) | = | $\pm 20.0\%$ |

Attachment 2
Supplemental Information

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Overall Estimate of Error for Solid Waste Radioactivity Reported

The estimated percentage of overall error for Solid Waste data at Shearon Harris Nuclear Power Plant has been determined to be $\pm 96\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

- | | | |
|--------------------------------------------------------|---|---------------|
| 1. Counting Standard (20000 counts/energy % error) | = | < $\pm 0.1\%$ |
| 2. Calibration Standard | = | $\pm 5.0\%$ |
| 3. Acceptable Counting Statistic for Nuclide ID (R.E.) | = | $\pm 95.0\%$ |
| 4. Sample Volume Variability | = | $\pm 0.001\%$ |
| 5. Instrument Errors | = | $\pm 5.0\%$ |
| 6. Dose Rate Measurement | = | $\pm 10.0\%$ |
| 7. Geometry | = | $\pm 5.0\%$ |
| 8. Volume Determinations | = | $\pm 5.0\%$ |
| 9. RADMAN Database (sample analysis variance) | = | $\pm 0.96\%$ |

Attachment 2 Supplemental Information

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Summary of Changes in Land Use Census Affecting Effluent Dose Calculations

The 2019 Land Use Census was performed July 24-25, 2019.

RESIDENCES

- No new residences were observed.

GARDENS ₁

- The garden in the E sector (2.16 miles) was replaced with a garden at 2.15 miles.
- The garden in the SE sector (4.11 miles) was not cultivated this year (2019) and a replacement garden could not be located in this sector.
- The garden in the SSE sector (4.26 miles) was not cultivated this year (2019) and a replacement garden could not be located in this sector.
- The garden in the SSW sector (4.13 miles) was replaced with a garden at 3.94 miles.
- A new garden was located in the SW sector at 4.32 miles this year (2019). A garden was not able to be located in this sector in 2018.
- The garden in the W sector (4.19 miles) was replaced with a garden at 2.82 miles.
- The garden in the WNW sector (3.75 miles) was not cultivated this year (2019) and a replacement garden was found at 4.03 miles.
- The garden in the NW sector (3.17 miles) was replaced with a garden found at 2.91 miles.

1: There were no gardens identified by the census as being irrigated from Harris Lake (Shearon Harris Reservoir).

MEAT ANIMALS ₂

The following meat animal attributes were identified during the Land Use Census:

- The meat animal in the N sector (2.21 miles) remains unchanged from 2018.
- The meat animal in the ENE Sector (2.01 miles) remains unchanged from 2018.
- The meat animal in the NNW sector (1.82 miles) remains unchanged from 2018.

2: Meat animals were only identified at the nearest garden or closer in each sector, and poultry and egg laying animals were not classified as meat animals for the 2019 census

MILK ANIMALS

- The milk animals (goats) located in the N sector (4.14 miles) were still present, and the owner indicated they are now processing enough milk to participate in the REMP. This dairy is not required to be added to the REMP due to HNP already having a dairy within 5 km (3.11 miles) and the dose being <1.0 mRem/year.
- The milk animals (goats) located in the W sector (2.82 miles) were still present, and currently participate in the HNP REMP Environmental Program. The goat milk is used to feed goat kids during the breeding months, and the remainder is consumed by the family. They also give the non-consumable milk to someone who makes soap.

Attachment 3
Solid Radioactive Waste Disposal

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 3

Solid Radioactive Waste Disposal

This attachment includes a summary of the solid waste shipped off-site for burial and/or disposal, including:

- Container volume
- Total Curie content
- Principal Radionuclides
- Source/Type of waste
- Solidification agent or absorbent
- Type of shipping container
- Number of shipments
- Other relevant information as necessary

Attachment 3 Solid Radioactive Waste Disposal

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

1. Solid Waste Shipped for Burial or Disposal (WASTE CLASS A)

NOTE: Values reported in sections 1.A.a, b, c & 1.B.a, b, c,d refers to radioactive solid waste materials shipped in 2019 to a vendor for processing and subsequent burial.

A. Type of Waste

a. Spent resins.

Note: Waste shipped in 2019 for processing and subsequent burial

Number of Shipments	4
Activity Shipped	2.05 E+01 Curies
Estimated Total Error	96%
Quantity Shipped	14.53 m ³
Solidification Agent	N/A
Container Type	NRC/DOT-Approved Package
Shipment Form	Dewatered, Compacted

b. Dry Active Waste (DAW), mechanical filters, contaminated equipment, etc.

Note: Waste shipped in 2019 for processing and subsequent burial.

Number of Shipments	7
Activity Shipped	8.33 E-01 Curies
Estimated Total Error	96%
Quantity Shipped	356.12 m ³
Solidification Agent	N/A
Container Type	General Design
Shipment Form	Compacted, Non-Compacted

c. Irradiated components, control rods, etc. (Ex-core detector)

Note: * No waste of this type was shipped during the report period

d. Other: GAC Vessels

Note: * No waste of this type was shipped during the report period

Attachment 3 Solid Radioactive Waste Disposal

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

1. Solid Waste Shipped for Burial or Disposal (WASTE CLASS A)
 - B. Estimate of Major Nuclide Composition (by type of Waste)
 - a. Spent Radwaste Bead Resin.

Note: Waste shipped in 2019 for processing and subsequent burial.

Class A Spent Resin Totals

Isotope	Activity(mci)	Activity (Ci)	Abundance
Be-7	8.17E+02	8.17E-01	3.98%
C-14	1.87E+02	1.87E-01	0.91%
Ce-144	1.63E+01	1.63E-02	0.08%
Co-57	1.14E+01	1.14E-02	0.06%
Co-58	5.23E+02	5.23E-01	2.55%
Co-60	3.61E+03	3.61E+00	17.63%
Cr-51	1.83E+00	1.83E-03	0.01%
Cs-137	1.51E+03	1.51E+00	7.38%
Fe-55	7.08E+03	7.08E+00	34.51%
Fe-59	6.17E+00	6.17E-03	0.03%
H-3	1.22E+02	1.22E-01	0.60%
I-129	3.70E-01	3.70E-04	0.00%
Mn-54	2.38E+03	2.38E+00	11.58%
Nb-95	9.00E+01	9.00E-02	0.44%
Ni-63	3.89E+03	3.89E+00	18.98%
Sb-125	1.84E+02	1.84E-01	0.90%
Sn-113	1.60E+01	1.60E-02	0.08%
Sr-89	5.44E+00	5.44E-03	0.03%
Sr-90	8.17E+00	8.17E-03	0.04%
Tc-99	2.38E+00	2.38E-03	0.01%
Zr-95	4.23E+01	4.23E-02	0.21%
Grand Total	2.05E+04	2.05E+01	100.00%

Attachment 3 Solid Radioactive Waste Disposal

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

1. Solid Waste Shipped for Burial or Disposal (WASTE CLASS A)
 - B. Estimate of Major Nuclide Composition (by type of Waste)
 - b. Dry Active Waste (DAW), mechanical filters, contaminated equipment, etc.

Note: Waste shipped in 2019 for processing and subsequent burial.

Class A DAW Totals

Isotope	Activity(mci)	Activity (Ci)	Abundance
C-14	4.43E+00	4.43E-03	0.53%
Ce-144	5.77E+00	5.77E-03	0.69%
Co-58	2.13E+01	2.13E-02	2.56%
Co-60	2.11E+02	2.11E-01	25.32%
Cr-51	4.80E+01	4.80E-02	5.76%
Cs-137	1.31E+01	1.31E-02	1.57%
Fe-55	2.19E+02	2.19E-01	26.32%
H-3	7.06E+01	7.06E-02	8.47%
I-129	3.33E-01	3.33E-04	0.04%
Mn-54	1.18E+01	1.18E-02	1.42%
Nb-95	1.30E+02	1.30E-01	15.63%
Tc-99	3.90E+00	3.90E-03	0.47%
Zr-95	9.35E+01	9.35E-02	11.22%
Grand Total	8.33E+02	8.33E-01	100.00%

Attachment 3
Solid Radioactive Waste Disposal

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

1. Solid Waste Shipped for Burial or Disposal (WASTE CLASS A)

B. Estimate of Major Nuclide Composition (by type of Waste)

c. Irradiated components, control rods, etc.

Note: * No waste of this type was shipped during the report period

d. Other

Note: * No waste of this type was shipped during the report period

1. Solid Waste Shipped for Burial or Disposal (WASTE CLASS A)

C. Solid Waste Disposal

Number of Shipments	11
Mode of Transportation	Truck
Destination	Energy Solutions

Note: Waste shipped in 2019 for processing and subsequent burial

2. Solid Waste Shipped for Burial or Disposal (WASTE CLASS B)

A. Type of Waste

a. Spent resins.

No waste of this type was shipped during this Report Period.

b. Dry Active Waste (DAW), mechanical filters, contaminated equipment, etc.

* No waste of this type was shipped during this Report Period.

c. Irradiated components, control rods, etc.

* No waste of this type was shipped during this Report Period.

d. Other (Describe)

* No waste of this type was shipped during this Report Period.

Attachment 3
Solid Radioactive Waste Disposal

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

- 3. Solid Waste Shipped for Burial or Disposal (WASTE CLASS B)
 - B. Estimate of Major Nuclide Composition (by type of Waste)
 - a. Dry Active Waste (DAW), mechanical filters, contaminated equipment, etc.
* No waste of this type was shipped during this Report Period.
 - C. Solid Waste Disposal
* No waste of this type was shipped during this Report Period.

- 3. Solid Waste Shipped for Burial or Disposal (WASTE CLASS C)
 - A. Type of Waste
 - a. Spent resins, filter sludge's, evaporator bottoms, etc.
No waste of this type was shipped during this Report Period.
 - b. Dry Active Waste (DAW), mechanical filters, contaminated equipment, etc.
No waste of this type was shipped during this Report Period.
 - c. Irradiated Components, Control Rods, etc.
No waste of this type was shipped during this Report Period.
 - d. Other (Describe)
No waste of this type was shipped during this Report Period.
 - B. Estimate of Major Nuclide Composition (by type of Waste)
N/A
 - C. Solid Waste Disposal
N/A

**Attachment 4
Meteorological Data**

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 4

Meteorological Data

This attachment includes a summary of meteorological joint frequency distributions of wind speed, wind direction, and atmospheric stability (hours of occurrence).

Attachment 4 Meteorological Data

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
A	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.01-1.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.26-1.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.51-2.00	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	2.01-3.00	0	0	3	1	1	2	0	0	0	0	0	0	0	0	0	0
	3.01-4.00	0	2	0	0	0	0	1	2	0	0	0	2	0	0	0	0
	4.01-5.00	0	1	0	1	0	0	0	1	1	2	1	0	0	0	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-Max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
B	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.01-1.25	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	1.26-1.50	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
	1.51-2.00	0	2	1	3	3	5	5	3	1	2	2	4	3	0	0	0
	2.01-3.00	4	8	12	10	16	6	8	16	4	1	6	5	5	3	5	2
	3.01-4.00	2	7	8	2	0	0	4	12	8	8	6	6	3	1	2	2
	4.01-5.00	2	3	1	0	0	0	0	2	1	9	5	2	3	2	6	0
	5.01-6.00	0	0	0	0	0	0	0	0	1	4	2	0	0	5	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-Max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Attachment 4 Meteorological Data

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
C	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.76-1.00	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	1.01-1.25	0	1	0	0	0	0	0	3	0	0	0	1	1	0	0	1
	1.26-1.50	0	0	1	5	4	5	6	6	6	3	2	2	2	1	1	1
	1.51-2.00	5	1	2	21	12	8	15	12	12	16	9	11	10	9	5	7
	2.01-3.00	23	20	23	27	9	12	15	40	26	37	33	26	17	14	15	16
	3.01-4.00	5	7	5	7	0	1	1	11	11	28	29	16	9	10	20	12
	4.01-5.00	2	3	1	0	0	0	0	0	4	9	7	5	5	9	5	1
	5.01-6.00	0	1	0	0	0	0	0	0	0	2	4	3	2	7	1	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-Max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
D	0.46-0.75	5	6	5	5	4	4	5	3	3	3	7	6	3	5	9	3
	0.76-1.00	10	14	15	14	11	8	9	7	14	9	13	7	10	5	6	12
	1.01-1.25	13	18	14	13	20	10	14	15	14	14	20	18	12	6	8	5
	1.26-1.50	25	29	31	38	28	15	23	21	27	32	35	16	16	16	12	19
	1.51-2.00	57	60	66	62	53	35	30	39	42	70	64	33	30	21	15	49
	2.01-3.00	100	113	77	71	42	36	31	86	102	157	78	63	38	30	42	61
	3.01-4.00	38	38	22	8	3	6	6	21	50	80	49	27	16	29	35	75
	4.01-5.00	14	20	2	1	0	0	0	5	31	47	19	11	13	23	14	19
	5.01-6.00	4	15	1	0	0	0	0	1	7	11	5	4	2	3	4	4
	6.01-8.00	1	0	0	0	0	0	0	0	2	4	0	0	0	0	0	0
	8.01-10.00	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
10.01-Max	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	

Attachment 4 Meteorological Data

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
E	0.46-0.75	10	13	10	17	15	9	10	15	9	10	10	6	7	2	9	6
	0.76-1.00	21	20	20	36	21	13	18	22	21	25	10	17	13	6	9	9
	1.01-1.25	22	21	17	22	12	16	23	12	22	22	12	14	7	4	7	9
	1.26-1.50	33	27	13	17	16	10	25	30	31	38	25	12	12	4	5	8
	1.51-2.00	27	45	23	19	12	6	20	35	45	53	15	22	20	6	11	19
	2.01-3.00	30	19	6	6	5	0	8	23	75	60	27	17	14	17	8	25
	3.01-4.00	2	0	1	0	0	1	0	3	22	26	11	5	5	3	7	5
	4.01-5.00	0	0	0	0	0	0	0	0	2	4	6	0	2	3	0	0
	5.01-6.00	0	2	1	0	0	0	0	0	0	0	2	0	0	1	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-Max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
F	0.46-0.75	9	18	17	15	14	11	11	5	10	7	5	3	11	3	8	6
	0.76-1.00	13	15	26	21	8	13	6	4	5	8	12	13	8	9	2	9
	1.01-1.25	14	8	8	12	4	2	6	2	6	6	9	11	12	9	4	12
	1.26-1.50	10	13	9	6	2	2	3	2	5	4	1	4	3	3	3	4
	1.51-2.00	11	5	3	4	0	0	2	1	3	2	4	10	5	4	1	2
	2.01-3.00	1	0	1	0	0	0	0	0	0	0	0	1	4	0	1	2
	3.01-4.00	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	4.01-5.00	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-Max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Attachment 4 Meteorological Data

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
G	0.46-0.75	46	53	42	43	12	5	1	5	10	6	4	9	9	13	25	44
	0.76-1.00	8	10	20	16	5	2	4	1	4	4	4	2	7	3	12	16
	1.01-1.25	3	4	2	2	0	0	2	0	4	1	2	3	1	4	0	3
	1.26-1.50	2	0	1	1	0	0	0	0	2	1	1	1	1	1	1	2
	1.51-2.00	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2
	2.01-3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3.01-4.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4.01-5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-Max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

**Attachment 5
Unplanned Offsite Releases**

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 5

Unplanned Offsite Releases

This attachment includes a summary of the unplanned offsite releases of gaseous and liquid radioactive effluents.

Attachment 5
Unplanned Offsite Releases

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Shearon Harris Nuclear Power Plant had zero (0) unplanned liquid release in 2019.

Shearon Harris Nuclear Power Plant had zero (0) unplanned gaseous release in 2019.

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 6

Assessment of Radiation Dose from Radioactive Effluents to Members of the Public
(includes fuel cycle dose calculation results)

This attachment includes an assessment of radiation doses to the maximum exposed member of the public due to radioactive liquid and gaseous effluents released from the site for each calendar quarter for the calendar year of the report as well as the total dose for the calendar year.

This attachment also includes an assessment of radiation doses to the maximum exposed member of the public from all uranium fuel cycle sources within 8 km of the site for the calendar year of this report to show conformance with 40 CFR Part 190.

Methods for calculating the dose contribution from liquid and gaseous effluents are given in the Offsite Dose Calculation Manual (ODCM).

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Noble Gases						
1. Maximum Gamma Air	mRAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
(a) Limit	mRAD	5.00E+00	5.00E+00	5.00E+00	5.00E+00	1.00E+01
(b) % of Limit		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Maximum Beta Air	mRAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
(a) Limit	mRAD	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(b) % of Limit		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Receptor Location **2.14 km SW**

B. Iodine, H-3, & Particulates						
1. Maximum Organ Dose	mREM	7.45E-02	6.36E-02	6.04E-02	8.14E-02	2.80E-01
(a) Limit	mREM	7.50E+00	7.50E+00	7.50E+00	7.50E+00	1.50E+01
(b) % of Limit		9.94E-01	8.48E-01	8.05E-01	1.09E+00	1.87E+00

Receptor Location **2.14 km SW**

Critical Age **CHILD**

Critical Organ **Thyroid**

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

Liquid Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Batch Mode						
1. Maximum Organ Dose	mREM	4.21E-04	2.47E-03	8.11E-03	8.14E-03	1.91E-02
(a) Limit	mREM	5.00E+00	5.00E+00	5.00E+00	5.00E+00	1.00E+01
(b) % of Limit		8.42E-03	4.93E-02	1.62E-01	1.63E-01	1.91E-01
2. Maximum Total Body Dose	mREM	4.07E-04	2.27E-03	7.79E-03	4.76E-03	1.52E-02
(a) Limit	mREM	1.50E+00	1.50E+00	1.50E+00	1.50E+00	3.00E+00
(b) % of Limit		2.71E-02	1.51E-01	5.19E-01	3.17E-01	5.07E-01

Receptor Location **2.19 km S**
Critical Age **ADULT**
Critical Organ **GILLI**

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Shearon Harris Nuclear Power Plant Unit 1
 Period 1/1/2019 - 12/31/2019

40 CFR Part 190 Uranium Fuel Cycle Dose Calculation Results

In accordance with the requirements of 40 CFR Part 190, the annual dose commitment to any member of the general public shall be calculated to assure that doses are limited to 25 millirem to the total body or any organ with the exception of the thyroid which is limited to 75 millirem. The fuel cycle dose assessment for Shearon Harris Nuclear Power Plant includes liquid and gaseous effluent dose contributions from the plant. Direct and air-scatter dose from the reactor building and other onsite structures does not contribute measurable dose to the maximum exposed individual based on review of the 2019 environmental TLD data. No other uranium fuel cycle facility contributes significantly to the maximum exposed individual. Included below is an estimate of the dose contributed by Carbon-14 (Ref. Attachment 2, Supplemental Information, of this report for further information). Also included is dose from H-3 in the Shearon Harris Nuclear Power Plant Cooling Tower plume, evaporation of H-3 in Harris Lake, H-3 in on-site drinking water, and H-3 in fish from Harris Lake. The combined dose to a maximum exposed individual from effluent releases, combined with the additional dose pathways, is below 40 CFR Part 190 limits as shown by the following summary.

Note: The 40 CFR Part 190 effluent dose analysis to the maximum exposed individual from liquid and gas releases does not include the dose from noble gases (i.e., total body and skin) due to the low significance compared to other dose pathways.

40 CFR Part 190 Effluent Dose Summary																																																																							
<p>A. Gaseous Effluent Dose</p> <table style="width: 100%; border: none;"> <tr><td style="padding-left: 20px;">1. Location</td><td style="padding-left: 20px;">2.14 km SW</td></tr> <tr><td style="padding-left: 20px;">2. Critical Age</td><td style="padding-left: 20px;">CHILD</td></tr> <tr><td style="padding-left: 20px;">3. Critical Organ</td><td style="padding-left: 20px;">Thyroid</td></tr> <tr><td style="padding-left: 20px;">4. Organ Dose (mREM)</td><td style="padding-left: 20px;">2.80E-01</td></tr> <tr><td style="padding-left: 20px;">5. Total Body Dose (mREM)</td><td style="padding-left: 20px;">2.80E-01</td></tr> </table> <p>B. Liquid Effluent Dose</p> <table style="width: 100%; border: none;"> <tr><td style="padding-left: 20px;">1. Location</td><td style="padding-left: 20px;">2.19 km S</td></tr> <tr><td style="padding-left: 20px;">2. Critical Age</td><td style="padding-left: 20px;">ADULT</td></tr> <tr><td style="padding-left: 20px;">3. Critical Organ</td><td style="padding-left: 20px;">GI-LLI</td></tr> <tr><td style="padding-left: 20px;">4. Organ Dose (mREM)</td><td style="padding-left: 20px;">1.91E-02</td></tr> <tr><td style="padding-left: 20px;">5. Total Body Dose (mREM)</td><td style="padding-left: 20px;">1.52E-02</td></tr> </table> <p>C. Carbon-14 Dose</p> <table style="width: 100%; border: none;"> <tr><td style="padding-left: 20px;">1. Location</td><td style="padding-left: 20px;">2.91 km NNE</td></tr> <tr><td style="padding-left: 20px;">2. Critical Age</td><td style="padding-left: 20px;">CHILD</td></tr> <tr><td style="padding-left: 20px;">3. Critical Organ</td><td style="padding-left: 20px;">BONE</td></tr> <tr><td style="padding-left: 20px;">4. Organ Dose (mREM)</td><td style="padding-left: 20px;">2.27E-01</td></tr> <tr><td style="padding-left: 20px;">5. Total Body Dose (mREM)</td><td style="padding-left: 20px;">4.51E-02</td></tr> </table> <p>D. Cooling Tower Plume H-3 Dose</p> <table style="width: 100%; border: none;"> <tr><td style="padding-left: 20px;">1. Location</td><td style="padding-left: 20px;">2.91 km NNE</td></tr> <tr><td style="padding-left: 20px;">2. Critical Age</td><td style="padding-left: 20px;">CHILD</td></tr> <tr><td style="padding-left: 20px;">3. Critical Organ</td><td style="padding-left: 20px;">N/A</td></tr> <tr><td style="padding-left: 20px;">4. Organ Dose (mREM)</td><td style="padding-left: 20px;">2.31E-03</td></tr> <tr><td style="padding-left: 20px;">5. Total Body Dose (mREM)</td><td style="padding-left: 20px;">2.31E-03</td></tr> </table>	1. Location	2.14 km SW	2. Critical Age	CHILD	3. Critical Organ	Thyroid	4. Organ Dose (mREM)	2.80E-01	5. Total Body Dose (mREM)	2.80E-01	1. Location	2.19 km S	2. Critical Age	ADULT	3. Critical Organ	GI-LLI	4. Organ Dose (mREM)	1.91E-02	5. Total Body Dose (mREM)	1.52E-02	1. Location	2.91 km NNE	2. Critical Age	CHILD	3. Critical Organ	BONE	4. Organ Dose (mREM)	2.27E-01	5. Total Body Dose (mREM)	4.51E-02	1. Location	2.91 km NNE	2. Critical Age	CHILD	3. Critical Organ	N/A	4. Organ Dose (mREM)	2.31E-03	5. Total Body Dose (mREM)	2.31E-03	<p>E. Harris Lake Evaporation H-3 Dose</p> <table style="width: 100%; border: none;"> <tr><td style="padding-left: 20px;">1. Location</td><td style="padding-left: 20px;">6.65 km SSW</td></tr> <tr><td style="padding-left: 20px;">2. Critical Age</td><td style="padding-left: 20px;">CHILD</td></tr> <tr><td style="padding-left: 20px;">3. Critical Organ</td><td style="padding-left: 20px;">N/A</td></tr> <tr><td style="padding-left: 20px;">4. Organ Dose (mREM)</td><td style="padding-left: 20px;">5.22E-02</td></tr> <tr><td style="padding-left: 20px;">5. Total Body Dose (mREM)</td><td style="padding-left: 20px;">5.22E-02</td></tr> </table> <p>F. Drinking Water H-3 Dose</p> <table style="width: 100%; border: none;"> <tr><td style="padding-left: 20px;">1. 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Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

Total dose from liquid and gaseous effluents from Shearon Harris Nuclear Power Plant and the additional pathways mentioned above is conservatively estimated to be less than 2 mrem/yr for total body and organ. It is recognized summing dose for different organs and age groups is not entirely accurate. However, the sum of the organ and age specific doses will always be less than the sum of the maximums of each. Therefore, summing the maximum values of each provides the most conservative value to ensure compliance with 40 CFR 190. The dose from all pathways related to operation of Shearon Harris Nuclear Power Plant meets the 40 CFR Part 190 requirements of an annual dose commitment to any member of the general public of less than 25 mrem total body or any organ and 75 mrem to the thyroid.

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 7

Information to Support the NEI Ground Water Protection Initiative

This attachment includes a summary of voluntary reports made in accordance with the NEI Ground Water Protection Initiative and a summary of ground water well sample data.

**Attachment 7
Information to Support the NEI Ground Water Protection Initiative**

**Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019**

Samples were taken at various locations throughout the plant in support of the Groundwater Protection Initiative. Samples included Groundwater Monitoring Wells along the Cooling Tower Blowdown Line, Storm Drains, Vaults and Yard Drains that could potentially affect groundwater. None of the vaults, yard drains, or storm drains indicated plant related gamma emitters or tritium above the investigation limit. HNP Self Assessment (AR-0202000) determined Groundwater Monitoring location #76 did not meet the requirements for waterborne monitoring, so in September 2016 it was removed from the site's Radiological Environmental Monitoring Program (REMP). The well is located within the protected area and is not used as a source of drinking water or irrigation, thus is not a potential dose pathway. In addition, in June 2015 12 new groundwater monitoring wells were installed near the site's Waste Neutralization Basin. These wells are not listed in the ODCM or part of the REMF. The data for these wells are located below. Per NEI 07-07 the results of the Groundwater Monitoring Wells were included in the REMF and are not listed in this report but included in the AREOR.

Results from sampling during 2019 are shown in the table below.

Well #	Tritium Concentration (pCi/L)		# Samples
	1st Half of Yr	2nd Half of Yr	
76	315	443	2
HMW1S	363	221	2
HMW2S	<MDA	<MDA	2
HMW3S	<MDA	<MDA	2
HMW4D	<MDA	<MDA	2
HMW4S	<MDA	<MDA	2
HMW5S	-	<MDA	1
HMW6S	287	343	2
HMW7S	-	<MDA	1
HMW8S	-	<MDA	1
HMW9S	-	<MDA	1
HMW10S	-	<MDA	1
HMW11S	-	<MDA	1

NOTE: Minimum Detectable Activity (MDA) for monitoring wells is approximately
185 pCi/L

Zero (0) events meeting the criteria for voluntary notification per NEI 07-07, Industry Ground Water Protection Initiative, occurred at Shearon Harris Nuclear Power Plant in 2019.

**Attachment 8
Inoperable Equipment**

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 8

Inoperable Equipment

This attachment includes an explanation of inoperable instruments related to effluent monitoring in excess of allowed time defined by licensing bases and an explanation of temporary outside liquid storage tanks exceeding 10 Curies total activity (excluding tritium and dissolved or entrained noble gases).

Attachment 8 Inoperable Equipment

Shearon Harris Nuclear Power Plant Unit 1 Period 1/1/2019 - 12/31/2019

On March 10, 2019, REM-1WL-3540 (TL&HS Tank Effluent) was declared inoperable at 23:10 following a communication failure (NCR2261933) and OWP-RM-10 was implemented. All releases were suspended from the TL&HS system until restoration was achieved on April 08, 2019.

On June 13, 2019 at 0816 REM-21WL-3541, Waste Monitor Tank Discharge Effluent Rad Monitor was declared inoperable due to loss of communication (NCR 02277201). OWP-RM-010 was implemented, Rad Monitor was restored to operable state on August 02, 2019 at 00:34 following implementation of digital upgrade to plant radiation monitoring system.

On June 16, 2019 The HNP REMP drinking water sampler at location 51 (indicator location on HNP site) incurred a deviation to the normal monthly composite for scheduled collection period 13MAY2019 – 10JUN2019 due to a GFCI breaker trip during the composite period. The deviation for DW-51's composite sampler is part of the REMP program and the incurred deviation will be documented in the 2019 HNP AREOR. However, due to DW-51 sample data being utilized for calculating the drinking water dose provided in Attachment 2 of the 2019 HNP ARERR, this deviation is being captured in the ARERR as well.

On July 26, 2019 REM-21WS-3542, Secondary Waste Sample Tank Discharge Monitor, was declared inoperable due to sample pump not functioning properly (NCR 02283874). OWP-RM-11 implemented and restoration completed on September 04, 2019 at 1032.

On September 17, 2019 REM-21WS-3542, Secondary Waste Sample Tank Discharge Monitor, was declared inoperable due not maintaining sample flow (NCR 02292359) . OWP-RM-11 was implemented and restoration completed on October 10, 2019.

No unplanned or unmonitored releases occurred at Shearon Harris Nuclear Plant during 2019.

Shearon Harris Nuclear Power Plant did not experience temporary outside liquid storage tanks exceeding 10 Curies total activity (excluding tritium and dissolved or entrained noble gases) during 2019.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 9

Summary of Changes to the Offsite Dose Calculation Manual

This attachment includes a summary of changes to the ODCM.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

I. Description of Change

The ODCM was revised to incorporate programmatic changes to the site's Radiological Environmental Monitoring Program (REMP), administrative changes to the site's Effluent Management Program (EMS), and incorporate the changes associated with the infrastructure upgrade for the Distribution Instrumentation & Controls Systems Platform upgrade (EC 66216).

Programmatic Changes were as follows:

- Deletion of Air Samplers #1, #47 and TLDs #30 and #53
- Addition of new TLDs #130 and #153 and Groundwater Wells #84, #85, #86

Administrative Changes were as follows:

- Added liquid dose factors for Se-75, Sb-126, Sn-113, Sn-117m
- Added equations for the calculation of the post dilution concentration for liquid radwaste releases and the calculation of drinking water dose.

SHEARON HARRIS NUCLEAR POWER PLANT
OFF-SITE DOSE CALCULATION MANUAL

(ODCM)

Revision 28

Docket No. STN-50-400

DUKE ENERGY PROGRESS, Inc
Formerly known as Carolina Power & Light Company

Approval by ORC (PNSC) Chairman Brian C. M. U.

Approval by General Manager - Harris Plant [Signature]

Prepared by Heather Boyler

Reviewed by [Signature]

Effective Date 5/29/19

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ODCM REV. 28 CHANGE SUMMARY

Revision 28 to the ODCM is as follows:
 DRR's 578445, 2222275, 2235211, 2240429

Section	Page	Description
Table of Contents	i	Changed to "ODCM REV.28 CHANGE SUMMARY",
ODCM REV 28 CHANGE SUMMARY	v	Changed to reflect Rev. 28 revisions.
2.1.1 Batch Releases	2-6	Revised R_{wmax} as the "Liquid effluent tank discharge flow rate as specified in Table 2.1-1b" to clarify the actual pump. Added flow allocation factors for batch and continuous releases (DRR 2235211)
2.1.1 Batch Releases	2-7	Added equations 2.1-8 and 2.1-9 for Post Dilution Concentration to further clarify the concentration of radionuclides post dilution to show compliance with 10 CFR 20 limits in liquid release permits. (DRR 2235211)
Table 2.1-1a	2-21	Revised Table 2.1-1a to include tank capacity at overflow line based upon volumes in HNP FSAR.
Table 2.1-1b	2-21	Revised Table 2.1-1b to list liquid effluent release tanks volume and flow rate used for normal operations. These values were obtained from operations procedure OP-120.01.02 "Secondary Waste Sample Tank", OP-120.06.02 "Waste Evaporator Condensate Tanks", OP-120.09.03 "Radioactive Floor Drain Waste Monitor Tanks", OP-120.10.04 "Treated Laundry and Hot Shower Tanks". This also ensure that operations meet the minimum recirculation time needed for liquid effluent discharges (DRR 2235211)
Table 2.2-1	2-26 2-27	Included liquid dose factors for Se-75, Sb-126, Sn-113, Sn-117m. Reference CSD-RP-ALL-0028 (DRR 2222275)
Figure 3.1	3-63	As an infrastructure upgrade for the Distribution Instrumentation & Controls Systems Platform EC 66216 abandoned REM-1AV-3531 "RAB Normal Exhaust" because it was deemed to be non-critical to support plant operations. (DRR 578445)
Table 4.1	4-2	Delete Air Samplers #1 and #47 from the Radiological Environmental Monitoring Program. Self Assessment 2240431 showed that neither was located in the highest three DOQ sectors nor in vicinity of the community. (DRR 2240429)
Table 4.1	4-5	Deleted TLD #30 and #53 and added #130 and #153. Fleet Self Assessment 2202715 identified that TLD's #30 and #53 were not in the ideal locations. New TLD's #130 and #153 are in the same sectors as #30 and #53, respectively, but in better locations. (DRR 2240429)
Table 4.1	4-6 4-9	Deleted Note for Surface Water and Drinking Water "H-3 analysis is normally performed monthly". (DRR 2240429)
Table 4.1	4-8	Added new groundwater monitoring wells #84, #85, and #86 that we installed outside of the protected area and more representative of the groundwater close to the plant (AR 2173466)
Notes to Table 4.1	4-14	Note 6 - Changed equation reference 2.2-1 to 2.3-1. Equation 2.3-1 is the equation for calculating the drinking water dose that is used to determine if drinking water iodine analysis is required. Note 12 and 14 – Editorial revision to these notes
Table 4.2	4-15	Revised tables to incorporate new sample points #84, #85, #86, #130, #153 and delete air sample locations #1 and #47 and TLD #30 and #53
Table 4.3	4-16	
Figure 4.1-2	4-18	Revised tables to incorporate new sample points #84, #85, #86, #130, #153 and delete air sample locations #1 and #47 and TLD #30 and #53
Figure 4.1-3	4-19	
7.0	7-1	Added reference to ORC after PNSC, because name of meeting has changed from Plant Nuclear Safety Committee to On-site Review Committee.
F.3	F-4	

1.0 INTRODUCTION

The Off-Site Dose Calculation Manual (ODCM) provides the information and methodologies to be used by Shearon Harris Nuclear Power Plant (SHNPP) to ensure compliance with Operational Requirements 3.3.3.10, 3.3.3.11, 3/4.11.1, 3/4.11.2, 3/4.11.4, 4.12.1, 4.12.2, and 4.12.3 and reporting requirements in Appendix F of the ODCM. These operational requirements are those related to normal liquid and gaseous radiological effluents, environmental monitoring, and reporting. They are intended to show compliance with 10CFR20-based requirements, 10CFR50.36a, Appendix I of 10CFR50, and 40CFR190 in terms of appropriate monitoring instrumentation, setpoints, dose rate, and cumulative dose limitations. Off-site dose estimates from non-routine releases will be included in the cumulative dose estimates for the plant to comply with Appendix I of 10CFR50.

The ODCM is based on "Westinghouse Standard Technical Specifications" (NUREG 1301), "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants" (NUREG 0133), and guidance from the United States Nuclear Regulatory Commission (NRC). Specific plant and Nuclear Generation Group (NGG) procedures implement the ODCM program requirements.

The ODCM has been prepared as generically as possible in order to minimize the need for future revisions. However, some changes to the ODCM are expected in the future. Any such changes will be properly reviewed and approved as indicated in Administrative Controls Section 6.14 of the SHNPP Technical Specifications.

The assessment of annual radiation doses to members of the public from radioactive liquid and gaseous effluents from the plant is estimated using the methodology in the ODCM for the report period. These off-site dose estimates for each calendar year are reported in the Annual Radioactive Effluent Release Report required by Appendix F of the ODCM.

2.0 LIQUID EFFLUENTS

Radioactive materials released in liquid effluents from SHNPP to unrestricted areas are required to demonstrate compliance with 10 CFR 50 Appendix I (ODCM Operational Requirement 3.11.1.2) and, on an annual average basis, be limited to the concentrations specified in 10 CFR 20, Appendix B, Table 2, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to $2E-4$ $\mu\text{Ci/ml}$ total activity. On an individual release basis, the release concentration for liquid effluents will be limited to ten times (10x) the concentrations specified in 10 CFR 20, Appendix B, Table 2, Column 2, Effluent Concentration (ODCM Operational Requirement 3.11.1.1). The liquid effluent release point is at the point of discharge from the Cooling Tower Blowdown Line into Harris Lake (see Figure 2.1-3 and T/S Figure 5.1-3).

Figure 2.1-1, Liquid Waste Processing Flow Diagram, and Figure 2.1-2 Liquid Effluent Flow Stream Diagram, show how effluents are processed and where they are released.

Effluent monitor identification numbers are provided in Appendix C. Liquid effluent dilution prior to release to Harris Lake is provided by the Cooling Tower Blowdown Line. Concurrent batch releases shall not occur at SHNPP.

The Secondary Waste Sample Tank (SWST) and the Normal Service Water (NSW) system have a low potential for radioactive effluent releases. These releases are checked by effluent monitors on the SWST (Figure 2.1-2) and the NSW lines (Figure 2.1-3).

The Turbine Building floor drains and the outside tank area drains (Figure 2.1-4) are monitored effluent lines with low probability of radioactive contamination.

The radioactive liquid waste sampling and analysis required for batch and continuous releases are found in Table 4.11-1 of the ODCM Operational Requirements.

The SHNPP ODCM uses the Canberra, Inc, Effluent Management System (OpenEMS) software for automating the necessary calculations and recordkeeping.

2.1 Compliance with 10 CFR 20

10 CFR 20.1301 requires that the total effective dose equivalent to individual members of the public will not exceed 0.1 rem (100 mrem) in a year.

10 CFR 20.1302 states that a licensee can show compliance with the annual dose limit of 20.1301 by demonstrating that the annual average concentration of radioactive material released in liquid effluents at the boundary of the unrestricted area does not exceed the values specified in 10 CFR 20, Appendix B, Table 2, Column 2.

ODCM Operational Requirement 3.11.1.1 states that, on an individual release basis, the concentration of radioactive material released in liquid effluents to unrestricted area shall be limited to 10 times the values specified in 10 CFR 20, Appendix B, Table 2, Column 2.

ODCM Operational Requirement 3.3.10 requires that radioactive effluent instrumentation have alarm/trip setpoints that will ensure that an alarm/trip will occur prior to exceeding 10 times the limits of ODCM Operational Requirement 3.11.1.1. for principal gamma emitters.

Liquid effluent monitors have two setpoints, the high alarm and the alert alarm. The high alarm setpoint, S_{max} , provides alarm and isolation if the radionuclide concentrations, when diluted, would approach the ODCM Operational Requirement limits for concentrations in unrestricted areas. Alert alarm setpoints, S_{alert} , are set at a fraction of the S_{max} to provide an early warning of the approach to ODCM Operational Requirement limits.

2.1.1 Batch Releases

Radioactive liquids are routinely released as batches from Treated Laundry and Hot Shower Tanks (TL&HST), Waste Evaporator Condensate Tank. Batch releases may also originate from the Secondary Waste Sample Tank (SWST) and Waste Monitor Tanks (WMT). These tanks are shown in Figures 2.1-1 and 2.1-2. Based on analysis of the tank contents, the tank release rate is adjusted, based on the Cooling Tower Blowdown Line flow rate, to dilute the tank activities to 50 percent of the allowable concentrations at the release point to Harris Lake.

The ODCM software calculates a nuclide specific response setpoint which is based on the sum of responses for each nuclide. The nuclide specific response setpoint equates all gamma-emitting nuclides to Cs-137, to which the monitor is calibrated.

If analysis of the batch sample indicates all gamma-emitting nuclides are < LLD, (as defined in ODCM Operational Requirement Table 4.11-1), the tank gamma activity, C_i , may be assumed to consist only of Cs-134. This nuclide has the lowest Effluent Concentration Limit (ECL) of any to be found in liquid effluents and provides a conservative basis for a monitor setpoint.

2.1.1 Batch Releases (continued)

1. Minimum Tank Mixing Time

Footnote 2 to ODCM Operational Requirement Table 4.11-1 requires that the method used to mix an isolated effluent tank prior to sampling and analysis be described.

Equation 2.1-1 below provides an acceptable method for ensuring a well mixed tank so that a representative sample can be taken for radioactivity or other appropriate analyses.

$$R = \frac{(V) (E) (N)}{(RR) (60)} \quad (2.1-1)$$

where:

R = Minimum allowable mixing time, hr

V = Tank capacity, gal

E = Educator factor

RR = Pump design recirculation flow rate, gpm

N = Number of tank volumes for turnover; this will be a minimum of two

60 = 60 min/hr

Table 2.1-1a lists the tank capacities, educator factors, and pump design recirculation flow rates for individual liquid effluent release tanks.

Table 2.1-1b lists actual operational tank capacities, educator factors, pump recirculation flows and pressures. These values are used by operations to ensure adequate mixing of two tank volumes.

The greater of the two minimum mixing times is used for determining time for obtaining a representative sample for release.

2.1.1 Batch Releases (continued)

2. Required Dilution Factor

ODCM Operational Requirement 3.11.1.1 requires that the sum of concentrations divided by ECL values must not exceed 10 for an individual release. Therefore:

$$\sum_i \frac{C_i}{ECL_i} \leq 10 \quad (2.1-2)$$

where:

C_i = the concentration of nuclide i to be released

ECL_i = the Effluent Concentration Limit for nuclide i from 10CFR20, Appendix B, Table 2, Column 2.

If the summation is greater than 10, dilution is required. The total required dilution factor, D_{req} , is the minimum acceptable dilution factor required to meet the limits of ODCM Operational Requirement 3.11.1.1, based on pre-release and composite analysis.

$$D_{req} = D_{req,g} + D_{req,ng} \quad (2.1-3)$$

where:

$D_{req,g}$ = Required dilution factor for gamma-emitters

$$= \frac{\sum_{i=g} \frac{C_i}{ECL_i}}{f \cdot R_{max}} \quad (2.1-4)$$

f = 0.5

= A safety factor to assure that the nuclide concentrations are 50% of the ODCM Operational Requirement limit at the point of discharge.

R_{max} = The maximum ECL ratio for the release point (normally set to 10).

2.1.1 Batch Releases (continued)

$D_{req,ng}$ = Required dilution factor for non-gamma-emitters

$$= \frac{\sum_{i=ng} \frac{C_i}{ECL_i}}{f \cdot R_{max}} + \frac{r}{f \cdot R_{max}} \quad (2.1-5)$$

and

f = 0.5

= A safety factor to assure that the nuclide concentrations are 50% of the ODCM Operational Requirement limit at the point of discharge.

r = 1

= the ratio of the maximum tritium concentration to the H-3 ECL, to take into account that tritium is potentially being released via the settling basin discharge to the cooling tower discharge line. The maximum tritium value is set to 1.0E-03, which is the H-3 ECL.

NOTE: site has a target limit of 2.0E-04 $\mu\text{Ci/ml}$.

R_{max} = The maximum ECL ratio for the release point (normally set to 10).

The sums include gamma-emitters (g) and non-gamma-emitters (ng), respectively.

The measured concentration of each gamma-emitting nuclide, including noble gases, is reported in $\mu\text{Ci/ml}$. If no gamma activity is detectable then an activity of 9E-07 $\mu\text{Ci/ml}$ of Cs-134 is assumed for setpoint calculations. The measured concentration of non-gamma emitters is determined by analysis of the liquid effluent or previous composite sample, and is reported in $\mu\text{Ci/ml}$.

2.1.1 Batch Releases (continued)

3. Maximum Waste Flow

For liquid releases, the maximum permissible waste flow rate for this release, W_{max} is the minimum of R_{cwmmax} and R_{wmax} ,

where

$$R_{cwmmax} = \frac{F_{avail} \cdot f_{alloc}}{D_{req}} \quad (2.1-6)$$

R_{wmax} = Liquid effluent tank discharge flow rate, as specified in Table 2.1-1b. This value is the same as F_{waste} .

and

F_{avail} = The available dilution flow is the minimum dilution stream flow (Cooling Tower Blowdown) that can be ensured for the period of the release. Since only one batch release occurs at a time out of a single discharge point, the flow is not corrected for other releases in progress, for any activity in the dilution stream, or reduced by a safety factor. The minimum dilution flow rate for each setting is shown in Table 2.1-2.

f_{alloc} = Fraction of the available dilution volume which may be assigned to a particular release to ensure discharge point limits are not exceeded by simultaneous radioactive liquid releases. The value of f_{alloc} is based on assumed operational considerations for simultaneous releases.

= 0.8 for a batch release and 0.2 for a continuous release.

4. Minimum Dilution Flow Rate

The Minimum Dilution Flow Rate (min_dflow) is the minimum Cooling Tower discharge flow necessary to dilute the release to less than ODCM Operational Requirement Limits.

If $D_{req} \leq 1$, the minimum dilution flow rate is set to 0.0. If $D_{req} > 1$, the minimum dilution flow rate is determined as follows:

$$min_dflow = \frac{F_{waste} \cdot D_{req}}{f_{alloc}} \quad (2.1-7)$$

where

F_{waste} = waste flow anticipated for this release

2.1.1 Batch Releases (continued)

5. Post Dilution Concentration

The post dilution concentration of a nuclide assumes that a fraction of the available dilution volume is unavailable due to simultaneous radioactive batch and continuous releases.

$$C_{post\ i} = \frac{C_i \times F_{waste}}{F_{avail} \times f_{alloc}} \quad (2.1-8)$$

where

$$C_{post\ i} = \text{dilution of nuclide } i \text{ by the dilution stream}$$

The sum of the post dilution concentrations divided by ECL values must not exceed 10 for an individual release.

$$\sum \frac{C_{post\ i}}{ECL_i} \leq 10 \quad (2.1-9)$$

6. Setpoint Calculations

The ODCM software calculates a nuclide specific response setpoint, which is based on the sum of responses for each nuclide. The setpoint equates all gamma-emitting nuclides to Cs-137, to which the monitor is calibrated. The setpoint is listed in terms of Cs-equiv and the units are $\mu\text{Ci/ml}$.

If analysis of the batch sample indicates all gamma-emitting nuclides are < LLD, (as defined in ODCM Operational Requirement Table 4.11-1), the tank gamma activity, C_i , may be assumed to consist only of Cs-134. This nuclide has the lowest ECL of any to be found in liquid effluents and provides a conservative basis for a monitor setpoint.

(1) Maximum setpoint value, based on Nuclide Specific Response

$$S_{max} \text{ (Cs-equiv)} = (S_{adj} \bullet R_{mon}) + B \quad (2.1-10)$$

where

$$S_{adj} = \text{Setpoint adjustment factor.}$$

$$= \frac{\frac{f_{alloc} \bullet F_{avail}}{F_{waste}} - D_{req,ng}}{D_{req,g}} \quad (2.1-11)$$

S_{adj} should always be greater than 1 to ensure that adequate dilution flow is available for the release.

$$B = \text{monitor background } (\mu\text{Ci/ml})$$

2.1.1 Batch Releases (continued)

$$R_{\text{mon}} = \sum \text{slope}_i \bullet C_i$$

where the sum extends over all nuclides which have response factors stored in the database for the monitor of interest

and

slope_i = the Liquid Effluent Monitor Gamma Sensitivities (from Table 2.1-4) for nuclide i, relative to Cs-137. To make nuclide i relative to Cs-137, the nuclide sensitivity is divided by the Cs-137 sensitivity.

$$= \frac{\text{Sensitivity (nuclide i)}}{\text{Cs-137 Sensitivity}}$$

(2) Monitor alert alarm setpoint, S_{alert} (Cs-equiv)

An Alert Alarm setpoint is calculated to provide an operator with adequate warning that the high alarm setpoint is being approached. S_{alert} is calculated from the nuclide specific response setpoint.

$$S_{\text{alert}} = [(S_{\text{max}} - B) \bullet F_x] + B \quad (2.1-12)$$

where:

F_x = A value <1.0 designed to provide an operator with adequate warning that the high alarm setpoint is being approached.

(3) Check for Excessive Monitor Background

In order to differentiate between the S_{alert} and the statistical fluctuations associated with a high monitor background, a check for excessive monitor background is made. As a check, verify that the minimum detectable concentration (MDC) for the monitor is less than 0.1 of the net S_{alert} ; therefore, background is acceptable if:

$$\text{MDC} \leq 0.1[(S_{\text{max}} - B) \bullet F_x] \quad (2.1-13)$$

where:

$$\text{MDC} = \frac{2 \sqrt{\frac{\text{Bkg}}{2\tau}}}{E_m} \quad (2.1-14)$$

where:

τ = Signal Processor Time constant, minutes. (Table 2.1-3)

Bkg = Background Count Rate, in cpm

$$= B / E_m$$

E_m = Monitor efficiency for the Cs-137 gamma energy, cpm/ $\mu\text{Ci/ml}$ determined by primary calibration.

If not, postpone the release and decontaminate or replace the sample chamber to reduce the background, then recalculate S_{max} and S_{alert} using the new, lower background.

2.1.1 Batch Releases (continued)

7. Post-Release Compliance

After the release is made, actual concentrations are used to check 10 CFR 20 limits, and the actual dilution flow and waste flow are used instead of the anticipated dilution flow and waste flow.

For batch releases, the duration is determined from the start and end dates and times of the release. This is used with the actual release volume to calculate the release rate.

2.1.2 Continuous Releases

The continuous releases from the SWST and the NSW return lines are monitored as shown in Figures 2.1-2 and 2.1-3. The function of these monitors, in contrast to the isolation function of batch release tank monitors, is to provide an indication of low levels of radioactivity in the effluent. The continuous effluent monitor setpoint is based on an assumed FSAR nuclide mix for the SWST (from Table 11.2.1-5 of the FSAR).

The software does not calculate continuous release setpoints.

1. Monitor High Alarm Setpoint, S_{max} ($\mu\text{Ci/ml}$).

$$S_{max} = \frac{0.1 (ECL_{eff} \bullet Sens_{eff}) + Bkg}{E_m} \quad (2.1-15)$$

where:

ECL_{eff} = Weighted Effluent Concentration Limit for the SWST nuclides listed in Table 11.2.1-5 of the FSAR.

$Sens_{eff}$ = $\sum_g (Sens_i \times \% \text{ abundance})$ for the SWST nuclide mix, $\text{cpm}/\mu\text{Ci/ml}$.

2. Monitor Alert Alarm Setpoint, S_{alert} (Cs-equiv)

$$S_{alert} = [(S_{max} - B) \bullet F_x] + B \quad (2.1-16)$$

When the monitor is operable and not in alarm, analysis of weekly composite samples is not required by ODCM Operational Requirement Table 4.11-1.

If the monitor is in alarm or the presence of non-naturally occurring radioactivity > effluent LLD is confirmed, the releases may continue provided the sampling and analysis required by ODCM Operational Requirement Table 4.11-1 are performed. The results of the sample analysis will be evaluated for compliance with ODCM Operational Requirement 3.11.1.1.

The monitor alarm setpoints may be recalculated using the methodology in Section 2.1.1 with the results of the gamma analysis and analyses of the composite sample.

3. Check for Excessive Monitor Background

Monitor background is considered excessive when the minimum detectable concentration (MDC) for the monitor is $>0.01 ECL_{eff}$. Therefore, background is acceptable if:

$$MDC \leq \frac{0.01 (ECL_{eff} \bullet Sens_{eff})}{E_m} \quad (2.1-17)$$

2.1.3 Other Liquid Releases

1. Outdoor Tank Area Drain Effluent Line

The outdoor tank area drain effluent line routes rain water collected in the outdoor tank area to the storm drain system and from there directly to the lake. The line is monitored for radioactivity by the Tank Area Drain Transfer Pump Monitor. Because no radioactivity is normally expected in this line, the monitor high alarm and alert alarm setpoints are determined using the methodology in Section 2.1.2. If the setpoint is exceeded, the discharge pump is automatically secured. Effluent can then be diverted to the floor drain system for processing and eventual release (see Figures 2.1-1 and 2.1-2).

2. Turbine Building Floor Drains Effluent Line

Water collected in the turbine building floor drains is normally routed to the yard oil separator for release to the environment via the waste neutralization system and then to the cooling tower discharge line. Tritium is expected to be detected in this pathway from sources such as background from the lake. Because no other radioactivity is normally expected in this path, the setpoints for the turbine building drain monitor are determined using the methodology in Section 2.1.2. Should the setpoint be exceeded, the release is automatically terminated. Effluent can then be diverted to the secondary waste treatment system for processing and eventual release (see Figures 2.1-1 and 2.1-2).

2.2 Compliance with 10 CFR 50 Appendix I

2.2.1 Cumulation of Doses

The dose contribution from each release of liquid effluents will be calculated and a cumulative summation of the total body and each organ dose will be maintained for each 31 days (monthly), each calendar quarter, and the year.

The dose is the total over all pathways which apply to that receptor. A receptor is defined by receptor ID, age group (infant, child, teen, or adult), sector, and distance from the plant.

The dose contribution for batch releases and all defined periods of continuous release received by receptor "r" from a released nuclide "i" will be calculated using the following equation:

$$D_{i\tau r} = A_{i\tau r} \cdot \sum \Delta t_s C_{is} F_{rs} \quad (2.2-1)$$

where:

$D_{i\tau r}$ = the cumulative dose or dose commitment to the total body or an organ " τ " by nuclide "i" for receptor "r" from the liquid effluents for the total time period of the release, in mrem.

$A_{i\tau r}$ = site-related ingestion dose or dose commitment factor for receptor "r" to the total body or organ " τ " for nuclide "i", in mrem/hr per $\mu\text{Ci/ml}$.

Δt_s = length of time period 's', over which the concentration and F value are averaged, for all liquid releases, in hours.

C_{is} = the average concentration of nuclide "i" in undiluted liquid effluent during time period Δt_s from any liquid release, in $\mu\text{Ci/ml}$.

F_{rs} = the near field average dilution factor for receptor "r" during any liquid effluent release

Where:

$$F_{rs} = \frac{F_{waste}}{F_{waste} + F_{avail}} \cdot R_{mix} \quad (2.2-2)$$

and

R_{mix} = mixing ratio

= fraction of the release that reaches the receptor. At the SHNPP, this value is set to 1.

Also, the sum extends over all time periods 's'.

In the case of a continuous secondary waste sample tank radioactive release, C_i = the concentration of nuclide "i" in the SWST composite sample. For the NSW, C_i = concentration of nuclide "i" in the cooling tower basin and F_{waste} = discharge from the cooling tower basin while F_{avail} = the flow from the makeup ater cross-tie. For a release through the Turbine Building Floor Drain Line to the waste neutralization system, C_i = the Turbine Building floor drain sample activity, F_{waste} = discharge from the Turbine Building floor drain line, and F_{avail} = the average flow during the period of the total Cooling Tower discharge. The total Cooling Tower discharge is the sum of the Cooling Tower Blowdown flow and the Cooling Tower Bypass Line flow.

When there is a primary-to-secondary leak, the change in concentration of tritium in the steam generators times the secondary loses (balance of plant), will be used for effluent accountability. The secondary loss rate will also be used for volume accountability.

The dose factor $A_{i\tau}$ (see NUREG-0133, Section 4.3.1) was calculated for an adult for each isotope "i" using the following equation:

$$A_{i\tau} = 1.14E + 05 \left(\frac{730}{D_w} + 21BF_i \right) DF_{i\tau} \cdot e^{-\lambda_i t_p} \quad (2.2-3)$$

where:

$A_{i\tau}$ = The ingestion dose commitment factor to the whole body or any organ " τ " for an adult for each nuclide "i". Corresponding to fish consumption from the Harris Lake (dilution = 1) and drinking water from Lillington (dilution = 13.95).
= Values for the adult total body and organs in mrem/hr per μ Ci/ml are given in Table 2.2-1.

1.14E+05 = Unit Conversion Factor

$$= \frac{10^6 \text{ pci}}{1 \text{ } \mu\text{Ci}} \cdot \frac{1000 \text{ ml}}{1 \text{ liter}} \cdot \frac{1 \text{ yr}}{8760 \text{ hrs}} \quad (2.2-4)$$

21 = Adult fish consumption rate (from Table E-5 of Regulatory Guide 1.109, Rev. 1), kg/yr;

730 = Adult water consumption rate (from Table E-5 of Regulatory Guide 1.109, Rev. 1), liters/yr.

D_w = Dilution factor for the drinking water pathway

= 13.95

BF_i = Bioaccumulation factor for nuclide "i" in fish (from Table A-1 of Regulatory Guide 1.109, Rev. 1), pCi/kg per pCi/l

$DF_{i\tau}$ = Dose conversion factor for nuclide "i" for adults for a particular organ τ (from Table E-11 of Regulatory Guide 1.109, Rev. 1), mrem/pCi

λ_i = Radiological decay constant of nuclide "i," hr^{-1} ;

$$= \frac{0.693}{(t_{1/2})_i}$$

$(t_{1/2})_i$ = Radiological half-life of nuclide "i," hr;

t_p = Average transport time to reach point of exposure, hr;

= 12 hours. The more limiting decay time for the drinking water and fish exposure pathways (Reg. Guide 1.109, Appendix A, Rev. 1).

Table 2.2-1 presents the $A_{i\tau}$ values for an adult receptor. Values of $e^{-\lambda_i t_p}$ are presented in Table 2.1-4 for each nuclide "i".

2.2.2 Comparison Against Limits

The sum of the cumulative dose from all batch and any continuous releases for a quarter is compared to one-half the design objectives for total body and any organ. The sum of the cumulative doses from all releases for a calendar year is compared to the design objective doses. The following relationships should hold for the SHNPP to show compliance with ODCM Operational Requirement 3.11.1.2.

For the calendar quarter:

$$D_{itr} \leq 1.5 \text{ mrem total body} \quad (2.2-5)$$

$$D_{itr} \leq 5 \text{ mrem any organ} \quad (2.2-6)$$

For the calendar year:

$$D_{itr} \leq 3 \text{ mrem total body} \quad (2.2-7)$$

$$D_{itr} \leq 10 \text{ mrem any organ} \quad (2.2-8)$$

where:

$$D_{itr} = \text{Cumulative total dose to any organ } t \text{ or the total body from all releases, mrem:}$$

The quarterly limits given above represent one-half the annual design objective of 10 CFR 50, Appendix I, Section II.A. If any of the limits in equations (2.2-5) through (2.2-8) are exceeded, a special report pursuant to SHNPP Technical Specification 6.9.2 must be filed with the NRC. This report complies with Section IV.A of Appendix I, 10 CFR 50.

The calculations described in Section 2.2.1 will be used to ensure compliance with the limits in 10 CFR 50 Appendix I for each release. Summation of doses for all releases for the quarter and year are compared to the limits in 10CFR50 Appendix I to ensure compliance.

The SHNPP ODCM uses a "modified" NUREG 0133 equation with conservative assumptions. It calculates the dose to a single maximum (ALARA) individual. The ALARA individual is an individual that consumes fish caught in the Harris Lake (dilution of 1.0) and receives their drinking water from Lillington, North Carolina (dilution 13.95).

After the release is made, the doses are compared to the 10CFR50 limits. The actual dilution flow and waste flow are used instead of the anticipated dilution flow and waste flow.

For batch releases, the duration is determined from the actual start and end dates and times of the release. This is used with the actual volume input to calculate the release rate. Each month the dilution volume is updated for times when no releases were being made in order to update the quarterly and yearly doses for comparison with the 10CFR50 Appendix I limits.

2.2.3 Projection of Doses

Dose projections for this section are required at least once per 31 days (monthly) in ODCM Operational Requirement 4.11.1.3.1 whenever the liquid radwaste treatment systems are not being fully utilized.

The doses will be calculated using Equation 2.2-1, and projected using the following expression:

$$D_{p\tau} = (D_{\tau} \cdot p) + D_{at} \quad (2.2-9)$$

where:

- $D_{p\tau}$ = the 31 Day Projected Dose by organ τ
- D_{τ} = sum of all open and closed release points from the start of the quarter to the end of the current release in mrem per organ τ .
- p = the Projection Factor which is the result of 31 divided by the number of days from start of the quarter to the end of the release.
- D_{at} = Additional Anticipated Dose for liquid releases by organ r and quarter of release.

NOTE: The 31 Day Projected Dose values appear on the Standard Permit Reports. The 31 day dose projections include any additional dose.

When possible, expected operational evolutions (i.e., outages, increased power levels, major planned liquid releases, etc.) should be accounted for in the dose projections. This may be accomplished by using the source-term data from similar historical operating experiences where practical, and adding the dose as Additional Anticipated Dose.

To show compliance with ODCM Operational Requirement 3.11.1.3, the projected 31 day dose should be compared to the following limits:

$$D_{p\tau} \leq 0.06 \text{ mrem for total body} \quad (2.2-10)$$

and

$$D_{p\tau} \leq 0.2 \text{ mrem for any organ} \quad (2.2-11)$$

If the projections exceed either Expressions 2.3-2 or 2.3-3, then the appropriate portions of the liquid radwaste treatment system shall be used to reduce releases of radioactivity.

2.3 Doses from Return/Re-use of Previously Discharged Radioactive Effluents

Known Potential Pathways from Return/Re-use of Previously Discharge Effluents

The dose contribution from return/re-use of previously radioactive effluents (tritium from the lake) should be calculated at the end of each year. If the dose from the particular pathway is greater than 10 percent of the total dose from all pathways from plant releases (liquid, gaseous, iodines particulates > 8 day half life's & tritium from gaseous releases) the dose from the return of previously discharged effluents is to be reported in annual effluent report. The total body, each organ, and each age group if applicable the dose should be calculated at the end of year unless it is known to be less than 10 percent of all doses.

The current potential pathways are evaporation from the cooling tower, dose to the county fire training personnel & HE&EC Training center that is being used of offsite personnel, the dose to the nearest resident to the lake from lake evaporation, and the consumption of fish from Harris Lake.

2.3.1 The dose from drinking water to the worker at the Wake County Fire Training Center and/or HE&EC Training Center are to be calculated as follows:

Worker Drinking Water Pathway –

$$R_{apj} = U_{ap} * D_{apj} * C_{ip} \quad (2.3-1)$$

Where;

R_{apj} = Annual dose to organ j of individual of age group (adult in this case) from tritium in p pathway (ingestion), mrem/yr

U_{ap} = Usage term, 730 liters/year per Reg. 1.109 based on 50 weeks/year, this equals 14.6 liters/week or 2.085 liters/day. Half of the water is consumed at work 1.042 liters/day times 5 work days/week times 50 weeks /year equals 261 liters/year of drinking water from HNP.

C_{ip} = Concentration (picoCurie/liter) of drinking water obtained from the annual average monthly composite from DW-51

D_{api} = Dose factor specific to age group (adult in this case), for nuclide i (H-3 in this case) in units of mrem/picoCurie, 1.05E-07 mrem/pCi for total body & all organs with the exception of bone which has no dose

$$R_{apj} = (261 \text{ liters/yr}) * (1.05E-07 \text{ mrem/pCi}) * (\text{concentration pCi/L from DW-51})$$

2.3.2 Tritium dose to the nearest resident from the Cooling Tower (CT)Plume.
 The dose from inhalation to the nearest resident from the cooling tower plume is calculated by the following meteorology for the current year (using the elevated mode of release), the monthly composite tritium analysis from the cooling tower blowdown, and the evaporation rate from the top of the cooling tower.

The dose from Cooling Tower Plume can be calculated as follows:

$$D_{Ttr} = (3.17E - 08) * (R_{Ttr}) * (X/Q_{EIV}) \sum Q_{VT} \quad (2.3-2)$$

where:

D_{Ttr} = the cumulative dose or dose commitment to the total body or an organ "r" by Tritium for receptor "r" from the CT Plume for the total time period of the release, in mrem.

3.17 E-08 = The inverse of the number of seconds in a year (sec/year)⁻¹

R_{Ttr} = Dose factor for an organ "r" for the tritium from the inhalation pathway in mrem/hr per μ Ci/ml.

X/Q_{EIV} = The highest elevated calculated annual average relative concentration for the nearest resident from the Cooling Tower (sec/m³).

Q_{VT} = $E_{vr} * \Delta t_s * C_{TBD} * q_t$
 The total tritium (μ Ci) released from the top of the Cooling Tower.

where:

E_{vr} = the average evaporation rate from top of the Cooling Tower (C_{TBD})* (3785 ml/gal) = ml/min.

C_{TBD} = Average Cooling Tower Blowdown flow rate (gpm)

Δt_s = length of time period 's', over which the monthly tritium concentration value for Cooling Tower Tritium is used (number of days) * (1440 min/day) = minutes

q_t = Tritium concentration in Cooling Tower Blowdown for the time period (μ Ci/ml).

2.3.3 Tritium dose to the nearest lake resident from lake evaporation.

The dose from inhalation to the nearest resident to the lake from lake evaporation is calculated by the meteorology for the current year (using the ground level mode of release), the monthly composite tritium analysis from Harris lake Spillway, and the evaporation rate from the lake.

1. Release Calculation from Evaporation:

Three methods are used to calculate monthly lake evaporation to the environment from the reservoir.

- a. Analytical Method: Calculation of monthly evaporation using an empirical analytical formula developed by Meyer (1905) based on Dalton's Law.

$$E_v = C * (E_s - E_d) * (1 + U_{25}/10) \quad (2.3-3)$$

Where:

- E_v = evaporation from a lake or pond in inches per month times 25.4 mm/inch times meter/1000mm equals meters of evaporation
- C = Coefficient that equals 11 for small lakes and reservoirs 15 for shallow ponds (for Harris Lake use 11)
- E_s = saturation vapor pressure (inches of Hg) of air at the water temperature (1 foot deep)
- E_d = actual vapor pressure (inches of Hg) of air, equals to $E_s * \text{Relative Humidity (RH)}$ in fraction
- U_{25} = average wind velocity (miles/hr) at a height of 25 feet above the lake or surrounding areas

- b. Derive the average evaporation rate from historical data.

Monthly historical evaporation data are available for the Chapel Hill station.

- c. When available, use the monthly published evaporation rates by the State Climate Office of North Carolina.

Calculate the average evaporation rate from the above three methods (if data is obtainable from all three) for each month.

2. Yearly Calculation of Tritium Release from Lake (μCi)

$$Q_T = \sum (L_{\text{area}} * E_{\text{ave}} * (L_{\text{TConc}} * 1\text{E-}09)) \quad (2.3-4)$$

Where:

- Q_T = Yearly Tritium Release from Lake (Ci)
- L_{area} = Lake area, 4169.61 acres which equals 1.687E+07 square meters
- E_{ave} = evaporation from a lake or pond in inches per month times 25.4 mm/inch times meter/1000mm equals meters of evaporation
- L_{TConc} = Monthly lake Tritium concentration from SW-26, pCi/l
- $1\text{E-}09$ = $\text{Ci}/1.0\text{E}12 \text{ pCi} * \text{liter}/1000 \text{ cm}^3 * 100 \text{ cm}/\text{meter} * 100 \text{ cm}/\text{meter} * 100 \text{ cm}/\text{meter} = \text{Curies}/\text{meter}^3$

3. Lake Harris total surface area is 4169.61 acres. Being a large body of water the lake was divided into thirteen sections for analysis using Auto CAD Engineering Software. The area of each section and its centroid location were calculated (see Figure 2.3-1) and the following list for the respective section areas. The distances from the centroid to each nearest resident and its downwind sector are now established.

Lake Sect.	Area Acres	Area m ²
1	316.40	1.280E+06
2	276.55	1.119E+06
3	156.32	6.326E+05
4	220.74	8.933E+05
5	230.05	9.310E+05
6	388.74	1.573E+06
7	392.03	1.587E+06
8	579.23	2.344E+06
9	426.97	1.728E+06
10	429.05	1.736E+06
11	316.52	1.281E+06
12	193.90	7.847E+05
13	243.10	9.838E+05
Total	4169.61	1.687E+07

The impact of each lake section are be calculated and then summed to determine the impact of the point of interest. The tritium concentration from each section of the lake to the point of interest for all points of interest is calculated as follows:

$$q_{Tsect} = \sum (Q_T * X/Q * 3.17E+04) \quad (2.3-5)$$

Where:

q_{Tsect} = Total tritium concentration from the thirteen lake sections at point of interest (X,pCi/m³)

Q_T = Yearly Tritium Release from Lake Section, (Ci/yr)

X/Q = The relative concentration at the point of interest from lake section X, (sec/m³)

3.17E+04 = Conversion factor, (1.0E+12 pCi/Ci)/(8760 hr/yr)*(3600 sec/hr)

The dose for each age group at each point of interest is to be calculated as follows:

$$\text{Dose}_{a,\text{poi}} = (q_{\text{Tsect}}) * (\text{DFA})_a * (\text{BR})_a \quad (2.3-6)$$

Where:

$\text{Dose}_{a,\text{poi}}$ = Total tritium dose for age group (a) at point of interest (mrem) for the year

q_{Tsect} = Total tritium concentration from the thirteen lake sections at point of interest (pCi/m³)

$(\text{DFA})_a$ = Organ inhalation factor for tritium at the point of interest of age group "a" (mrem/pCi), for tritium the dose factor is same for the liver, total body, thyroid, kidney, lung, and Gi-LLi (no bone dose). Infant = 4.62 E-07, Child = 3.04 E-07, Teen = 1.59 E-07, and Adult 1.58 E-07, mrem/pCi.

$(\text{BR})_a$ = Breathing rate of age group "a" (m³/yr), Infant = 1400, Child = 3700, Teen = 8000, and Adult = 8000 m³/yr

- 2.3.4 The dose from the consumption of fish from Harris Lake. The concentration of tritium in fish is directly related to the concentration of tritium in the water. Equilibrium ratios between the concentration of tritium in the water and concentration of tritium in the flesh is based upon the bioaccumulation factor for tritium. Because the adult age group will always have the maximum dose from fish consumption, adult is only age group considered.

Fish consumption Dose –

$$R_{\text{apj}} = U_{\text{ap}} * D_{\text{apj}} * C_{\text{ip}} * \text{BF}_i \quad (2.3-7)$$

Where;

R_{apj} = Annual dose to organ j of individual of age group (adult in this case) from tritium in p pathway (ingestion), mrem/yr

U_{ap} = Usage term, 21 kg/yr per Reg. Guide 1.109 Table E-11 for an adult

C_{ip} = Concentration (pCi/L) of drinking water obtained from the annual average monthly composite from SW-26

D_{api} = Dose factor specific to age group (adult in this case), for nuclide i (H-3 in this case) in units of mrem/pCi, 1.05E-07 mrem/pCi for total body & all organs with the exception of bone which is no dose

BF_i = Bioaccumulation factor for nuclide "i" in fish (from Table A-1 of Regulatory Guide 1.109, Rev. 1), pCi/kg per pCi/l, 0.90 pCi/kg per pCi/L

TABLE 2.1-1a

LIQUID EFFLUENT RELEASE TANKS AND PUMPS DESIGN BASIS ⁽¹⁾

Tank ⁽²⁾	No. of Tanks	PUMP DESIGN CAPACITY (gpm)		Eductor Factor	Tank Design Capacity (gal)	Tank Capacity @ Overflow Line (gal)	Radiation Effluent Monitor ID
		Discharge	Recirculation				
SWST	1	100	100	0.2	25,000	23,922	REM-3542
WECT	2	35	100	1.0	10,000	9,649	REM-3541
WMT	2	35 ⁽³⁾	100	0.25	25,000	24,135	REM-3541
TL&HS	2	100	100	0.25	25,000	24,261	REM-3540

¹ Reference SHNPP FSAR Tables 11.5.1-1 and 11.2.1-7

² SWST: Secondary Waste Sample Tank
WECT: Waste Evaporator Condensate Tank
WMT: Waste Monitor Tank
TL&HS: Treated Laundry and Hot Shower Tank

³ Waste Monitor Tanks pump capacity is increased to 100 gpm when the waste monitor tanks are used as an alternate secondary waste sample tank

TABLE 2.1-1b

LIQUID EFFLUENT RELEASE TANKS AND PUMPS FOR NORMAL OPERATIONS ⁽⁴⁾

Tank ⁽²⁾	No. of Tanks	PUMP CAPACITY			Eductor Factor	Operational Tank Capacity (gal)	Radiation Effluent Monitor ID
		Discharge (gpm)	Recirculation (gpm)	Pressure (psig)			
SWST	1	100	80	≤71	0.2	24,093	REM-3542
WECT	2	35	35	≤110	1.0	9,588	REM-3541
WMT ⁽³⁾	2	35	80	≤101	0.25	24,112	REM-3541
TL&HS	2	35	80	≤91	0.25	24,241	REM-3540

⁴ Typical values used for normal operations.

The settling basin has two pumps. When one pump is running, the design flow rate is 500 gpm. When both pumps are running, the design flow rate is 800 gpm.

TABLE 2.1-2

Setpoints for Cooling Tower Blowdown Dilution Flow Rates (F_{avail})

Setting	Trip Flow Rate (gpm)	Minimum Dilution Flow Rate (gpm)
1	4,000 ± 5%	3,800
2	7,000 ± 5%	6,650
3	11,000 ± 5%	10,450
4	15,000 ± 5%	14,250

TABLE 2.1-3

Signal Processor Time Constants (τ) for GA Technologies
 RD-53 Liquid Effluent Monitors

Detector Background (cpm)	τ (min)
$10^1 - 10^2$	10
$10^2 - 10^3$	10^3 /cpm bkg
$10^3 - 10^4$	10^3 /cpm bkg
$10^4 - 10^5$	10^3 /cpm bkg
$10^5 - 10^6$	0.01
$10^6 - 10^7$	0.01

TABLE 2.1-4

Nuclide Parameters

Nuclide	Half-Life (hr)	λ (hr ⁻¹)	$e^{-\lambda t}$	Sensitivity (cpm/ μ Ci/ml)	Slope	Sensitivity TB Bldg. Drain Only (cpm/ μ Ci/ml)
H-3	1.08E+05	6.44E-06	1.00E+00	0.00E+00	0.00E+00	0.00E+00
C-14	5.02E+07	1.38E-08	1.00E+00	0.00E+00	0.00E+00	0.00E+00
F-18	1.83E+00	3.78E-01	1.07E-02	0.00E+00	0.00E+00	7.78E+07
Na-24	1.50E+01	4.62E-02	5.74E-01	9.36E+07	9.00E-01	9.11E+07
P-32	3.43E+02	2.02E-03	9.76E-01	0.00E+00	0.00E+00	0.00E+00
Cr-51	6.65E+02	1.04E-03	9.88E-01	1.61E+07	1.55E-01	2.79E+06
Mn-54	7.50E+03	9.24E-05	9.99E-01	1.03E+08	9.90E-01	4.45E+07
Mn-56	2.58E+00	2.68E-01	4.00E-02	1.01E+08	9.71E-01	6.41E+07
Fe-55	2.37E+04	2.93E-05	1.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-59	1.07E+03	6.47E-04	9.92E-01	1.26E+08	1.21E+00	4.58E+07
Co-57	6.50E+03	1.07E-04	9.99E-01	0.00E+00	0.00E+00	5.82E+06
Co-58	1.70E+03	4.08E-04	9.95E-01	1.46E+08	1.40E+00	5.68E+07
Co-60	4.62E+04	1.50E-05	1.00E+00	1.89E+08	1.82E+00	9.07E+07
Ni-63	8.78E+05	7.89E-07	1.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-65	2.52E+00	2.75E-01	3.67E-02	2.24E+07	2.15E-01	1.96E+07
Cu-64	1.27E+01	5.46E-02	5.19E-01	5.16E+07	4.96E-01	1.46E+07
Zn-65	5.87E+03	1.18E-04	9.99E-01	5.24E+07	5.04E-01	2.41E+07
Zn-69	9.27E-01	7.48E-01	1.26E-04	2.22E+03	2.13E-05	5.00E+02
Zn-69m	1.38E+01	5.03E-02	5.47E-01	0.00E+00	0.00E+00	3.52E+07
Br-82	3.53E+01	1.96E-02	7.90E-01	0.00E+00	0.00E+00	1.43E+08
Br-83	2.38E+00	2.91E-01	3.05E-02	1.95E+06	1.88E-02	5.74E+05
Br-84	5.30E-01	1.31E+00	1.53E-07	6.50E+07	6.25E-01	5.06E+07
Br-85	4.78E-02	1.45E+01	3.02E-76	6.76E+06	6.50E-02	3.21E+06
Rb-86	4.48E+02	1.55E-03	9.82E-01	8.39E+06	8.07E-02	3.96E+06
Rb-88	2.97E-01	2.34E+00	6.66E-13	1.45E+07	1.39E-01	1.83E+07
Rb-89	2.57E-01	2.70E+00	8.43E-15	1.22E+08	1.17E+00	7.00E+07
Sr-89	1.21E+03	5.71E-04	9.93E-01	1.46E+04	1.40E-04	6.72E+03
Sr-90	2.50E+05	2.77E-06	1.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-91	9.50E+00	7.30E-02	4.17E-01	8.16E+07	7.85E-01	3.48E+07
Sr-92	2.72E+00	2.55E-01	4.68E-02	1.01E+08	9.71E-01	4.61E+07
Y-90	6.42E+01	1.08E-02	8.78E-01	0.00E+00	0.00E+00	0.00E+00
Y-91	1.41E+03	4.93E-04	9.94E-01	2.83E+05	2.72E-03	1.36E+05
Y-91m	8.28E-01	8.37E-01	4.36E-05	1.28E+08	1.23E+00	3.96E+07
Y-92	3.53E+00	1.96E-01	9.50E-02	2.76E+07	2.65E-01	1.17E+07
Y-93	1.01E+01	6.86E-02	4.39E-01	1.37E+07	1.32E-01	3.96E+06
Zr-95	1.54E+03	4.51E-04	9.95E-01	1.07E+08	1.03E+00	4.35E+07
Zr-97	1.68E+01	4.12E-02	6.10E-1	2.68E+07	2.58E-01	9.16E+06
Nb-95	8.42E+02	8.24E-04	9.90E-01	1.06E+08	1.02E+00	4.41E+07
Nb-97	1.20E+00	5.771E-01	9.86E-04	0.00E+00	0.00E+00	4.33E+07
Mo-99	6.60E+01	1.05E-02	8.82E-01	3.47E+07	3.34E-01	9.38E+06
Tc-99m	6.02E+00	1.15E-01	2.51E-01	1.11E+08	1.07E+00	7.33E+06

TABLE 2.1-4

Nuclide Parameters
 (continued)

Nuclide	Half-Life (hr)	λ (hr ⁻¹)	$e^{-\lambda t}$	Sensitivity (cpm/ μ Ci/ml)	Slope	Sensitivity TB Bldg. Drain Only (cpm/ μ Ci/ml)
Tc-101	2.37E-01	2.93E+00	5.45E-16	1.66E+08	1.60E+00	2.92E+07
Ru-103	9.45E+02	7.33E-04	9.91E-01	1.38E+08	1.33E+00	3.83E+07
Ru-105	4.43E+00	1.56E-01	1.53E-01	1.71E+08	1.64E+00	5.21E+07
Ru-106	8.83E+03	7.85E-05	9.99E-01	4.52E+07	4.35E-01	1.43E+07
Ag-110m	6.00E+03	1.16E-04	9.99E-01	3.22E+08	3.10E+00	1.41E+08
Sn-113	2.76E+03	2.51E-04	9.97E-01	3.08E+06	2.96E-02	4.28E+05
Sb-124	1.45E+03	4.80E-04	9.94E-01	1.59E+08	1.53E+00	8.31E+07
Sb-125	2.43E+04	2.85E-05	1.00E+00	1.21E+08	1.16E+00	3.20E+07
Te-125m	1.39E+03	4.98E-04	9.94E-01	3.00E+05	2.88E-03	1.17E+04
Te-127m	2.62E+03	2.65E-04	9.97E-01	1.33E+04	1.28E-04	6.29E+03
Te-127	9.35E+00	7.41E-02	4.11E-01	1.97E+06	1.89E-02	4.14E+05
Te-129m	8.07E+02	8.59E-04	9.90E-01	5.17E+06	4.97E-02	1.95E+06
Te-129	1.16E+00	5.98E-01	7.69E-04	1.58E+07	1.52E-01	4.02E+06
Te-131m	3.00E+01	2.31E-02	7.58E-01	2.17E+08	2.09E+00	7.37E+07
Te-131	4.17E-01	1.66E+00	2.14E-09	1.50E+08	1.44E+00	2.58E+07
Te-132	7.82E+01	8.87E-03	8.99E-01	1.39E+08	1.34E+00	1.69E+07
I-130	1.24E+01	5.60E-02	5.10E-01	4.13E+08	3.97E+00	1.41E+08
I-131	1.93E+02	3.59E-03	9.58E-01	1.55E+08	1.49E+00	3.21E+07
I-132	2.30E+00	3.01E-01	2.69E-02	3.31E+08	3.18E+00	1.30E+08
I-133	2.08E+01	3.33E-02	6.71E-01	1.39E+08	1.34E+00	4.28E+07
I-134	8.77E-01	7.91E-01	7.58E-05	3.08E+08	2.96E+00	1.31E+08
I-135	6.62E+00	1.05E-01	2.84E-01	1.03E+08	9.90E-01	5.82E+07
Cs-134	1.80E+04	3.85E-05	1.00E+00	2.60E+08	2.50E+00	9.68E+07
Cs-136	3.17E+02	2.19E-03	9.74E-01	3.37E+08	3.24E+00	1.11E+08
Cs-137	2.65E+05	2.62E-06	1.00E+00	1.04E+08	1.00E+00	3.90E+07
Cs-138	5.37E-01	1.29E+00	1.86E-07	1.15E+08	1.11E+00	8.43E+07
Ba-139	1.39E+00	5.00E-01	2.46E-03	2.34E+07	2.25E-01	2.17E+06
Ba-140	3.07E+02	2.26E-03	9.73E-01	6.01E+07	5.78E-01	1.45E+07
Ba-141	3.05E-01	2.27E+00	1.43E-12	2.53E+08	2.43E+00	5.42E+07
Ba-142	1.78E-01	3.89E+00	5.54E-21	1.47E+08	1.41E+00	4.44E+07
La-140	4.02E+01	1.73E-02	8.13E-01	1.53E+08	1.47E+00	9.06E+07
La-142	1.59E+00	4.36E-01	5.35E-03	9.59E+07	9.22E-01	7.75E+07
Ce-141	7.80E+02	8.89E-04	9.89E-01	6.11E+07	5.88E-01	4.29E+06
Ce-143	3.30E+01	2.10E-02	7.77E-01	9.60E+07	9.23E-01	1.90E+07
Ce-144	6.82E+03	1.02E-04	9.99E-01	1.30E+07	1.25E-01	7.96E+05
Pr-143	3.25E+02	2.13E-03	9.75E-01	1.08E+02	1.04E-06	5.27E-01
Pr-144	2.88E-01	2.40E+00	2.96E-13	1.68E+06	1.62E-02	1.14E+06
Nd-147	2.63E+02	2.63E-03	9.69E-01	2.86E+07	2.75E-01	8.08E+06
Hf-181	1.02E+03	6.80E-04	9.92E-01	2.08E+08	2.00E+00	4.14E+07
W-187	2.38E+01	2.91E-02	7.05E-01	1.04E+08	1.00E+00	3.09E+07
Np-239	5.65E+01	1.23E-02	8.63E-01	1.13E+08	1.09E+00	1.01E+07

TABLE 2.1-4

Nuclide Parameters
 (continued)

Nuclide	Half-Life (hr)	λ (hr ⁻¹)	$e^{-\lambda t}$	Sensitivity (cpm/ μ Ci/ml)	Slope	Sensitivity TB Bldg. Drain Only (cpm/ μ Ci/ml)
Ar-41	1.83E+00	3.78E-01	1.07E-02	9.28E+07	8.92E-01	4.51E+07
Kr-83m	1.83E+00	3.78E-01	1.07E-02	0.00E+00	0.00E+00	0.00E+00
Kr-85	9.40E+04	7.37E-06	1.00E+00	6.20E+05	5.96E-03	1.75E+05
Kr-85m	4.48E+00	1.55E-01	1.56E-01	1.20E+08	1.15E+00	1.12E+07
Kr-87	1.27E+00	5.45E-01	1.44E-03	9.19E+07	8.84E-01	3.22E+07
Kr-88	2.83E+00	2.45E-01	5.31E-02	7.49E+07	7.20E-01	5.19E+07
Kr-89	5.27E-02	1.32E+01	2.58E-69	1.39E+08	1.34E+00	6.52E+07
Kr-90	8.95E-03	7.72E+01	0.00E+00	1.59E+08	1.53E+00	5.43E+07
Xe-131m	2.85E+02	2.45E-03	9.71E-01	2.62E+06	2.52E-02	2.21E+05
Xe-133	1.23E+02	5.51E-03	9.36E-01	9.90E+04	9.52E-04	9.33E+03
Xe-133m	5.25E+01	1.32E-02	8.53E-01	1.59E+07	1.53E-01	2.02E+06
Xe-135	9.12E+00	7.60E-02	4.02E-01	1.47E+08	1.41E+00	2.10E+07
Xe-135m	2.57E-01	2.70E+00	8.43E-15	1.14E+08	1.10E+00	3.30E+07
Xe-137	6.38E-02	1.09E+01	2.57E-57	4.85E+07	4.66E-01	1.32E+07
Xe-138	2.35E-01	2.95E+00	4.25E-16	1.20E+08	1.15E+00	4.25E+07

Notes to Table 2.1-4

Sensitivity = 80% of weighted response to 100 - 1400 keV gammas for offline and an adjacent to line monitor which are sodium iodide (NaI) detectors (reference GA Manual E-115-904, June 1980, and Figure 5, Expected Energy Response Normalized for one gamma per disintegration, Drawing 0360-8934 Rev A, page 14, respectively). Abundances for each gamma from "Radioactive Decay Tables" by David C. Kocher (Report DOE/TIC-11026, Washington, D.C., 1981)

Slope = The Liquid Effluent Monitor Gamma Sensitivities for nuclide "i", relative to Cs-137. To make nuclide "i" relative to Cs-137, the nuclide sensitivity is divided by the Cs-137 sensitivity. This column does not apply to TB Drains monitor.

TABLE 2.2-1

A_{i,r,p} VALUES FOR THE ADULT FOR THE SHEARON HARRIS NUCLEAR POWER PLANT

$$A_{i,r,p} = 1.14E + 05 \left(\frac{730}{D_w} + 21BF_i \right) DF_{i\tau} \bullet e^{-\lambda_i \tau} \quad p$$

(mrem/hr per μ Ci/ml)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	8.54E-01	8.54E-01	8.54E-01	8.54E-01	8.54E-01	8.54E-01
C-14	3.13E+04	6.27E+03	6.27E+03	6.27E+03	6.27E+03	6.27E+03	6.27E+03
Na-24	2.40E+02	2.40E+02	2.40E+02	2.40E+02	2.40E+02	2.40E+02	2.40E+02
P-32	4.52E+07	2.81E+06	1.75E+06	0.00E+00	0.00E+00	0.00E+00	5.08E+06
Cr-51	0.00E+00	0.00E+00	1.28E+00	7.63E-01	2.81E-01	1.69E+00	3.21E+02
Mn-54	0.00E+00	4.41E+03	8.41E+02	0.00E+00	1.31E+03	0.00E+00	1.35E+04
Mn-56	0.00E+00	4.44E+00	7.87E-01	0.00E+00	5.63E+00	0.00E+00	1.42E+02
Fe-55	6.76E+02	4.67E+02	1.09E+02	0.00E+00	0.00E+00	2.60E+02	2.68E+02
Fe-59	1.06E+03	2.49E+03	9.54E+02	0.00E+00	0.00E+00	6.95E+02	8.29E+03
Co-57	0.00E+00	2.20E+01	3.66E+01	0.00E+00	0.00E+00	0.00E+00	5.58E+02
Co-58	0.00E+00	9.33E+01	2.09E+02	0.00E+00	0.00E+00	0.00E+00	1.89E+03
Co-60	0.00E+00	2.69E+02	5.94E+02	0.00E+00	0.00E+00	0.00E+00	5.06E+03
Ni-63	3.20E+04	2.21E+03	1.07E+03	0.00E+00	0.00E+00	0.00E+00	4.62E+02
Ni-65	4.76E+00	6.19E-01	2.82E-01	0.00E+00	0.00E+00	0.00E+00	1.57E+01
Cu-64	0.00E+00	5.45E+00	2.56E+00	0.00E+00	1.37E+01	0.00E+00	4.64E+02
Zn-65	2.32E+04	7.39E+04	3.34E+04	0.00E+00	4.94E+04	0.00E+00	4.65E+04
Zn-69M	4.46E+02	1.07E+03	9.79E+01	0.00E+00	6.48E+02	0.00E+00	6.54E+04
Zn-69	6.25E-03	1.20E-02	8.32E-04	0.00E+00	7.77E-03	0.00E+00	1.80E-03
Se-75	6.04E+02	2.32E+02	4.65E+03	2.32E+02	4.65E+01	5.58E+02	6.51E+02
Br-82	0.00E+00	0.00E+00	1.81E+03	0.00E+00	0.00E+00	0.00E+00	2.07E+03
Br-83	0.00E+00	0.00E+00	1.24E+00	0.00E+00	0.00E+00	0.00E+00	1.79E+00
Br-84	0.00E+00	0.00E+00	8.07E-06	0.00E+00	0.00E+00	0.00E+00	6.33E-11
Rb-86	0.00E+00	9.95E+04	4.63E+04	0.00E+00	0.00E+00	0.00E+00	1.96E+04
Rb-88	0.00E+00	1.94E-10	1.03E-10	0.00E+00	0.00E+00	0.00E+00	2.67E-21
Rb-89	0.00E+00	1.62E-12	1.14E-12	0.00E+00	0.00E+00	0.00E+00	9.43E-26
Sr-89	2.38E+04	0.00E+00	6.84E+02	0.00E+00	0.00E+00	0.00E+00	3.82E+03
Sr-90	5.91E+05	0.00E+00	1.45E+05	0.00E+00	0.00E+00	0.00E+00	1.71E+04
Sr-91	1.84E+02	0.00E+00	7.43E+00	0.00E+00	0.00E+00	0.00E+00	8.77E+02
Sr-92	7.84E+00	0.00E+00	3.39E-01	0.00E+00	0.00E+00	0.00E+00	1.55E+02
Y-90	5.57E-01	0.00E+00	1.49E-02	0.00E+00	0.00E+00	0.00E+00	5.91E+03
Y-91M	2.61E-07	0.00E+00	1.01E-08	0.00E+00	0.00E+00	0.00E+00	7.67E-07
Y-91	9.24E+00	0.00E+00	2.47E-01	0.00E+00	0.00E+00	0.00E+00	5.09E+03
Y-92	5.29E-03	0.00E+00	1.55E-04	0.00E+00	0.00E+00	0.00E+00	9.27E+01
Y-93	7.75E-02	0.00E+00	2.14E-03	0.00E+00	0.00E+00	0.00E+00	2.46E+03
Zr-95	4.20E-01	1.35E-01	9.12E-02	0.00E+00	2.11E-01	0.00E+00	4.27E+02
Zr-97	1.42E-02	2.87E-03	1.31E-03	0.00E+00	4.34E-03	0.00E+00	8.90E+02
Nb-95	4.43E+02	2.47E+02	1.33E+02	0.00E+00	2.44E+02	0.00E+00	1.50E+06

TABLE 2.2-1

(Continued)

A_{ir} VALUES FOR THE ADULT FOR THE SHEARON HARRIS NUCLEAR POWER PLANT
(mrem/hr per μCi/ml)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Nb-97	3.70E-03	9.36E-04	3.42E-04	0.00E+00	1.09E-03	0.00E+00	3.45E+00
Mo-99	0.00E+00	1.14E+02	2.17E+01	0.00E+00	2.58E+02	0.00E+00	2.64E+02
Tc-99M	2.60E-03	7.35E-03	9.36E-02	0.00E+00	1.12E-01	3.60E-03	4.35E+00
Tc-101	5.81E-18	8.37E-18	8.21E-17	0.00E+00	1.51E-16	4.28E-18	2.52E-29
Ru-103	5.49E+00	0.00E+00	2.37E+00	0.00E+00	2.10E+01	0.00E+00	6.41E+02
Ru-105	7.07E-02	0.00E+00	2.79E-02	0.00E+00	9.13E-01	0.00E+00	4.32E+01
Ru-106	8.23E+01	0.00E+00	1.04E+01	0.00E+00	1.59E+02	0.00E+00	5.33E+03
Ag-110M	1.84E+00	1.70E+00	1.01E+00	0.00E+00	3.34E+00	0.00E+00	6.93E+02
Sn-113	2.52E+03	9.68E+02	1.94E+04	9.68E+02	1.94E+02	2.32E+03	2.71E+03
Sn-117M	2.39E+03	9.20E+02	1.84E+04	9.20E+02	1.84E+02	2.21E+03	2.58E+03
Sb-124	2.33E+01	4.40E-01	9.24E+00	5.65E-02	0.00E+00	1.82E+01	6.62E+02
Sb-125	1.50E+01	1.67E-01	3.57E+00	1.52E-02	0.00E+00	1.16E+01	1.65E+02
Sb-126	2.74E+02	5.58E+00	9.90E+01	1.68E+00	0.00E+00	1.68E+02	2.24E+04
Te-125M	2.57E+03	9.32E+02	3.44E+02	7.73E+02	1.05E+04	0.00E+00	1.03E+04
Te-127m	6.51E+03	2.33E+03	7.94E+02	1.66E+03	2.65E+04	0.00E+00	2.18E+04
Te-127	4.36E+01	1.57E+01	9.44E+00	3.23E+01	1.78E+02	0.00E+00	3.44E+03
Te-129M	1.10E+04	4.10E+03	1.74E+03	3.77E+03	4.59E+04	0.00E+00	5.53E+04
Te-129	2.33E-02	8.76E-03	5.68E-03	1.79E-02	9.80E-02	0.00E+00	1.76E-02
Te-131M	1.27E+03	6.19E+02	5.16E+02	9.80E+02	6.27E+03	0.00E+00	6.14E+04
Te-131	4.07E-08	1.70E-08	1.28E-08	3.35E-08	1.78E-07	0.00E+00	5.76E-09
Te-132	2.19E+03	1.41E+03	1.33E+03	1.56E+03	1.36E+04	0.00E+00	6.69E+04
I-130	1.62E+01	4.77E+01	1.88E+01	4.05E+03	7.45E+01	0.00E+00	4.11E+01
I-131	1.67E+02	2.39E+02	1.37E+02	7.84E+04	4.10E+02	0.00E+00	6.31E+01
I-132	2.29E-01	6.12E-01	2.14E-01	2.14E+01	9.75E-01	0.00E+00	1.15E-01
I-133	4.00E+01	6.95E+01	2.12E+01	1.02E+04	1.21E+02	0.00E+00	6.25E+01
I-134	3.37E-04	9.15E-04	3.27E-04	1.59E-02	1.46E-03	0.00E+00	7.98E-07
I-135	5.29E+00	1.38E+01	5.11E+00	9.13E+02	2.22E+01	0.00E+00	1.56E+01
Cs-134	2.99E+05	7.10E+05	5.81E+05	0.00E+00	2.30E+05	7.63E+04	1.24E+04
Cs-136	3.05E+04	1.20E+05	8.65E+04	0.00E+00	6.69E+04	9.17E+03	1.37E+04
Cs-137	3.83E+05	5.23E+05	3.43E+05	0.00E+00	1.78E+05	5.91E+04	1.01E+04
Cs-138	4.92E-05	9.72E-05	4.82E-05	0.00E+00	7.14E-05	7.06E-06	4.15E-10
Ba-139	3.72E-03	2.65E-06	1.09E-04	0.00E+00	2.48E-06	1.50E-06	6.60E-03
Ba-140	3.08E+02	3.86E-01	2.02E+01	0.00E+00	1.31E-01	2.21E-01	6.33E+02
Ba-141	1.05E-12	7.94E-16	3.55E-14	0.00E+00	7.38E-16	4.51E-16	4.95E-22
Ba-142	1.84E-21	1.89E-24	1.16E-22	0.00E+00	1.60E-24	1.07E-24	2.59E-39
La-140	1.34E-01	6.75E-02	1.78E-02	0.00E+00	0.00E+00	0.00E+00	4.96E+03
La-142	4.51E-05	2.05E-05	5.11E-06	0.00E+00	0.00E+00	0.00E+00	1.50E-01

TABLE 2.2-1

(Continued)

A_{ir} VALUES FOR THE ADULT FOR THE SHEARON HARRIS NUCLEAR POWER PLANT
 (mrem/hr per μ Ci/ml)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Ce-141	7.76E-02	5.24E-02	5.95E-03	0.00E+00	2.44E-02	0.00E+00	2.01E+02
Ce-143	1.07E-02	7.94E+00	8.79E-04	0.00E+00	3.50E-03	0.00E+00	2.97E+02
Ce-144	4.08E+00	1.71E+00	2.19E-01	0.00E+00	1.01E+00	0.00E+00	1.38E+03
Pr-143	5.91E-01	2.37E-01	2.93E-02	0.00E+00	1.37E-01	0.00E+00	2.59E+03
Pr-144	5.88E-16	2.44E-16	2.99E-17	0.00E+00	1.38E-16	0.00E+00	8.46E-23
Nd-147	4.02E-01	4.64E-01	2.78E-02	0.00E+00	2.71E-01	0.00E+00	2.23E+03
W-187	2.10E+02	1.75E+02	6.12E+01	0.00E+00	0.00E+00	0.00E+00	5.74E+04
Np-239	3.08E-02	3.03E-03	1.67E-03	0.00E+00	9.44E-03	0.00E+00	6.21E+02

Figure 2.1-1

Liquid Waste Processing Flow Diagram

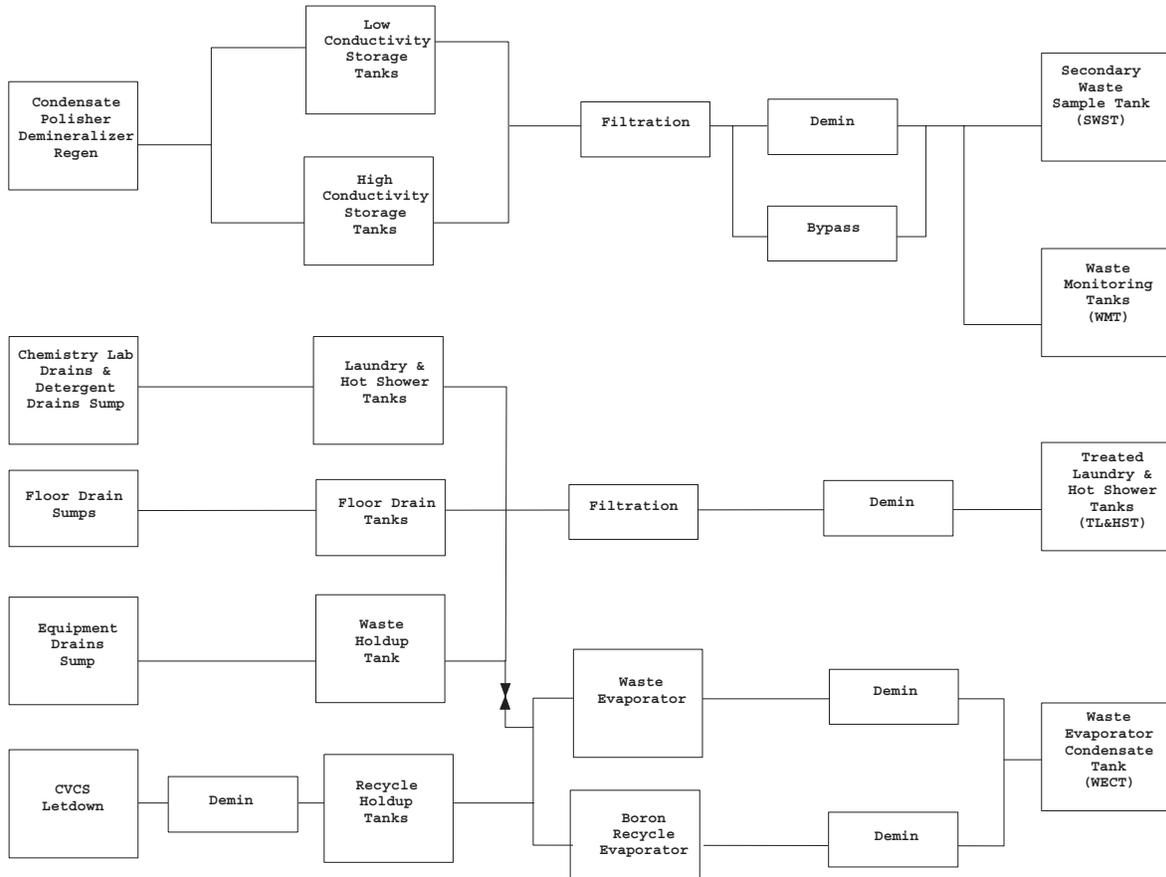


Figure 2.1-2

Liquid Effluent Flow Stream Diagram

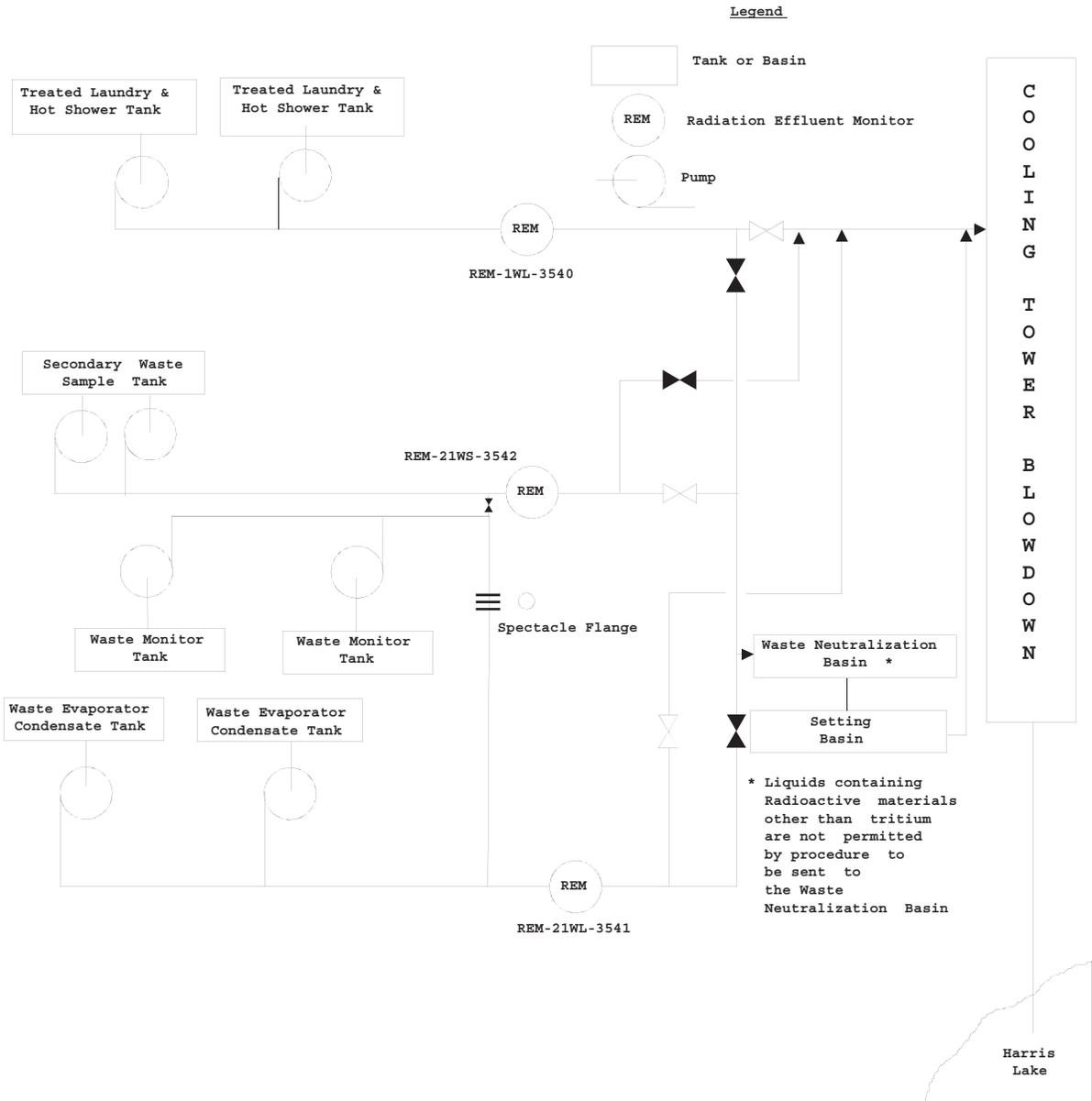


Figure 2.1-3

Normal Service Water Flow Diagram

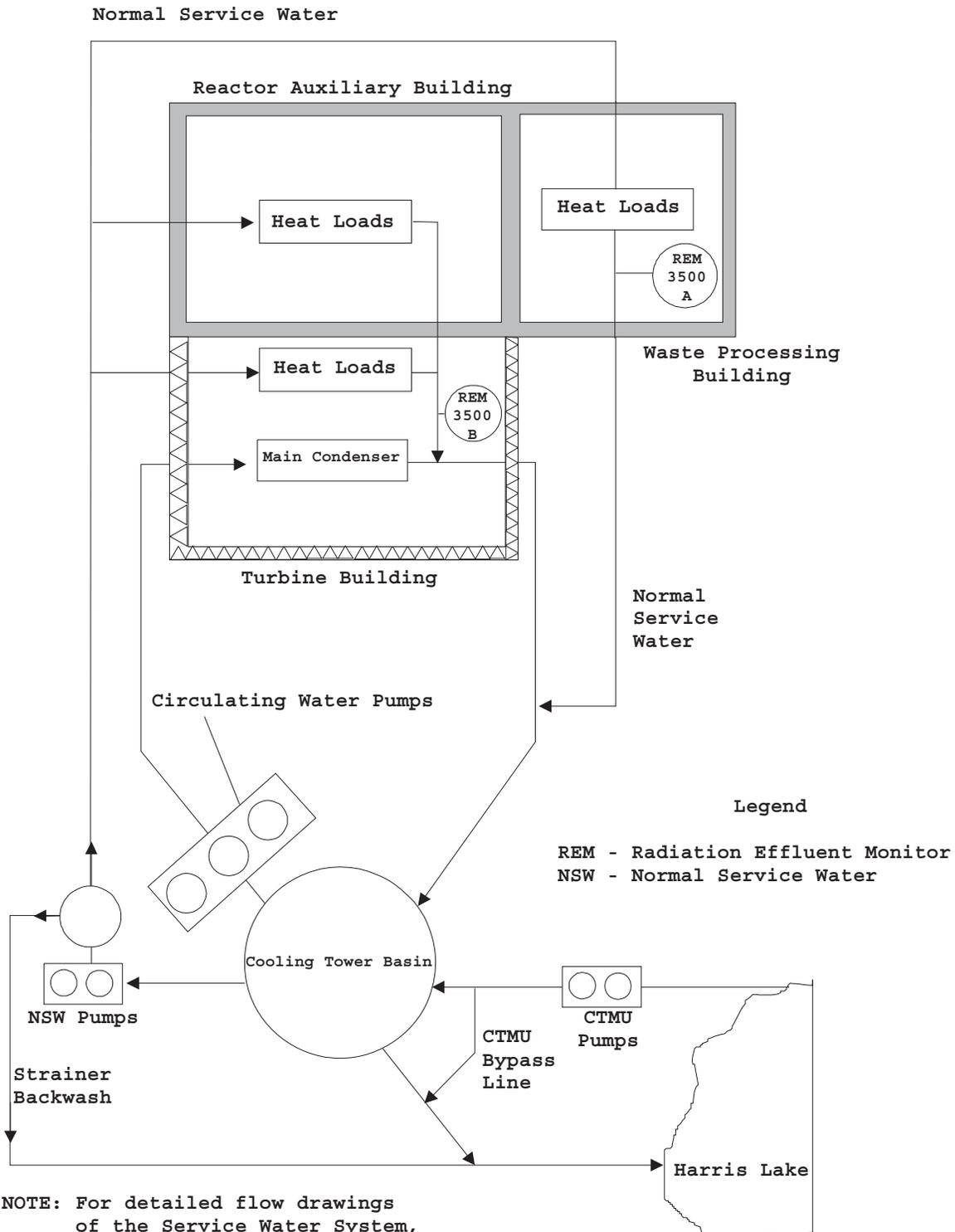
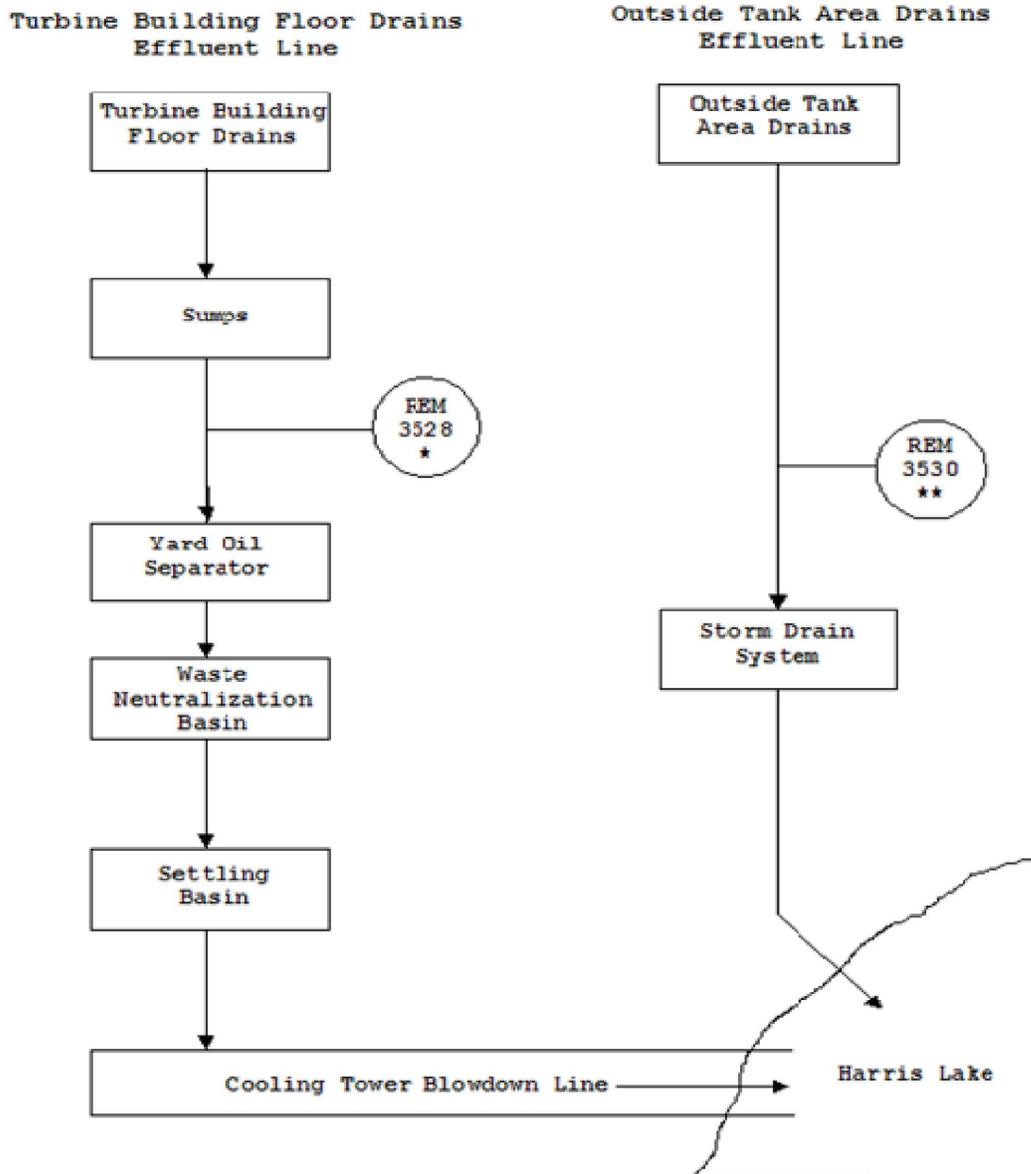


Figure 2.1-4

Other Liquid Effluent Pathways

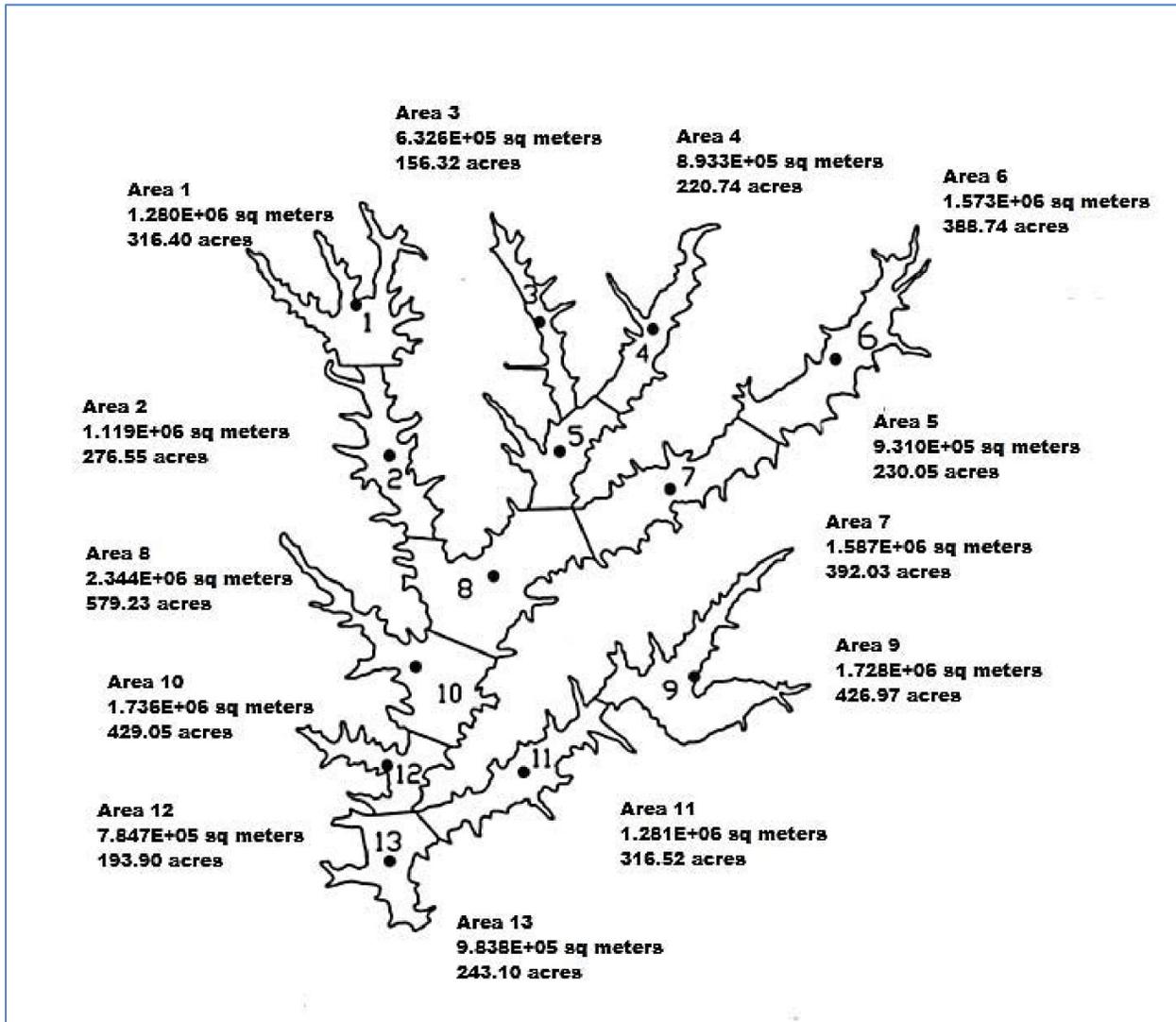


* Turbine Building Floor Drains Effluent can be Diverted to the Secondary Waste Treatment System

** Outside Tank Area Drains Effluent can be Diverted to the Liquid Radwaste Treatment System

Figure 2.3-1

Map of Harris Lake for Evaporation Dose Calculation



3.0 GASEOUS EFFLUENTS

At SHNPP there are four gaseous effluent discharge points: Plant Vent Stack 1, Turbine Building Vent Stack 3A, and the Waste Processing Building Vent Stacks 5 and 5A. During refueling outage the Equipment Hatch is removed and has potential airborne particulate releases. These are shown in Figures 3.1, 3.2, and 3.3 along with their tributaries. Minor release pathways, such as steam leaks, steam dumps, and open penetrations are evaluated for significant of release. All gaseous effluent releases at the plant are considered ground releases.

3.1 Monitor Alarm Setpoint Determination (ODCM Operational Requirement 3.3.3.11)

This section provides the methodology for stack effluent monitor setpoints to ensure that the dose rates from noble gases at the site boundary do not exceed the limits of 500 mrem/year to the whole body or 3000 mrem/year to the skin as specified in ODCM Operational Requirement 3.11.2.1. The 500 mrem/year to the whole body or 3000 mrem/year to the skin limits are more conservative than the 10 CFR 50.73 limits concerning airborne radioactivity release concentrations to unrestricted areas, and therefore the setpoint methodology set forth here is based on the limits of 500 mrem/year to the whole body or 3000 mrem/year to the skin.

The radioactivity effluent monitors for each stack and for specific effluent streams are shown in Figures 3.1 and 3.3 and are listed in Appendix C.

Gamma spectroscopy analysis of the gas sample should provide the nuclide identification and activity. However, in the case where the noble gas activities are < LLD the relative nuclide composition can be assumed from the GALE code activities for projected normal operating releases (Table 3.1-1). The GALE code is used to establish a default setpoint for each vent stack. This setpoint will be used as a "fixed" setpoint until a more conservative setpoint is calculated, using either a different assumed mix or actual sample results.

3.1.1 Default Continuous Release Monitor Setpoints Using a Conservative mix (GALE code)

The following methodology is the default setpoint for the continuous release vent stacks based on conservative assumptions of mix (GALE code) and maximum stack flow rate.

1. Determine the noble gas radionuclide activity (Q_i) in μCi , and the activity release rate \dot{Q}_i in $\mu\text{Ci}/\text{sec}$ for each nuclide "i". \dot{Q}_i is the release rate of nuclide "i" in gaseous effluent from discharge point "v", in $\mu\text{Ci}/\text{sec}$.

$$Q_i = C_i \cdot F_v \cdot \text{duration} \cdot 28316.85 \quad (3.1-1a)$$

and

$$\dot{Q}_i = C_i \cdot F_v \cdot 28316.85 / 60 \quad (3.1-1b)$$

where:

v = index over all vent stacks

C_i = concentration of nuclide, in $\mu\text{Ci}/\text{cc}$
 = the GALE code activities from Table 3.1-1.

F_v = effluent release rate or vent flow rate in cfm
 = the maximum effluent design flow rate at the point of discharge (acfm) from Table 3.1-3.

duration = duration of release, in minutes

28316.85 = conversion factor for cc/ft^3

60 = seconds per minute

2. Determine the maximum whole body and skin dose rate (mrem/year) during the release.

$$Q_{m\text{-wb}} = \overline{(X / Q)} [\sum_i K_i \dot{Q}_i] \quad (3.1-2a)$$

and

$$Q_{m\text{-s}} = \overline{(X / Q)} [\sum_i (L_i + 1.1M_i) \dot{Q}_i] \quad (3.1-2b)$$

where:

i = index over all nuclides

K_i = the total body dose factor due to gamma emissions for noble gas radionuclide i (in mrem/yr per $\mu\text{Ci}/\text{m}^3$), from Table 3.2-3.

L_i = The skin dose factor due to beta emissions for noble gas radionuclide i (mrem/yr per $\mu\text{Ci}/\text{m}^3$), from Table 3.2-3

M_i = The air dose factor due to gamma emissions for noble gas radionuclide i (mrad/yr per $\mu\text{Ci}/\text{m}^3$). A unit conversion constant of 1.1 mrad/mrem converts air dose to skin dose, from Table 3.2-3

$\overline{X/Q}$ = The highest calculated annual average relative concentration for any sector at or beyond the exclusion boundary (sec/m^3)

= $1.8\text{E-}05 \text{ sec}/\text{m}^3$ (Site Boundary SW) from Table A1 through A4, Appendix A

3.1.1 Default Continuous Release Monitor Setpoints Using a Conservative mix (GALE code) (continued)

3. Determine the ratio of dose rate limit to dose rate.

$$\text{Whole Body ratio} = \frac{500}{Q_{m-wb}} \quad (3.1-3a)$$

and

$$\text{Skin ratio} = \frac{3000}{Q_{m-s}} \quad (3.1-3b)$$

where:

500 = site dose rate limit for whole body in mrem/year.

3000 = site dose rate limit for skin in mrem/year.

4. Determine S_{max} , the maximum concentration setpoint in $\mu\text{Ci/cc}$, and RR_{max} the maximum release rate setpoint in $\mu\text{Ci/sec}$ for the monitor.

$$S_{max} = (f_s \cdot f_{alloc} \cdot nratio \cdot \sum C_i) + Bkg \quad (3.1-4a)$$

and

$$RR_{max} = S_{max} \cdot F_v \cdot 28316.852 / 60 \quad (3.1-4b)$$

where

f_s = safety factor for the discharge point

= 0.5

f_{alloc} = dose rate allocation factor for the discharge point

= fraction of the radioactivity from the site that may be released via the monitored pathway to ensure that the site boundary limit is not exceeded by simultaneous releases. These values are based on current plant conditions and ideal values that can be procedurally controlled are in Table 3.1-3. The sum of the allocation factors must be ≤ 1 .

$nratio$ = lesser of the ratios

Bkg = Monitor background, in $\mu\text{Ci/cc}$

= 0 for calculation of default setpoint.

3.1.1 Default Continuous Release Monitor Setpoints Using a Conservative mix (GALE code) (continued)

Using the GALE code activities from Table 3.1-1 and the maximum effluent design flow rate, continuous release stack maximum setpoints in $\mu\text{Ci}/\text{cc}$ and $\mu\text{Ci}/\text{sec}$ are determined. These values will be used as default values for the stack monitors. Based on sampling and analysis, the setpoint will be recalculated. If the sample analysis setpoint is higher than the default setpoint, the setpoint will not be changed. If the sample analysis setpoint is lower than the default, the setpoint will be changed to reflect the more conservative setpoint. When the setpoint changes again, the more conservative setpoint, comparing the default (GALE code) and sample analysis, will be used.

5. Determine S_{alert} , the gas channel alert alarm setpoint in $\mu\text{Ci}/\text{cc}$, and RR_{alert} the gas channel alert alarm release rate setpoint in $\mu\text{Ci}/\text{sec}$.

$$S_{\text{alert}} = [(S_{\text{max}} - \text{Bkg}) A_r] + \text{Bkg} \quad (3.1-5a)$$

and

$$RR_{\text{alert}} = [(RR_{\text{max}} - \text{Bkg}_{\text{rr}}) A_r] + \text{Bkg}_{\text{rr}} \quad (3.1-5b)$$

where:

A_r = A value < 1.0 designed to alert the operator that the high alarm setpoint is being approached.

Bkg_{rr} = $\text{Bkg} \cdot F_v \cdot 28316.85 / 60$

3.1.2 Monitor Setpoints Using Sample Results

In Stacks 1 and 5, the potential exists for batch releases concurrent with the normal continuous ventilation flow of effluents. The sources of batch releases for the Plant Vent Stack 1 include containment normal and pre-entry purge and pressure relief. Batch release sources for Vent Stack 5 include releases from the waste gas decay tanks (WGDT). In these cases, the monitor setpoint must reflect the contribution of both the continuous and batch sources.

The following methodology will calculate a setpoint for the continuous release vent stacks based on actual sample results and for batch releases occurring concurrently with continuous releases.

1. Determine the noble gas radionuclide activity (Q_i) in μCi , and the activity release rate \dot{Q}_i in $\mu\text{Ci}/\text{sec}$ for each nuclide "i". \dot{Q}_i is the average release rate of nuclide "i" in gaseous effluent from discharge point "v", in $\mu\text{Ci}/\text{sec}$. Noble gases may be averaged over a period of 1 hour.

$$Q_i = C_i \cdot F_v \cdot \text{duration} \cdot 28316.85 \quad (3.2-1a)$$

and

$$\dot{Q}_i = C_i \cdot F_v \cdot 28316.85 / 60 \quad (3.2-1b)$$

where:

C_i = concentration of nuclide, in $\mu\text{Ci}/\text{cc}$
 = the measured concentration from a stack effluent sample or pre-release sample. If there is no activity in the sample, then the GALE code activities from Table 3.1-1 will be used.

= $\frac{\text{WGDTs}}{(\mu\text{Ci}/\text{cc from analysis of WGDT})(6.45 \text{ E-}05) + (\mu\text{Ci}/\text{cc from analysis/GALE Code of Vent Stack 5})(0.9999)}$

= $\frac{\text{Containment Normal Purge (Batch)}}{(\mu\text{Ci}/\text{cc from analysis of Containment})(3.60 \text{ E-}03) + (\mu\text{Ci}/\text{cc from analysis/GALE Code of PV Stack 1})(0.9964)}$

= $\frac{\text{Containment Preentry Purge (Batch)}}{(\mu\text{Ci}/\text{cc from analysis of Containment})(8.19 \text{ E-}02) + (\mu\text{Ci}/\text{cc from analysis/GALE Code of PV Stack 1})(0.9181)}$

6.45 E-05 = Dilution factor WGDT = $(15 \text{ acfm}) / (232,500 \text{ acfm} + 15 \text{ acfm})$

0.9999 = Dilution factor Vent Stack 5
 = $232,500 \text{ acfm} / (232,500 \text{ acfm} + 15 \text{ acfm})$

3.60 E-03 = Dilution factor Normal Purge
 = $1500 \text{ acfm} / (415,000 \text{ acfm} + 1500 \text{ acfm})$

0.9964 = Dilution factor PV-1 = $415,000 \text{ acfm} / (415,000 \text{ acfm} + 1500 \text{ acfm})$

8.19 E-02 = Dilution factor Preentry Purge (Batch)
 = $37,000 \text{ acfm} / (415,000 \text{ acfm} + 37,000 \text{ acfm})$

0.9181 = Dilution factor PV-1
 = $415,000 \text{ acfm} / (415,000 \text{ acfm} + 37,000 \text{ acfm})$

3.1.2 Monitor Setpoints Using Sample Results (continued)

- F_v = effluent release rate or vent flow rate in CFM
- = for continuous releases, the measured effluent flow rate or the maximum effluent design flow rate at the point of release (acfm) from Table 3.1-3.
- = for batch releases, the release flow rate, in acfm
- = 1,500 acfm for containment normal purge + 415,000 acfm from Plant Vent Stack 1
- = 37,000 acfm for containment preentry purge + 415,000 acfm from Plan Vent Stack 1
- = 15 acfm for Waste Gas Decay Tank pre release permits + 232,500 acfm from Vent Stack 5
- for posting Waste Gas Decay Tank and Containment Pressure releases the following is used for effluent accountability.

$$= \frac{2.26E + 06 \left(\frac{\Delta P_c}{14.7} \right) \left(\frac{273^\circ}{T_c} \right)}{t}$$

for a containment pressure release

$$= \frac{600 \left(\frac{\Delta P_t}{14.7} \right) \left(\frac{273^\circ}{T_t} \right)}{t}$$

for a Waste Gas Decay Tank release

where:

2.26E+06 and 600 are the volumes in ft³ of the containment and decay tank, respectively, and T_c , T_t , ΔP_c , and ΔP_t are the estimated, respective temperature and change in pressure (psig) following the release of the containment and decay tank; and,

- 14.7 psi = 1 atmosphere pressure
- t = Length of release, min
- $\Delta P_c, \Delta P_t$ = change in pressure (psig) following the release of the containment or decay tank
- 273°K = 0°C
- T_t, T_c = 273°K + C°

- duration = duration of release, in minutes
- 28316.85 = conversion factor for cc/ft³

3.1.2 Monitor Setpoints Using Sample Results (continued)

2. Determine the maximum whole body and skin dose rate (mrem/year) during the release by summing together the dose rates for this release with all concurrent releases for the time of the release.

$$Q_{m-wb} = \overline{(X/Q)}[\sum_i K_i \dot{Q}_i] \quad (3.2-2a)$$

and

$$Q_{m-s} = \overline{(X/Q)}[\sum_i (L_i + 1.1M_i) \dot{Q}_i] \quad (3.2-2b)$$

where:

i = index over all radionuclides

K_i = the total body dose factor due to gamma emissions for noble gas radionuclide i (mrem/yr per μCi/m³), from Table 3.2-3.

L_i = The skin dose factor due to beta emissions for noble gas radionuclide i (mrem/yr per μCi/m³), from Table 3.2-3

M_i = The air dose factor due to gamma emissions for noble gas radionuclide i (mrad/yr per μCi/m³). A unit conversion constant of 1.1 mrad/mrem converts air dose to skin dose, from Table 3.2-3

$\overline{X/Q}$ = The highest calculated annual average relative concentration for any sector at or beyond the exclusion boundary (sec/m³)

= 1.8E-05 sec/m³ (Site Boundary SW) from Table A1 through A4, Appendix A

3.1.2 Monitor Setpoints Using Sample Results (continued)

3. Determine the ratio of dose rate limit to dose rate.

$$\text{Whole Body ratio} = \frac{500}{Q_{m-wb}} \quad (3.2-3a)$$

and

$$\text{Skin ratio} = \frac{3000}{Q_{m-s}} \quad (3.2-3b)$$

where:

500 = site dose rate limit for whole body in mrem/year.

3000 = site dose rate limit for skin in mrem/year.

4. Determine S_{max} , the maximum concentration setpoint in $\mu\text{Ci/cc}$, and RR_{max} the maximum release rate setpoint in $\mu\text{Ci/sec}$ for the monitor.

$$S_{max} = (f_s \cdot f_{alloc} \cdot nratio \cdot \sum C_i) + Bkg \quad (3.2-4a)$$

and

$$RR_{max} = S_{max} \cdot F_v \cdot 28316.85 / 60 \quad (3.2-4b)$$

where:

f_s = safety factor for the discharge point

= 0.5

f_{alloc} = dose rate allocation factor for the discharge point

= fraction of the radioactivity from the site that may be released via the monitored pathway to ensure that the site boundary limit is not exceeded by simultaneous releases. These values are based on current plant conditions and ideal values that can be procedurally controlled are in Table 3.1-3. The sum of the allocation factors must be ≤ 1 .

$nratio$ = lesser of the ratios

Bkg = Monitor background, in $\mu\text{Ci/cc}$

= measured background at time of release or 0.

3.1.2 Monitor Setpoints Using Sample Results (continued)

5. Determine S_{alert} , the gas channel alert alarm setpoint in $\mu\text{Ci}/\text{cc}$, and RR_{alert} the gas channel alert alarm release rate setpoint in $\mu\text{Ci}/\text{sec}$.

$$S_{\text{alert}} = [(S_{\text{max}} - \text{Bkg}) A_f] + \text{Bkg} \quad (3.2-5a)$$

and

$$RR_{\text{alert}} = [(RR_{\text{max}} - \text{Bkg}_{\text{rr}}) A_f] + \text{Bkg}_{\text{rr}} \quad (3.2-5b)$$

where:

A_f = A value < 1.0 designed to alert the operator that the high alarm setpoint is being approached.

$$\text{Bkg}_{\text{rr}} = \text{Bkg} \cdot F_v \cdot 28316.85 / 60$$

3.1.3 Effluent Monitoring During Hogging Operations

If the reactor has been shut down for greater than 30 days, the condenser vacuum pump discharge during initial hogging operations at plant start-up and prior to turbine operation may be routed as dual exhaust to (1) the Turbine Vent Stack 3A and (2) the atmosphere directly. In this instance, the blind flange on the latter exhaust route will be removed (see Figure 3.3).

A conservative effluent channel setpoint has been established for Vent Stack 3A. The monitor setpoint should be reduced proportionately to the estimated fraction of the main condenser effluent flowing directly to the atmosphere.

Table 3.1-1
GASEOUS SOURCE TERMS^(a,b)

Nuclide	Plant Vent Ventilation Flow via Stack 1		Condenser Vacuum Pump Ventilation Flow via Stack 3A		WPB Ventilation Flow via Stack 5		WPB Ventilation Flow ^(c) via Stack 5A		Containment Purge or Pressure Relief via Stack 1		WGDT Release via Stack 5	
	Ci (uCi/cc)	% Rel. Mix	Ci (uCi/cc)	% Rel. Mix	Ci (uCi/cc)	% Rel. Mix	Ci (uCi/cc)	% Rel. Mix	Ci (uCi/cc)	% Rel. Mix	Ci (uCi/cc)	% Rel. Mix
Kr-85m	4.86E-10	6.52	4.70E-9	9.52	0	0	1.96E-9	6.52	1.01E-7	3.79	0	0
Kr-85	0	0	0	0	1.60E-7	97.05	0	0	3.95E-8	1.49	2.22E-5	100.00
Kr-87	4.86E-10	6.52	4.70E-9	9.52	0	0	1.96E-9	6.52	3.59E-8	1.35	0	0
Kr-88	9.71E-10	13.04	7.04E-9	14.29	0	0	3.91E-9	13.04	1.29E-7	4.87	0	0
Xe-131m	3.24E-10	4.35	0	0	4.86E-9	2.95	1.30E-9	4.35	2.16E-7	8.12	0	0
Xe-133m	0	0	0	0	0	0	0	0	5.57E-8	2.10	0	0
Xe-133	1.78E-09	23.91	1.17E-8	23.81	0	0	7.17E-9	23.91	1.31E-6	49.39	0	0
Xe-135m	4.86E-10	6.52	2.35E-9	4.76	0	0	1.96E-9	6.52	7.19E-9	0.27	0	0
Xe-135	2.43E-9	32.61	1.64E-8	33.33	0	0	9.78E-9	32.61	7.55E-7	28.42	0	0
Xe-138	4.86E-10	6.52	2.35E-9	4.76	0	0	1.96E-9	6.52	5.39E-9	0.20	0	0

(a) Source terms are from SHNPP FSAR Table 11.3.3-1 and not actual releases. Values apply only to routine releases and not emergency situations.

(b) $(\text{uCi/cc}) = \frac{(\text{Ci/yr})(\text{yr}/5.256\text{E}5\text{min})(1\text{E}6\text{uCi/Ci})(\text{ft}^3/28320\text{cc})}{(\text{Flow Rate } \text{ft}^3/\text{min})^{(d)}}$

(c) Source term for this effluent stream not presented with FSAR. RAB mix assumed.

(d) Maximum Effluent Design Flow Rates:

- Plant Vent Ventilation via Stack 1 = 415,000 acfm
- Condenser Vacuum Pump Ventilation via Stack 3A = 28,620 acfm
- WPB Ventilation via Stack 5 = 232,500 acfm
- WPB Ventilation via Stack 5A = 103,050 acfm
- Containment Purge or Pressure Relief via Stack 1 = 37,000 acfm
- WGDT Release via Stack 5 = 15 acfm

TABLE 3.1-2

Deleted

TABLE 3.1-3

GASEOUS MONITOR PARAMETERS

	PVS-1	TBVS-3A	WPBVS-5	WPBVS-5A
Maximum effluent design flow rate, (acfm)	415,000	28,620	232,500	103,050
Flow Allocation Factor [f_{alloc}]	0.532	0.037	0.298	0.132

3.2 Postrelease Compliance with 10CFR20-Based ODCM Operational Requirement 3.11.2

3.2.1 Noble Gases

The gaseous effluent monitors' setpoints are utilized to show prerelease compliance with ODCM Operational Requirement 3.11.2.1. However, because they may be based upon a conservative (GALE code) mix of radionuclides, when using Table 3.1-1, the possibility exists that the setpoints could be exceeded and yet 10CFR20-based limits may actually be met. Therefore, the following methodology has been provided in the event that if the high alarm setpoints are exceeded, a determination may be made as to whether the actual releases have exceeded the dose rate limits of ODCM Operational Requirement 3.11.2.1.

The dose rate in unrestricted areas resulting from noble gas effluents is limited to 500 mrem/year to the total body and 3000 mrem/year to the skin. Based upon NUREG-0133, the following equations are used to show compliance:

$$\sum_i K_i \overline{(X/Q)}_v \dot{Q}_{i_v} \leq 500 \text{ mrem/yr} \quad (3.2-1)$$

$$\sum_i (L_i + 1.1M_i) \overline{(X/Q)}_v \dot{Q}_{i_v} \leq 3000 \text{ mrem/yr} \quad (3.2-2)$$

where:

- $\overline{(X/Q)}_v$ = The highest calculated annual average relative concentration for long-term vent stack releases for areas at or beyond the exclusion boundary sec/m^3 .
- = $1.8\text{E-}05 \text{ sec/m}^3$ (Site Boundary SW) from Table A1 through A4, Appendix A
- K_i = The total body dose factor due to gamma emissions for noble gas radionuclide "i," mrem/year per $\mu\text{Ci/m}^3$. Table 3.2-3.
- L_i = The skin dose factor due to beta emissions for noble gas radionuclide "i," mrem/year per $\mu\text{Ci/m}^3$. Table 3.2-3.
- M_i = The air dose factor due to gamma emissions for noble gas radionuclide "i," mrad/year per $\mu\text{Ci/m}^3$. Table 3.2-3
- 1.1 = The ratio of the tissue to air absorption coefficients over the energy range of the photon of interest. Converts mrad to mrem (Reference NUREG-0133).
- \dot{Q}_{i_v} = The release rate of radionuclide "i" in gaseous effluents from all plant vent stacks ($\mu\text{Ci/sec}$).

The determination of the controlling location for implementation of dose rate limits for noble gas exposure is a function of the historical annual average meteorology.

The radionuclide mix is based on the sampling and analysis required by ODCM Operational Requirement 4.11.2.1.2. If the analysis is < LLD, then the GALE code, historical data for the mix, or a Xe-133 / Kr-85 LLD mix for that analysis will be used to demonstrate compliance.

The release rate is derived from either the actual flow rate or the default flow rate and the known or assumed mix.

3.2.1 Noble Gases (continued)

$$\text{Release Rate } (\mu\text{Ci/sec}) = \text{Flow (cc/sec)} * \text{Concentration } (\mu\text{Ci/cc})$$

The noble gas radionuclide mix was based upon source terms calculated using the NRC GALE Code and presented in the SHNPP FSAR Table 11.3.3-1. They are reproduced in Table 3.2-1 as a function of release point.

The X/Q value utilized in the equations is the highest long-term annual average relative concentration $(X/Q)_v$ in the unrestricted area for the period 2010 - 2014. Long-term annual average $(X/Q)_v$ values at other special locations identified by the Land Use Census (see Operational Requirement 3.12.2) are presented in Appendix A. A description of their derivation is also provided in Appendix A.

To select the limiting location for ground-level releases, long-term annual average $(X/Q)_v$ values were calculated assuming no decay, undepleted transport to the exclusion boundary. These values are given in Table A1 through A4, Appendix A. The maximum exclusion boundary $(X/Q)_v$ for ground-level releases occurs in the SW sector. Therefore, the limiting location for implementation of the dose rate limits for noble gases is considered to be the exclusion boundary (1.33 miles) in the SW sector.

Values for K_i , L_i , and M_i which are to be used by SHNPP in Equations 3.2-1 and 3.2-2 to show compliance with ODCM Operational Requirement 3.11.2 are presented in Table 3.2-3. These values were taken from Table B-1 of NRC Regulatory Guide 1.109, Revision 1. The values have been multiplied by $1.0\text{E}+06$ to convert mrad/pCi to $\text{mrad}/\mu\text{Ci}$ for use in Equations 3.2-1 and 3.2-2.

3.2.2 Radioiodines and Particulates

The basis for ODCM Operational Requirement 3/4.11.2.1 states that the dose rate to the thyroid of a child in an unrestricted area resulting from the inhalation of radioiodines, tritium, and particulates with half-lives ≥ 8 days is limited to 1500 mrem/yr to any organ. Based upon NUREG-0133, the following is used to show compliance:

$$\sum_i P_{iI} [(\overline{X/Q})_v \dot{Q}_{iV}] \leq 1500 \text{ mrem / yr} \quad (3.2-3)$$

where:

P_{iI} = The dose parameter for radionuclides other than noble gases for the inhalation pathway, mrem/yr per $\mu\text{Ci}/\text{m}^3$, from Table 3.2-4.

In the calculation to show compliance with ODCM Operational Requirement 3.11.2.1.b, only the inhalation pathway is considered.

The radionuclide mix is based on the sampling and analysis required by ODCM Operational Requirement 4.11.2.1.2. If the analysis is $< \text{LLD}$, then no activity is assumed to have been released during the sampling period. The release rate is derived from the flow (actual or default) and the mix.

$$\text{Release Rate } (\mu\text{Ci}/\text{sec}) = \text{Flow } (\text{cc}/\text{sec}) * \text{Concentration } (\mu\text{Ci}/\text{cc})$$

The determination of the controlling exclusion boundary location was based upon the highest exclusion boundary $(X/Q)_v$ value. Values for P_{iI} in Eq. 3.2-3 were calculated for a child for various radionuclides for the inhalation pathway using the methodology of NUREG-0133. The P_{iI} values are presented in Table 3.2-4. A description of the methodology used in calculating the P_{iI} values is presented in Appendix B.

The $(\overline{X/Q})_v$ value utilized in Equation 3.2-3 is obtained from the tables presented in Appendix A. A description of the derivation of the X/Q values is provided in Appendix A.

Table 3.2-1

Releases from the Shearon Harris Nuclear Power Plant (a)
Normal Operation (Curies/year)

Waste Processing Bldg Exhaust and/or Waste Gas Decay Tanks (b) via VENT STACK 5			Waste Processing Bldg Exhaust via VENT STACK 5A RAB/FHB and Containment Exhaust via VENT STACK 1		Condenser Vacuum Pump and Turbine Building Exhaust via VENT STACK 3A		TOTAL
NOBLE GASES	SHUTDOWN	NORMAL OPERATIONS	CONTAINMENT	RAB/FHB	TURBINE	STACK 3A	
Kr-85m	0	0	5.6E+01	3.E+00	0	2.0E+00	6.1E+01
Kr-85	5.0E+00	5.6E+02	2.2E+01	0	0	0	5.9E+02
Kr-87	0	0	2.0E+01	3.0E+00	0	2.0E+00	2.5E+01
Kr-88	0	0	7.2E+01	6.0E+00	0	3.0E+00	8.1E+01
Xe-131m	0	1.7E+01	1.2E+02	2.0E+00	0	0	1.4E+02
Xe-133m	0	0	3.1E+01	0	0	0	3.10E+01
Xe-133	0	0	7.3E+02	1.1E+01	0	5.0E+00	7.5E+02
Xe-135m	0	0	4.0E+00	3.0E+00	0	1.0E+00	8.0E+00
Xe-135	0	0	4.2E+02	1.5E+01	0	7.0E+00	4.4E+02
Xe-138	0	0	3.0E+00	3.0E+00	0	1.0E+00	7.0E+00
Ar-41	---	---	---	---	---	---	3.4E+01

(a) Adapted from SHNPP FSAR Table 11.3.3-1 and do not reflect actual release data.
These values are only for routine releases and not for a complete inventory of gases in an emergency.

(b) Waste Gas Decay Tank releases assumed to be after a 90-day decay period.

TABLE 3.2-3

DOSE FACTORS FOR NOBLE GASES *

Radionuclide	Total Body Dose Factor K _i (mrem/yr per μCi/m ³)	Skin Dose Factor L _i (mrem/yr per μCi/m ³)	Gamma Air Dose Factor M _i (mrad/yr per μCi/m ³)	Beta Air Dose Factor N _i (mrad/yr per μCi/m ³)
Ar-41	8.840E+03	2.690E+03	9.300E+03	3.280E+03
Kr-83M	7.560E-02	0.000E+00	1.930E+01	2.880E+02
Kr-85M	1.170E+03	1.460E+03	1.230E+03	1.970E+03
Kr-85	1.610E+01	1.340E+03	1.720E+01	1.950E+03
Kr-87	5.920E+03	9.730E+03	6.170E+03	1.030E+04
Kr-88	1.470E+04	2.370E+03	1.520E+04	2.930E+03
Kr-89	1.660E+04	1.010E+04	1.730E+04	1.060E+04
Xe-127	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Xe-131M	9.150E+01	4.760E+02	1.560E+02	1.110E+03
Xe-133M	2.510E+02	9.940E+02	3.270E+02	1.480E+03
Xe-133	2.940E+02	3.060E+02	3.530E+02	1.050E+03
Xe-135M	3.120E+03	7.110E+02	3.360E+03	7.390E+02
Xe-135	1.810E+03	1.860E+03	1.920E+03	2.460E+03
Xe-137	1.420E+03	1.220E+04	1.510E+03	1.270E+04
Xe-138	8.830E+03	4.130E+03	9.210E+03	4.750E+03

* The listed dose factors are for radionuclides that may be detected in gaseous effluents.

TABLE 3.2-4
 P_{ij} VALUES (INHALATION) FOR A CHILD

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03
P-32	2.60E+06	1.14E+05	9.86E+04	0.00E+00	0.00E+00	0.00E+00	4.21E+04
Cr-51	0.00E+00	0.00E+00	1.54E+02	8.53E+01	2.43E+01	1.70E+04	1.08E+03
Mn-54	0.00E+00	4.29E+04	9.50E+03	0.00E+00	1.00E+04	1.57E+06	2.29E+04
Fe-59	2.07E+04	3.34E+04	1.67E+04	0.00E+00	0.00E+00	1.27E+06	7.06E+04
Co-58	0.00E+00	1.77E+03	3.16E+03	0.00E+00	0.00E+00	1.10E+06	3.43E+04
Co-60	0.00E+00	1.31E+04	2.26E+04	0.00E+00	0.00E+00	7.06E+06	9.61E+04
Zn-65	4.25E+04	1.13E+05	7.02E+04	0.00E+00	7.13E+04	9.94E+05	1.63E+04
Rb-86	0.00E+00	1.98E+05	1.14E+05	0.00E+00	0.00E+00	0.00E+00	7.98E+03
Rb-88	0.00E+00	8.36E+02	5.45E+02	0.00E+00	0.00E+00	0.00E+00	2.56E+01
Rb-89	0.00E+00	5.13E+02	4.31E+02	0.00E+00	0.00E+00	0.00E+00	2.81E+00
Sr-89	5.99E+05	0.00E+00	1.72E+04	0.00E+00	0.00E+00	2.15E+06	1.67E+05
Sr-90	1.01E+08	0.00E+00	6.43E+06	0.00E+00	0.00E+00	1.47E+07	3.43E+05
Y-91	9.13E+05	0.00E+00	2.43E+04	0.00E+00	0.00E+00	2.62E+06	1.84E+05
Zr-95	1.90E+05	4.17E+04	3.69E+04	0.00E+00	5.95E+04	2.23E+06	6.10E+04
Zr-97	2.79E+02	4.04E+01	2.38E+01	0.00E+00	5.78E+01	1.68E+05	5.22E+05
Nb-95	2.35E+04	9.16E+03	6.54E+03	0.00E+00	8.61E+03	6.13E+05	3.69E+04
Nb-97	6.38E-01	1.14E-01	5.36E-02	0.00E+00	1.27E-01	5.08E+03	4.14E+04
Mo-99	0.00E+00	2.56E+02	6.33E+01	0.00E+00	5.83E+02	2.01E+05	1.88E+05
Tc-99M	2.65E-03	5.18E-03	8.58E-02	0.00E+00	7.54E-02	1.41E+03	7.15E+03
Ru-103	2.79E+03	0.00E+00	1.07E+03	0.00E+00	7.02E+03	6.61E+05	4.47E+04
Ru-106	1.36E+05	0.00E+00	1.69E+04	0.00E+00	1.84E+05	1.43E+07	4.29E+05
Ag-110M	1.68E+04	1.14E+04	9.13E+03	0.00E+00	2.12E+04	5.47E+06	1.00E+05
Sn-113	9.00E+03	2.91E+02	9.83E+03	1.19E+02	2.02E+02	3.40E+05	7.45E+03
Sb-124	5.73E+04	7.40E+02	2.00E+04	1.26E+02	0.00E+00	3.24E+06	1.64E+05
Sb-125	9.84E+04	7.59E+02	2.07E+04	9.10E+01	0.00E+00	2.32E+06	4.03E+04
Te-127m	2.48E+04	8.53E+03	3.01E+03	6.06E+03	6.35E+04	1.48E+06	7.13E+04
Te-127	4.12E+00	1.41E+00	9.08E-01	2.92E+00	1.05E+01	1.49E+04	8.36E+04
Te-129M	1.92E+04	6.84E+03	3.04E+03	6.32E+03	5.02E+04	1.76E+06	1.81E+05
Te-129	1.45E-01	5.20E-02	3.54E-02	1.06E-01	3.82E-01	4.36E+03	3.79E+04
Te-131M	2.00E+02	8.80E+01	7.54E+01	1.45E+02	5.94E+02	3.06E+05	4.58E+05
Te-131	3.23E-02	1.25E-02	9.79E-03	2.52E-02	8.75E-02	3.05E+03	1.98E+03
Te-132	7.15E+02	4.05E+02	3.92E+02	4.72E+02	2.63E+03	5.61E+05	2.05E+05
I-131	4.80E+04	4.80E+04	2.72E+04	1.62E+07	7.87E+04	0.00E+00	2.84E+03
I-132	2.11E+03	4.06E+03	1.87E+03	1.93E+05	6.24E+03	0.00E+00	3.20E+03
I-133	1.66E+04	2.03E+04	7.68E+03	3.84E+06	3.37E+04	0.00E+00	5.47E+03
I-134	1.74E+03	3.21E+03	1.48E+03	7.54E+04	4.91E+03	0.00E+00	1.42E+03
I-135	4.91E+03	8.72E+03	4.14E+03	7.91E+05	1.34E+04	0.00E+00	4.43E+03
Cs-134	6.50E+05	1.01E+06	2.24E+05	0.00E+00	3.30E+05	1.21E+05	3.84E+03
Cs-136	6.50E+04	1.71E+05	1.16E+05	0.00E+00	9.53E+04	1.45E+04	4.17E+03
Cs-137	9.05E+05	8.24E+05	1.28E+05	0.00E+00	2.82E+05	1.04E+05	3.61E+03
Ba-140	7.39E+04	6.47E+01	4.32E+03	0.00E+00	2.11E+01	1.74E+06	1.02E+05
Ce-141	3.92E+04	1.95E+04	2.89E+03	0.00E+00	8.53E+03	5.43E+05	5.65E+04
Ce-144	6.76E+06	2.11E+06	3.61E+05	0.00E+00	1.17E+06	1.19E+07	3.88E+05
Hf-181	8.44E+04	3.28E+02	8.50E+03	2.76E+02	2.64E+02	7.95E+05	5.31E+04
Np-239	6.93E+02	4.97E+01	3.49E+01	0.00E+00	1.45E+02	8.64E+04	9.52E+04

3.3 COMPLIANCE WITH 10CFR50

The calculations described in Section 3.2 will be used to ensure compliance with the limits in 10 CFR 50 Appendix I for each release. Summation of doses for all releases for the quarter and year are compared to the limits in 10CFR50 Appendix I to ensure compliance.

With the exception of Carbon-14, the SHNPP ODCM calculates the dose to a single maximum (ALARA) individual. The ALARA individual is an individual that "lives" at the site boundary in the sector that has the most limiting long-term average X/Q value. The Carbon-14 dose is based upon the dose to a child who resides at the location with the most limiting X/Q for a garden.

3.3.1 Noble Gases

1. Cumulation of Doses

Based upon NUREG-0133, the air dose in the unrestricted area due to noble gases released in gaseous effluents can be determined by the following equations:

$$D_{\gamma} = 3.17 \text{ E} - 08 \sum_i M_i [\overline{(X / Q)}_{i_v} \tilde{Q}_{i_v} + \overline{(X / q)}_{i_v} \tilde{q}_{i_v}] \quad (3.3-1)$$

$$D_{\beta} = 3.17 \text{ E} - 08 \sum_i N_i [\overline{(X / Q)}_{i_v} \tilde{Q}_{i_v} + \overline{(X / q)}_{i_v} \tilde{q}_{i_v}] \quad (3.3-2)$$

where:

D_{γ} = The air dose from gamma radiation, mrad.

D_{β} = The air dose from beta radiation, mrad.

3.17 E-08 = The inverse of the number of seconds in a year (sec/year)⁻¹.

M_i = The air dose factor due to gamma emissions for each identified noble gas radionuclide (mrad/yr/ $\mu\text{Ci}/\text{m}^3$). A unit conversion constant of 1.1 mrad/mrem converts air dose to skin dose. Table 3.2-3.

N_i = The air dose factor due to beta emissions for each identified noble gas radionuclide "i," mrad/year per $\mu\text{Ci}/\text{m}^3$. Table 3.2-3.

$\overline{X/Q}_v$ = The relative concentration for areas at or beyond the exclusion boundary for long-term ground-level vent stack releases (≥ 500 hours/year), sec/m^3 . See Section 3.0 concerning ground-level releases at Shearon Harris Nuclear Plant or use $1.8\text{E}-05 \text{ sec}/\text{m}^3$ from Table A1 through A4, Appendix A as the most limiting X/Q_v .

$\overline{X/q}_v$ = The relative concentration for areas at or beyond the exclusion boundary for short-term ground-level vent stack releases (≤ 500 hours/year), sec/m^3 . See Section 3.0 concerning ground-level releases at Shearon Harris Nuclear Plant or use $1.8\text{E}-05 \text{ sec}/\text{m}^3$ from Table A1 through A4, Appendix A as the most limiting X/Q_v .

\tilde{Q}_{i_v} = The total release of noble gas radionuclide "i" in gaseous effluents for long term releases (>500 hrs/yr) from all vent stacks (μCi).

\tilde{q}_{i_v} = The total release of radionuclide "i" in gaseous releases for short-term releases (≤ 500 hours/year) from all vent stacks, (μCi).

3.3.1 Noble Gases (continued)

To show compliance with 10CFR50, Expressions 3.3-1 and 3.3-2 are evaluated at the controlling location where the air doses are at a maximum.

At SHNPP the limiting location is the exclusion boundary at 1.33 miles (~2.14 kilometers) in the SW sector based upon the tables presented in Appendix A (see Section 3.2.1 earlier). For this document, long-term annual average X/Q_v values can be used in lieu of short-term values. See Section 3.0 concerning ground-level releases at Shearon Harris Nuclear Plant.

The determination of the limiting location for implementation of 10CFR50 is a function of parameters such as radionuclide mix and meteorology. To select the limiting location, the highest annual average X/Q_v value for ground-level releases is controlling. The only source of short-term releases from the plant vent are containment purges, containment pressure relief, and waste gas decay tank release. Determination of source terms is described in 3.3.1.2.

Values for M_i and N_i , which are utilized in the calculation of the gamma air and beta air doses in Equation 3.3-1 to show compliance with 10CFR50, are presented in Table 3.2-3. These values originate from Table B-1 of the NRC Regulatory Guide 1.109, Revision 1. The values have been multiplied by $1.0E+06$ to convert from mrad/pCi to $\text{mrad}/\mu\text{Ci}$.

The following relationships should hold for SHNPP to show compliance with ODCM Operational Requirement 3.11.2.2.

For the calendar quarter:

$$D_\gamma \leq 5 \text{ mrad} \quad (3.3-3)$$

$$D_\beta \leq 10 \text{ mrad} \quad (3.3-4)$$

For the calendar year:

$$D_\gamma \leq 10 \text{ mrad} \quad (3.3-5)$$

$$D_\beta \leq 20 \text{ mrad} \quad (3.3-6)$$

The quarterly limits given above represent one-half of the annual design objectives of Section II.B.1 of Appendix I of 10CFR50. If any of the limits of Equations 3.3-3 through 3.3-6 are exceeded, a Special Report pursuant to Technical Specification 6.9.2 must be filed with the NRC. This report complies with Section IV.A of Appendix I of 10CFR50.

3.3.1 Noble Gases (continued)

2. Source Term Determination

Containment Batch Purge

A purge of containment may be started as a Batch purge and continued as a normal purge. The containment Batch Purge volume is considered to be two air containment volumes (RCB vol = 2.26E+06 ft³). The containment air is sampled and analyzed for noble gases and tritium prior to release. Stack 1 has a continuous particulate filter and iodine cartridge sampler that is analyzed weekly (minimum) and used for total particulate and iodine effluent accountability for continuous releases. The noble gases and tritium analysis are used for containment effluent accountability as follows;

$$q_i = C_i \cdot v_b \quad (3.3-7)$$

Where;

q_i = Activity of nuclide "i" released (μ Ci).

C_i = Concentration of radionuclide "i" (μ Ci/cc)

v_b = Containment purge volume (cc).

Waste Gas Decay Tank Batch Releases

Waste Gas Decay Tanks (WGDT) are sampled and analyzed for tritium and noble gases prior to each release. Stack 5 has a continuous particulate filter and iodine cartridge sampler that is analyzed weekly (minimum) and used for total particulate and iodine effluent accountability for continuous releases. The activity (μ Ci) for nuclide "i" for Waste Gas Decay Tank effluent accountability is calculated as follows;

$$q_i = \frac{(C_i \cdot \Delta P_t \cdot 600 \cdot 28316.85 \cdot 273)}{(14.7 \cdot 283)} \quad (3.3-7a)$$

Where;

q_i = Activity of nuclide "i" released (μ Ci).

C_i = Concentration of nuclide "i" (μ Ci/cc).

ΔP_t = Change in pressure (psia) of the WGDT
 (psia = psig + 14.7)

600 = WGDT volume, (ft³).

28316.85 = Conversion factor for converting from ft³ to cc.

273 = Standard Temperature for 0°C (°K).

14.7 = Sample pressure at time of measurement, (psia).

283 = WGDT Temperature, °k (see Note below)

NOTE: The FSAR assumes WGDT temperature to be in the 50-140 °F range. Since there is no indicator for the actual WGDT temperature, 50°F (10°C) is conservatively assumed as an acceptable substitute.

3.3.1 Noble Gases (continued)

Containment Pressure Releases

Containment Pressure Releases (ILRT) are calculated using the same methodology as Waste Gas Decay Tank Batch Releases. Containment Pressure Releases are released via Stack 1 and pressurization piping. The volume to use is 2.26E+06 ft³.

Continuous Releases

Each of the four effluent stacks at the HNP have noble gas monitors. Using the net concentration ($\mu\text{Ci/cc}$) from these monitors times the volume released (determined from the flow monitors) the total activity (μCi) of noble gases released are calculated as follows:

$$Q_x = C_x \cdot V_x \quad (3.3-8)$$

Where;

Q_x = Total activity (μCi) released from Stack "x".

C_x = Net concentration ($\mu\text{Ci/cc}$) from Stack "x" noble gas monitor.

V_x = Volume (cc) released from Stack "x" using the flow monitor and, if out of service use the compensatory measurements for volume determination.

The activity (μCi) released for radionuclide "i" equals the radionuclide "i" fraction of the radionuclide mix times the total activity released from Stack "x".

$$Q_i = Q_x \cdot S_i \quad (3.3-8a)$$

Where;

$$S_i = \frac{c_i}{\sum c_i} \quad (3.3-8b)$$

and;

S_i = The radionuclide "i" fraction of the radionuclide mix

C_i = The concentration of nuclide "i" in the grab sample ($\mu\text{Ci/cc}$).

$\sum C_i$ = Total activity in grab sample ($\mu\text{Ci/cc}$).

The radionuclide mix is based on the sampling and analysis required by ODCM Operational Requirement 4.11.2.2.1. If the grab sample activity is < LLD, then a mix based on historical data or a mix based on the Xe-133 / Kr-85 LLD mix of that sample may be used.

When a monitor is out of service, the results of the compensatory sampling for each nuclide times the volume released for that time interval will be used for effluent accountability. During this situation if the sample shows no detectable activity then there is no activity released.

Corrections for Double Accounting

For the two stacks that may have batch releases during the same time interval as continuous releases, the above calculations are corrected for double accounting as follows;

$$Q_{ic} = Q_i - q_i \quad (3.3-9)$$

Where;

Q_{ic} = Total corrected activity of nuclide "i" (μCi) from Stack "x" when batch releases are being made during that time period.

For short term (batch) releases, the effluent stream is sampled and analyzed. The results of the sampling and analysis is used as the source term for the batch release. Release rate is derived from the source term and the release flow rate.

3. Projection of Doses

Doses resulting from the release of gaseous effluents will be projected once every 31 days (monthly). The doses will be projected utilizing Equations 3.3-1 and 3.3-2, and projected using the following expression:

$$D_{p\tau} = (D\tau \cdot p) + D_{at} \quad (3.3-10)$$

where:

- $D_{p\tau}$ = the 31 Day Projected Dose by organ τ
- $D\tau$ = sum of all open and closed release points from the start of the quarter to the end of the release in mrem per organ τ .
- p = the Projection Factor which is the result of 31 divided by the number of days from start of the quarter to the end of the release.
- D_{at} = Additional Anticipated Dose for liquid releases by organ τ and quarter of release.

NOTE: The 31 Day Projected Dose values appear on the Standard Permit Reports. The 31 day dose projections include any additional dose.

Where possible, expected operational evolutions (i.e., outages, increased power levels, major planned batch gas releases, etc.) should be accounted for in the dose projections. This may be accomplished by using the source-term data from similar historical operating experiences where practical, and adding the dose as Additional Anticipated Dose.

To show compliance with ODCM Operational Requirement 3.11.2.4, the projected month's dose should be compared as in the following:

$$D_\gamma \leq 0.2 \text{ mrad to air for gamma radiation} \quad (3.3-11)$$

and

$$D_\beta \leq 0.4 \text{ mrad to air for beta radiation} \quad (3.3-12)$$

If the projections exceed either Equations 3.3-11 or 3.3-12, then the appropriate portions of the gaseous radwaste treatment system shall be used to reduce releases of radioactivity.

3.3.2 Radioiodine and Particulates

1. Cumulation of Doses

Section II.C of Appendix I of 10CFR50 limits the release of radioiodines and radioactive material in particulate form from a reactor such that the estimated dose or dose commitment to an individual in an unrestricted area from all pathways of exposure is not in excess of 15 mrem to any organ. Based upon NUREG-0133, the dose to an organ of an individual from radioiodines and particulates with half-lives greater than 8 days in gaseous effluents released to unrestricted areas can be determined by the following equation:

$$D_r = 3.17E-08 \sum_i (R_{iI}) \left[\overline{(X/Q)}_V \tilde{Q}_{iV} + \overline{(X/q)}_V \tilde{q}_{iV} \right] +$$

$$(R_{iM} + R_{iV} + R_{iG} + R_{iB}) \left[\overline{(D/Q)}_V \tilde{Q}_{iV} + \overline{(D/q)}_V \tilde{q}_{iV} \right] +$$

$$(R_{TM} + R_{TI} + R_{TV} + R_{TB}) \left[\overline{(X/Q)}_V \tilde{Q}_{TV} + \overline{(X/q)}_V \tilde{q}_{TV} \right]$$

where:

- D_τ = Dose to any organ τ from tritium, radioiodines, and particulates, mrem.
- $\overline{(D/Q)}_V$ = The highest long-term (> 500 hr/yr) annual average relative deposition: $9.0E-09 \text{ m}^{-2}$ for the food and ground plane pathways at the controlling location which is the exclusion boundary in the SW sector (from Table A1 through A4, Appendix A, for ground-level vent stack releases).
- $\overline{(D/q)}_V$ = The relative deposition factor for short term, ground-level vent releases ($\leq 500 \text{ hrs/yr}$), in m^{-2} . See Section 3.0 concerning ground-level releases at Shearon Harris Nuclear Plant if using "real" meteorology or use $9.0E-09 \text{ m}^{-2}$ from Table A1 through A4, Appendix A, for the food and ground plane pathways at the controlling location.
- R_{iM} = Dose factor for an organ for radionuclide "i" for either the cow milk or goat milk pathway, mrem/yr per $\mu\text{Ci/sec per m}^{-2}$.
- R_{iG} = Dose factor for an organ for radionuclide "i" for the ground plane exposure pathway, mrem/yr per $\mu\text{Ci/sec per m}^{-2}$.
- R_{iI} = Dose factor for an organ for radionuclide "i" for the inhalation pathway, mrem/yr per $\mu\text{Ci/m}^3$.
- R_{iV} = Dose factor for an organ for radionuclide "i" for the vegetable pathway, mrem/yr per $\mu\text{Ci/sec per m}^{-2}$.
- R_{iB} = Dose factor for an organ for radionuclide "i" for the meat pathway, mrem/yr per $\mu\text{Ci/sec per m}^{-2}$.
- R_{TM} = Dose factor for an organ for tritium for the milk pathway mrem/yr per $\mu\text{Ci/m}^3$.
- R_{TV} = Dose factor for an organ for tritium for the vegetable pathway, mrem/yr per $\mu\text{Ci/m}^3$.
- R_{TI} = Dose factor for an organ for tritium for the inhalation pathway, mrem/yr per $\mu\text{Ci/m}^3$.

3.3.2 Radioiodine and Particulates (continued)

R_{TB}	=	Dose factor for an organ for tritium for the meat pathway, mrem/yr per $\mu\text{Ci}/\text{m}^3$.
\tilde{Q}_{TV}	=	Release of tritium in gaseous effluents for long-term vent stack releases (> 500 hrs/yr), μCi .
\tilde{q}_{TV}	=	Release of tritium in gaseous effluents for short-term vent stack releases (\leq 500 hrs/yr), μCi .

To show compliance with 10CFR50, Equation 3.3-13 is evaluated for a hypothetical individual at the limiting location. At SHNPP the SW sector has the highest X/Q_v and the SW and SSW sector have the highest annual average D/Q_v values. This assures that the actual exposure of a member of the public will not be substantially underestimated. The critical receptor is a child.

Appropriate X/Q_v and D/Q_v values from tables in Appendix A are used. For this document, long-term annual average X/Q_v and D/Q_v values may be used in lieu of short-term values (see Section 3.0 concerning ground-level releases at Shearon Harris Nuclear Plant).

The determination of a limiting location for implementation of 10CFR50 for radioiodines and particulates is a function of:

1. Isotopic mix
2. Meteorology
3. Exposure pathway
4. Receptor's age

In the determination of the limiting location, the radionuclide mix of radioiodines and particulates is based on the sampling and analysis required by ODCM Operational Requirement 4.11.2.1.2. If the analysis is < LLD, then no activity is assumed to have been released during the sampling period. The release rate is derived from the flow (actual or default) and the isotopic mix.

In the determination of the limiting sector, all age groups and all of the exposure pathways are evaluated using the highest XOQDOQ values in Appendix A at the site boundary. These include beef and vegetable ingestion, inhalation, and ground plane exposure.

SHNPP ODCM Operational Requirement 3.12.2 requires that a land-use census survey be conducted on an annual basis. The age groupings at the various receptor locations are also determined during this survey. Thus, depending on the results of the survey, a new limiting location and receptor age group could result.

To avoid possible annual revisions to the ODCM software which evaluates effluent releases for compliance with 10CFR50, the limiting sector location has been fixed at the exclusion boundary in the SW sector. (Appendix A). With all of the exposure pathways identified in the Land Use Census (ODCM Operational Requirement 3.12.2). This approach avoids a substantial underestimate of the dose to a real member of the public.

Long-term X/Q_v and D/Q_v values for ground-level releases are provided in tables in Appendix A. They may be utilized if an additional special location arises different from those presented in the special locations of the Land Use Census (ODCM Operational Requirement 3.12.2). A description of the derivation of the various X/Q and D/Q values is presented in Appendix A.

3.3.2 Radioiodine and Particulates (continued)

Tables 3.3-1 through 3.3-19 present R_i values for the total body, GI-tract, bone, liver, kidney, thyroid, and lung organs for the ground plane, inhalation, cow milk, goat milk, vegetable, and meat ingestion pathways for the infant, child, teen, and adult age groups as appropriate to the pathways. These values were calculated using the methodology described in NUREG-0133 assuming a grazing period of eight months. A description of the methodology is presented in Appendix B.

The following relationship should hold for SHNPP to show compliance with SHNPP ODCM Operational Requirement 3.11.2.3.

For the calendar quarter:

$$D_{\tau} \leq 7.5 \text{ mrem} \quad (3.3-14)$$

For the calendar year:

$$D_{\tau} \leq 15 \text{ mrem} \quad (3.3-15)$$

The quarterly limits given above represent one-half the annual design objectives of Section II.C of Appendix I of 10CFR50. If any of the limits of Equations 3.3-14 or 3.3-15 are exceeded, a Special Report pursuant to Technical Specification 6.9.2 must be filed with the NRC. This report complies with Section IV.A of Appendix I of 10CFR50.

3.3.2 Radioiodine and Particulates (continued)

2. Projection of Doses

Doses resulting from release of radioiodines and particulates will be projected once every 31 days (monthly). The doses will be projected utilizing Equation 3.3-13, and projected using the following expression:

$$D_{p\tau} = (D_{\tau} \cdot p) + D_{at} \quad (3.3-16)$$

where:

- $D_{p\tau}$ = the 31 Day Projected Dose by organ τ
- D_{τ} = sum of all open and closed release points from the start of the quarter to the end of the release in mrem per organ τ .
- p = the Projection Factor which is the result of 31 divided by the number of days from start of the quarter to the end of the release.
- D_{at} = Additional Anticipated Dose for gaseous releases by organ τ and quarter of release.

NOTE: The 31 Day Projected Dose values appear on the Standard Permit Reports. The 31 day dose projections include any additional dose.

When possible, expected operational evolutions (i.e., outages, increased power levels, major planned batch gas releases, etc.) should be accounted for in the dose projections. This may be accomplished by using the source-term data from similar historical operating experiences where practical, and adding the dose as Additional Anticipated Dose.

To show compliance with ODCM Operational Requirement 3.11.2.4, the projected month's dose should be compared as in the following:

$$D \leq 0.3 \text{ mrem to any organ} \quad (3.3-17)$$

If the projections exceed Expression 3.3-14, then the appropriate portions of the gaseous radwaste treatment system shall be used to reduce releases of radioactivity.

3.3.2 Carbon 14

Carbon-14 may become a principal radionuclide for the gaseous effluent pathway. It is produced by several nuclear reactions. In a nuclear reactor the most dominate mechanism is the reaction of O-17 in the fuel or water with a neutron to produce C-14 and an alpha particle. C-14 releases in PWRs occur primarily as a mix of organic carbon and carbon dioxide released from the waste gas system. Because the dose contribution of C-14 from liquid radioactive waste is much less than that contributed by gaseous radioactive waste, evaluation of C-14 in liquid waste is not required. The dose rate and subsequent dose to an individual from C-14 intake depends upon the specific activity of the food from each source and the amount of the ingested C-14 which is retained over the period under consideration.

The quantity of C-14 discharged can be estimated by sample measurements or by use of a normalized C-14 source term and scaling factors based upon power generation. NUREG-0017 Rev 1 "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Reactors" gives a C-14 source term based on measurements at 10 operating power plants. The C-14 source term recommended by NUREG-0017 (FSAR 11.1.5) is 7.3 curies/year for an 80% capacity factory or 292 Effective Full Power Days. It is not necessary to calculate uncertainties for C-14 or to include C-14 uncertainty in any calculation of overall uncertainty.

In the determination of the limiting sector, all age groups and all of the exposure pathways are evaluated using the highest XOQDOQ values in Appendix A at the site boundary. These include milk, meat and vegetable ingestion, and inhalation. Inorganic atmosphere Carbon Dioxide (CO₂)

3.3.2 Carbon 14 (continue)

and Methane (CO) is incorporated in cellular material by the photosynthetic actions of green plants. Plants and grasses, from which most food stuff are derived, equilibrate with the C-14 CO₂ of the air. Due to the Primary Water System reducing environment, only 30% of the C-14 is released in the inorganic form.

Reg Guide 1.21, Rev 2 states that for PWR C-14 is released primarily through the waste gas system. IAEA Technical Reports Series No. 421 states that 70% of C-14 gaseous effluent from PWRs can be assumed to be from batch releases (WGDTs) and 30% from continuous stack releases. To address intermittent releases, a photosynthesis factor (p factor) is used as the ratio of the total release time (for C-14 atmospheric releases) to the total time which photosynthesis occurs (taken to be 4460 hours/year or 1115 hours/quarter).

SHNPP ODCM Operational Requirement 3.12.2 requires that a land-use census survey be conducted on an annual basis. The age groupings at the various receptor locations are also determined during this survey. Thus, depending on the results of the survey, a new limiting location and receptor age group could result.

Regulatory Guide 1.109 provides the detailed implementation guidance to show compliance with Appendix I of 10 CFR 50 limits.

1. Dose from Inhalation of Carbon-14 in Air

The average airborne concentration of C-14 at the location with respect to the release point may be determined as:

$$X_c = 3.17 \times 10^4 Q_c \left(\frac{X}{Q} \right) \quad (3.3-18)$$

X_c = the average ground-level concentration of C-14 in air, in pCi/m³

Q_c = is the release rate of C-14 to the atmosphere, in Ci/yr, this can be determined by:

(1) using actual sample data obtained during the reporting period

(2) estimation by correcting the FSAR 11.1.5 annual C-14 curies released for actual capacity factor using the number of effective full power days (EFPD) for the reporting period

$$Q_c = \frac{7.3 \times \text{EFPD}}{292} \quad (3.3-19)$$

X/Q = annual average atmosphere dispersion factor, in sec/m³ for ground level release with no decay, Table A1 through A4, Appendix A

3.17×10^4 = is the number of pCi/Ci divided by the number of sec/yr

The dose associated with inhalation for C-14, to organ (j) to an age group (a), is then:

$$D_{ja}^A = (U_a^i)(DFA_{ja})(X_c) \quad (3.3-20)$$

D_{ja}^A = the dose from inhalation to an organ (j) of an age group (a) from C-14 in mrem

X_c = the average ground-level concentration of C-14 in air, in pCi/m³

U_a^i = Inhalation rate for age group (a), Table 3.3-20, in m³/yr

DFA_{ja} = Dose factor for an organ from carbon-14 for the inhalation pathway to an organ (j) of an age group (a), mrem/pCi Table 3.3-21

3.3.2 Carbon 14 (continue)

2. Concentration of Airborne Carbon-14 in vegetation

The concentration of Carbon-14 in vegetation at location with respect to the release point may be determined as:

$$C_{14}^V = (3.17 \times 10^7)(p)(Q_{14})\left(\frac{X}{Q}\right)\left(\frac{0.11}{0.16}\right) \quad (3.3-21)$$

C_{14}^V = The concentration of C-14 in vegetation in pCi/kg

p = the fractional equilibrium fraction, dimensionless

$$= (0.70)(\text{WGDT Release Hr})/(L) + (0.30)(\text{Continuous Release Hrs})/(L)$$

L = hours photosynthesis occurs
L = 1115 hours/qtr or 4460 hours/yr

Q_{14} = release rate of C-14 from a PWR, assume 30% of C-14 release rate in lieu of site specific data, in Ci

$$= 0.30 \times Q_c$$

X/Q = annual average atmosphere dispersion factor, in sec/m^3 for ground level release with no decay, Table A1 through A4, Appendix A

$$3.17 \text{ E}+07 = (10^{12} \text{ pCi}/\text{Ci})(10^3 \text{ g}/\text{kg}) / (3.15\text{E}+07 \text{ sec}/\text{yr})$$

0.11 = fraction of total plant mass that is natural carbon, dimensionless

0.16 = concentration of natural carbon in the atmosphere, in g/m^3

3. Concentration of Airborne Carbon-14 in Milk

The concentration of Carbon-14 in milk is dependent on the amount of contamination level of the feed consumed by the animal.

$$C_{14}^M = (F_m)(C_{14}^V)(Q_f) \quad (3.3-22)$$

C_{14}^M = The concentration of C-14 in milk, pCi/L

F_m = average fraction of the animal's daily intake of C-14 that appears in each liter of milk, in days/liter

$$= \text{Cow or cattle} = 0.012 \text{ days}/\text{liter}, \text{ goat} = 0.10 \text{ days}/\text{liter}$$

C_{14}^V = The concentration of C-14 in animal's feed, in pCi/kg

Q_f = amount of feed consumed by the animal per day, in kg/day

$$= \text{Cow or cattle} = 50 \text{ kg}, \text{ goat} = 6 \text{ kg}$$

3.3.2 Carbon 14 (continue)

4. Concentration of Airborne Carbon-14 in Meat

$$C_{14}^B = (F_F)(C_{14}^V)(Q_f) \quad (3.3-23)$$

- C_{14}^B = The concentration of C-14 in meat, pCi/kg
- F_F = average fraction of the animal's daily intake of C-14 that appears in each kilogram of flesh, in days/kg
- = 0.031
- C_{14}^V = The concentration of C-14 in animal's feed, in pCi/kg
- Q_f = amount of feed consumed by the animal per day, in kg/day
- = Cow or cattle = 50 kg, goat = 6 kg

5. Dose from Atmospherically Released Carbon-14 in Foods

$$D_{ja}^D = DFI_{ja} [U_a^V f_g C_{14}^V + U_a^M C_{14}^M + U_a^B C_{14}^B + U_a^L f_l C_{14}^V] \quad (3.3-24)$$

- D_{ja}^D = the dose to organ (j) of an individual in age group (a) from the dietary intake of atmospherically released Carbon-14, in mrem
- DFI_{ja} = the dose conversion factor for the ingestion of Carbon-14, organ (j), and age group (a), in mrem/pCi Table 3.3-22
- U_a^V = ingestion rate of produce (non-leafy vegetables, fruit, grains), in kg/yr, Table 3.3-20
- U_a^M = ingestion rate of milk, in l/yr, Table 3.3-20
- U_a^B = ingestion rate of meat and poultry in kg/yr, Table 3.3-20
- U_a^L = ingestion rate of leafy vegetables, in kg/yr, Table 3.3-20
- f_g = fraction of produce ingested grown in the garden of interest
- = 0.76, in lieu of site specific data
- f_l = fraction of leafy vegetables in the garden of interest
- = 1.0, in lieu of site specific data
- C_{14}^V = The concentration of C-14 in vegetation, in pCi/kg
- C_{14}^M = The concentration of C-14 in milk, pCi/kg
- C_{14}^B = The concentration of C-14 in meat, pCi/kg

TABLE 3.3-1
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Ground

AGE GROUP = ALL

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Na-24	1.71E+07	1.71E+07	1.71E+07	1.71E+07	1.71E+07	1.71E+07	1.71E+07
Cr-51	4.66E+06	4.66E+06	4.66E+06	4.66E+06	4.66E+06	4.66E+06	4.66E+06
Mn-54	1.34E+09	1.34E+09	1.34E+09	1.34E+09	1.34E+09	1.34E+09	1.34E+09
Mn-56	1.29E+06	1.29E+06	1.29E+06	1.29E+06	1.29E+06	1.29E+06	1.29E+06
Fe-59	2.75E+08	2.75E+08	2.75E+08	2.75E+08	2.75E+08	2.75E+08	2.75E+08
Co-57	1.88E+08	1.88E+08	1.88E+08	1.88E+08	1.88E+08	1.88E+08	1.88E+08
Co-58	3.79E+08	3.79E+08	3.79E+08	3.79E+08	3.79E+08	3.79E+08	3.79E+08
Co-60	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.15E+10
Ni-65	4.24E+05	4.24E+05	4.24E+05	4.24E+05	4.24E+05	4.24E+05	4.24E+05
Cu-64	8.67E+05	8.67E+05	8.67E+05	8.67E+05	8.67E+05	8.67E+05	8.67E+05
Zn-65	7.49E+08	7.49E+08	7.49E+08	7.49E+08	7.49E+08	7.49E+08	7.49E+08
Zn-69M	3.44E+06	3.44E+06	3.44E+06	3.44E+06	3.44E+06	3.44E+06	3.44E+06
Br-82	5.11E+07	5.11E+07	5.11E+07	5.11E+07	5.11E+07	5.11E+07	5.11E+07
Br-83	6.94E+03	6.94E+03	6.94E+03	6.94E+03	6.94E+03	6.94E+03	6.94E+03
Br-84	2.89E+05	2.89E+05	2.89E+05	2.89E+05	2.89E+05	2.89E+05	2.89E+05
Rb-86	8.99E+06	8.99E+06	8.99E+06	8.99E+06	8.99E+06	8.99E+06	8.99E+06
Rb-88	4.72E+04	4.72E+04	4.72E+04	4.72E+04	4.72E+04	4.72E+04	4.72E+04
Rb-89	1.75E+05	1.75E+05	1.75E+05	1.75E+05	1.75E+05	1.75E+05	1.75E+05
Sr-89	2.23E+04	2.23E+04	2.23E+04	2.23E+04	2.23E+04	2.23E+04	2.23E+04
Sr-91	3.07E+06	3.07E+06	3.07E+06	3.07E+06	3.07E+06	3.07E+06	3.07E+06
Sr-92	1.11E+06	1.11E+06	1.11E+06	1.11E+06	1.11E+06	1.11E+06	1.11E+06
Y-90	6.42E+03	6.42E+03	6.42E+03	6.42E+03	6.42E+03	6.42E+03	6.42E+03
Y-91M	1.43E+05	1.43E+05	1.43E+05	1.43E+05	1.43E+05	1.43E+05	1.43E+05
Y-91	1.08E+06	1.08E+06	1.08E+06	1.08E+06	1.08E+06	1.08E+06	1.08E+06
Y-92	2.57E+05	2.57E+05	2.57E+05	2.57E+05	2.57E+05	2.57E+05	2.57E+05
Y-93	2.62E+05	2.62E+05	2.62E+05	2.62E+05	2.62E+05	2.62E+05	2.62E+05
Zr-95	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08
Zr-97	4.21E+06	4.21E+06	4.21E+06	4.21E+06	4.21E+06	4.21E+06	4.21E+06
Nb-95	1.36E+08	1.36E+08	1.36E+08	1.36E+08	1.36E+08	1.36E+08	1.36E+08
Nb-97	4.43E+07	4.43E+07	4.43E+07	4.43E+07	4.43E+07	4.43E+07	4.43E+07
Mo-99	5.71E+06	5.71E+06	5.71E+06	5.71E+06	5.71E+06	5.71E+06	5.71E+06
Tc-99M	2.63E+05	2.63E+05	2.63E+05	2.63E+05	2.63E+05	2.63E+05	2.63E+05

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-1 (Continue)
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Ground

AGE GROUP = ALL

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Tc-101	2.91E+04	2.91E+04	2.91E+04	2.91E+04	2.91E+04	2.91E+04	2.91E+04
Ru-103	1.09E+08	1.09E+08	1.09E+08	1.09E+08	1.09E+08	1.09E+08	1.09E+08
Ru-105	9.08E+05	9.08E+05	9.08E+05	9.08E+05	9.08E+05	9.08E+05	9.08E+05
Ru-106	4.19E+08	4.19E+08	4.19E+08	4.19E+08	4.19E+08	4.19E+08	4.19E+08
Ag-110M	3.48E+09	3.48E+09	3.48E+09	3.48E+09	3.48E+09	3.48E+09	3.48E+09
Sn-113	1.22E+07	6.21E+06	1.44E+07	1.33E+07	1.00E+07	8.14E+06	6.28E+06
Sb-124	8.99E+08	7.76E+08	8.76E+08	1.01E+09	8.17E+08	8.23E+08	7.53E+08
Sb-125	2.34E+09	2.34E+09	2.34E+09	2.34E+09	2.34E+09	2.34E+09	2.34E+09
Te-125M	1.55E+06	1.55E+06	1.55E+06	1.55E+06	1.55E+06	1.55E+06	1.55E+06
Te-127m	9.15E+04	9.15E+04	9.15E+04	9.15E+04	9.15E+04	9.15E+04	9.15E+04
Te-127	4.25E+03	4.25E+03	4.25E+03	4.25E+03	4.25E+03	4.25E+03	4.25E+03
Te-129M	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07
Te-129	3.75E+04	3.75E+04	3.75E+04	3.75E+04	3.75E+04	3.75E+04	3.75E+04
Te-131M	1.15E+07	1.15E+07	1.15E+07	1.15E+07	1.15E+07	1.15E+07	1.15E+07
Te-131	4.17E+04	4.17E+04	4.17E+04	4.17E+04	4.17E+04	4.17E+04	4.17E+04
Te-132	6.05E+06	6.05E+06	6.05E+06	6.05E+06	6.05E+06	6.05E+06	6.05E+06
I-130	7.88E+06	7.88E+06	7.88E+06	7.88E+06	7.88E+06	7.88E+06	7.88E+06
I-131	1.72E+07	1.72E+07	1.72E+07	1.72E+07	1.72E+07	1.72E+07	1.72E+07
I-132	1.24E+06	1.24E+06	1.24E+06	1.24E+06	1.24E+06	1.24E+06	1.24E+06
I-133	2.47E+06	2.47E+06	2.47E+06	2.47E+06	2.47E+06	2.47E+06	2.47E+06
I-134	6.38E+05	6.38E+05	6.38E+05	6.38E+05	6.38E+05	6.38E+05	6.38E+05
I-135	2.56E+06	2.56E+06	2.56E+06	2.56E+06	2.56E+06	2.56E+06	2.56E+06
Cs-134	6.82E+09	6.82E+09	6.82E+09	6.82E+09	6.82E+09	6.82E+09	6.82E+09
Cs-136	1.49E+08	1.49E+08	1.49E+08	1.49E+08	1.49E+08	1.49E+08	1.49E+08
Cs-137	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.03E+10
Cs-138	5.13E+05	5.13E+05	5.13E+05	5.13E+05	5.13E+05	5.13E+05	5.13E+05
Ba-139	1.51E+05	1.51E+05	1.51E+05	1.51E+05	1.51E+05	1.51E+05	1.51E+05
Ba-140	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.05E+07
Ba-141	5.97E+04	5.97E+04	5.97E+04	5.97E+04	5.97E+04	5.97E+04	5.97E+04
Ba-142	6.41E+04	6.41E+04	6.41E+04	6.41E+04	6.41E+04	6.41E+04	6.41E+04
La-140	2.74E+07	2.74E+07	2.74E+07	2.74E+07	2.74E+07	2.74E+07	2.74E+07
La-142	1.09E+06	1.09E+06	1.09E+06	1.09E+06	1.09E+06	1.09E+06	1.09E+06
Ce-141	1.36E+07	1.36E+07	1.36E+07	1.36E+07	1.36E+07	1.36E+07	1.36E+07
Ce-143	3.30E+06	3.30E+06	3.30E+06	3.30E+06	3.30E+06	3.30E+06	3.30E+06
Ce-144	6.95E+07	6.95E+07	6.95E+07	6.95E+07	6.95E+07	6.95E+07	6.95E+07
Pr-144	2.62E+03	2.62E+03	2.62E+03	2.62E+03	2.62E+03	2.62E+03	2.62E+03
Nd-147	8.40E+06	8.40E+06	8.40E+06	8.40E+06	8.40E+06	8.40E+06	8.40E+06
Hf-181	2.30E+08	1.70E+08	1.97E+08	2.33E+08	1.77E+08	1.82E+08	1.63E+08
W-187	3.36E+06	3.36E+06	3.36E+06	3.36E+06	3.36E+06	3.36E+06	3.36E+06
Np-239	2.44E+06	2.44E+06	2.44E+06	2.44E+06	2.44E+06	2.44E+06	2.44E+06

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-2
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Vegetation

AGE GROUP = Adult

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	2.28E+03	2.28E+03	2.28E+03	2.28E+03	2.28E+03	2.28E+03
Na-24	6.83E+05	6.83E+05	6.83E+05	6.83E+05	6.83E+05	6.83E+05	6.83E+05
P-32	1.53E+09	9.51E+07	5.91E+07	0.00E+00	0.00E+00	0.00E+00	1.72E+08
Cr-51	0.00E+00	0.00E+00	4.60E+04	2.75E+04	1.01E+04	6.10E+04	1.16E+07
Mn-54	0.00E+00	3.05E+08	5.83E+07	0.00E+00	9.09E+07	0.00E+00	9.36E+08
Mn-56	0.00E+00	3.98E+01	7.06E+00	0.00E+00	5.05E+01	0.00E+00	1.27E+03
Fe-55	2.00E+08	1.38E+08	3.22E+07	0.00E+00	0.00E+00	7.70E+07	7.91E+07
Fe-59	1.24E+08	2.93E+08	1.12E+08	0.00E+00	0.00E+00	8.17E+07	9.75E+08
Co-57	0.00E+00	1.13E+07	1.88E+07	0.00E+00	0.00E+00	0.00E+00	2.86E+08
Co-58	0.00E+00	2.99E+07	6.71E+07	0.00E+00	0.00E+00	0.00E+00	6.07E+08
Co-60	0.00E+00	1.66E+08	3.67E+08	0.00E+00	0.00E+00	0.00E+00	3.12E+09
Ni-63	1.20E+10	8.31E+08	4.02E+08	0.00E+00	0.00E+00	0.00E+00	1.73E+08
Ni-65	1.50E+02	1.95E+01	8.90E+00	0.00E+00	0.00E+00	0.00E+00	4.95E+02
Cu-64	0.00E+00	2.34E+04	1.10E+04	0.00E+00	5.89E+04	0.00E+00	1.99E+06
Zn-65	4.01E+08	1.28E+09	5.77E+08	0.00E+00	8.54E+08	0.00E+00	8.04E+08
Zn-69M	5.73E+04	1.38E+05	1.26E+04	0.00E+00	8.32E+04	0.00E+00	8.39E+06
Zn-69	1.29E-05	2.47E-05	1.72E-06	0.00E+00	1.61E-05	0.00E+00	3.72E-06
Br-82	0.00E+00	0.00E+00	3.90E+06	0.00E+00	0.00E+00	0.00E+00	4.47E+06
Br-83	0.00E+00	0.00E+00	7.57E+00	0.00E+00	0.00E+00	0.00E+00	1.09E+01
Br-84	0.00E+00	0.00E+00	5.51E-11	0.00E+00	0.00E+00	0.00E+00	4.32E-16
Rb-86	0.00E+00	2.21E+08	1.03E+08	0.00E+00	0.00E+00	0.00E+00	4.36E+07
Rb-88	0.00E+00	6.73E-22	3.57E-22	0.00E+00	0.00E+00	0.00E+00	9.30E-33
Rb-89	0.00E+00	6.19E-26	4.35E-26	0.00E+00	0.00E+00	0.00E+00	3.59E-39
Sr-89	1.00E+10	0.00E+00	2.87E+08	0.00E+00	0.00E+00	0.00E+00	1.60E+09
Sr-90	6.70E+11	0.00E+00	1.64E+11	0.00E+00	0.00E+00	0.00E+00	1.93E+10
Sr-91	7.70E+05	0.00E+00	3.11E+04	0.00E+00	0.00E+00	0.00E+00	3.67E+06
Sr-92	1.07E+03	0.00E+00	4.64E+01	0.00E+00	0.00E+00	0.00E+00	2.13E+04
Y-90	3.43E+04	0.00E+00	9.19E+02	0.00E+00	0.00E+00	0.00E+00	3.63E+08
Y-91M	1.20E-08	0.00E+00	4.66E-10	0.00E+00	0.00E+00	0.00E+00	3.53E-08
Y-91	5.01E+06	0.00E+00	1.34E+05	0.00E+00	0.00E+00	0.00E+00	2.76E+09
Y-92	2.25E+00	0.00E+00	6.59E-02	0.00E+00	0.00E+00	0.00E+00	3.95E+04
Y-93	4.29E+02	0.00E+00	1.18E+01	0.00E+00	0.00E+00	0.00E+00	1.36E+07
Zr-95	1.16E+06	3.71E+05	2.51E+05	0.00E+00	5.82E+05	0.00E+00	1.17E+09
Zr-97	8.50E+02	1.72E+02	7.84E+01	0.00E+00	2.59E+02	0.00E+00	5.31E+07
Nb-95	1.40E+05	7.79E+04	4.19E+04	0.00E+00	7.70E+04	0.00E+00	4.73E+08
Nb-97	5.13E-06	1.30E-06	4.74E-07	0.00E+00	1.51E-06	0.00E+00	4.79E-03
Mo-99	0.00E+00	1.59E+07	3.02E+06	0.00E+00	3.60E+07	0.00E+00	3.68E+07
Tc-99M	7.81E+00	2.21E+01	2.81E+02	0.00E+00	3.35E+02	1.08E+01	1.31E+04

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-2 (continue)
R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Vegetation

AGE GROUP = Adult

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLi
Tc-101	1.51E-30	2.18E-30	2.14E-29	0.00E+00	3.93E-29	1.11E-30	0.00E+00
Ru-103	4.74E+06	0.00E+00	2.04E+06	0.00E+00	1.81E+07	0.00E+00	5.53E+08
Ru-105	1.34E+02	0.00E+00	5.28E+01	0.00E+00	1.73E+03	0.00E+00	8.18E+04
Ru-106	1.94E+08	0.00E+00	2.46E+07	0.00E+00	3.75E+08	0.00E+00	1.26E+10
Ag-110M	1.13E+07	1.05E+07	6.23E+06	0.00E+00	2.06E+07	0.00E+00	4.28E+09
Sn-113	1.44E+07	5.66E+05	1.36E+07	1.96E+05	4.09E+05	0.00E+00	2.52E+08
Sb-124	1.01E+08	1.92E+06	4.02E+07	2.46E+05	0.00E+00	7.90E+07	2.88E+09
Sb-125	1.34E+08	1.50E+06	3.20E+07	1.37E+05	0.00E+00	1.04E+08	1.48E+09
Te-125M	1.21E+08	4.38E+07	1.62E+07	3.64E+07	4.92E+08	0.00E+00	4.83E+08
Te-127m	5.02E+08	1.80E+08	6.12E+07	1.28E+08	2.04E+09	0.00E+00	1.68E+09
Te-127	1.46E+04	5.25E+03	3.16E+03	1.08E+04	5.95E+04	0.00E+00	1.15E+06
Te-129M	2.98E+08	1.11E+08	4.71E+07	1.02E+08	1.24E+09	0.00E+00	1.50E+09
Te-129	1.85E-03	6.96E-04	4.51E-04	1.42E-03	7.78E-03	0.00E+00	1.40E-03
Te-131M	2.38E+06	1.16E+06	9.71E+05	1.84E+06	1.18E+07	0.00E+00	1.16E+08
Te-131	3.24E-15	1.35E-15	1.02E-15	2.66E-15	1.42E-14	0.00E+00	4.58E-16
Te-132	1.14E+07	7.36E+06	6.91E+06	8.13E+06	7.09E+07	0.00E+00	3.48E+08
I-130	1.96E+05	5.78E+05	2.28E+05	4.90E+07	9.02E+05	0.00E+00	4.98E+05
I-131	8.07E+07	1.15E+08	6.61E+07	3.78E+10	1.98E+08	0.00E+00	3.04E+07
I-132	5.57E+01	1.49E+02	5.21E+01	5.21E+03	2.37E+02	0.00E+00	2.80E+01
I-133	2.11E+06	3.67E+06	1.12E+06	5.39E+08	6.40E+06	0.00E+00	3.30E+06
I-134	4.49E-05	1.22E-04	4.36E-05	2.11E-03	1.94E-04	0.00E+00	1.06E-07
I-135	4.05E+04	1.06E+05	3.91E+04	7.00E+06	1.70E+05	0.00E+00	1.20E+05
Cs-134	4.54E+09	1.08E+10	8.83E+09	0.00E+00	3.49E+09	1.16E+09	1.89E+08
Cs-136	4.19E+07	1.66E+08	1.19E+08	0.00E+00	9.21E+07	1.26E+07	1.88E+07
Cs-137	6.63E+09	9.07E+09	5.94E+09	0.00E+00	3.08E+09	1.02E+09	1.76E+08
Cs-138	8.62E-11	1.70E-10	8.43E-11	0.00E+00	1.25E-10	1.24E-11	7.26E-16
Ba-139	6.87E-02	4.89E-05	2.01E-03	0.00E+00	4.57E-05	2.78E-05	1.22E-01
Ba-140	1.28E+08	1.61E+05	8.40E+06	0.00E+00	5.47E+04	9.22E+04	2.64E+08
Ba-141	2.49E-21	1.88E-24	8.40E-23	0.00E+00	1.75E-24	1.07E-24	1.17E-30
La-140	5.06E+03	2.55E+03	6.73E+02	0.00E+00	0.00E+00	0.00E+00	1.87E+08
La-142	4.89E-04	2.22E-04	5.54E-05	0.00E+00	0.00E+00	0.00E+00	1.62E+00
Ce-141	1.93E+05	1.31E+05	1.48E+04	0.00E+00	6.07E+04	0.00E+00	4.99E+08
Ce-143	2.55E+03	1.89E+06	2.09E+02	0.00E+00	8.30E+02	0.00E+00	7.05E+07
Ce-144	3.15E+07	1.32E+07	1.69E+06	0.00E+00	7.80E+06	0.00E+00	1.06E+10
Pr-143	6.23E+04	2.50E+04	3.09E+03	0.00E+00	1.44E+04	0.00E+00	2.73E+08
Pr-144	6.43E-26	2.67E-26	3.27E-27	0.00E+00	1.50E-26	0.00E+00	9.24E-33
Nd-147	3.33E+04	3.85E+04	2.30E+03	0.00E+00	2.25E+04	0.00E+00	1.85E+08
Hf-181	9.51E+06	5.36E+04	1.07E+06	3.41E+04	4.48E+04	0.00E+00	7.06E+08
W-187	9.69E+04	8.10E+04	2.83E+04	0.00E+00	0.00E+00	0.00E+00	2.65E+07
Np-239	3.67E+03	3.61E+02	1.99E+02	0.00E+00	1.13E+03	0.00E+00	7.40E+07

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-3
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Vegetation

AGE GROUP = Teen

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	2.61E+03	2.61E+03	2.61E+03	2.61E+03	2.61E+03	2.61E+03
Na-24	6.07E+05	6.07E+05	6.07E+05	6.07E+05	6.07E+05	6.07E+05	6.07E+05
P-32	1.75E+09	1.09E+08	6.80E+07	0.00E+00	0.00E+00	0.00E+00	1.47E+08
Cr-51	0.00E+00	0.00E+00	6.11E+04	3.39E+04	1.34E+04	8.72E+04	1.03E+07
Mn-54	0.00E+00	4.43E+08	8.79E+07	0.00E+00	1.32E+08	0.00E+00	9.09E+08
Mn-56	0.00E+00	3.59E+01	6.38E+00	0.00E+00	4.54E+01	0.00E+00	2.36E+03
Fe-55	3.10E+08	2.20E+08	5.13E+07	0.00E+00	0.00E+00	1.40E+08	9.53E+07
Fe-59	1.77E+08	4.14E+08	1.60E+08	0.00E+00	0.00E+00	1.30E+08	9.78E+08
Co-57	0.00E+00	1.72E+07	2.89E+07	0.00E+00	0.00E+00	0.00E+00	3.21E+08
Co-58	0.00E+00	4.25E+07	9.79E+07	0.00E+00	0.00E+00	0.00E+00	5.85E+08
Co-60	0.00E+00	2.47E+08	5.57E+08	0.00E+00	0.00E+00	0.00E+00	3.22E+09
Ni-63	1.85E+10	1.31E+09	6.28E+08	0.00E+00	0.00E+00	0.00E+00	2.08E+08
Ni-65	1.40E+02	1.79E+01	8.14E+00	0.00E+00	0.00E+00	0.00E+00	9.68E+02
Cu-64	0.00E+00	2.12E+04	9.95E+03	0.00E+00	5.35E+04	0.00E+00	1.64E+06
Zn-65	5.36E+08	1.86E+09	8.68E+08	0.00E+00	1.19E+09	0.00E+00	7.88E+08
Zn-69M	5.31E+04	1.25E+05	1.15E+04	0.00E+00	7.61E+04	0.00E+00	6.88E+06
Zn-69	1.21E-05	2.31E-05	1.61E-06	0.00E+00	1.51E-05	0.00E+00	4.25E-05
Br-82	0.00E+00	0.00E+00	3.44E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	7.10E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	5.01E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.76E+08	1.30E+08	0.00E+00	0.00E+00	0.00E+00	4.09E+07
Rb-88	0.00E+00	6.22E-22	3.32E-22	0.00E+00	0.00E+00	0.00E+00	5.33E-29
Rb-89	0.00E+00	5.57E-26	3.94E-26	0.00E+00	0.00E+00	0.00E+00	8.54E-35
Sr-89	1.52E+10	0.00E+00	4.36E+08	0.00E+00	0.00E+00	0.00E+00	1.81E+09
Sr-90	8.32E+11	0.00E+00	2.05E+11	0.00E+00	0.00E+00	0.00E+00	2.33E+10
Sr-91	7.19E+05	0.00E+00	2.86E+04	0.00E+00	0.00E+00	0.00E+00	3.26E+06
Sr-92	9.99E+02	0.00E+00	4.26E+01	0.00E+00	0.00E+00	0.00E+00	2.54E+04
Y-90	3.20E+04	0.00E+00	8.63E+02	0.00E+00	0.00E+00	0.00E+00	2.64E+08
Y-91M	1.12E-08	0.00E+00	4.28E-10	0.00E+00	0.00E+00	0.00E+00	5.29E-07
Y-91	7.68E+06	0.00E+00	2.06E+05	0.00E+00	0.00E+00	0.00E+00	3.15E+09
Y-92	2.12E+00	0.00E+00	6.12E-02	0.00E+00	0.00E+00	0.00E+00	5.81E+04
Y-93	4.02E+02	0.00E+00	1.10E+01	0.00E+00	0.00E+00	0.00E+00	1.23E+07
Zr-95	1.69E+06	5.35E+05	3.68E+05	0.00E+00	7.86E+05	0.00E+00	1.23E+09
Zr-97	7.87E+02	1.56E+02	7.17E+01	0.00E+00	2.36E+02	0.00E+00	4.22E+07
Nb-95	1.89E+05	1.05E+05	5.77E+04	0.00E+00	1.02E+05	0.00E+00	4.48E+08
Nb-97	4.76E-06	1.18E-06	4.31E-07	0.00E+00	1.38E-06	0.00E+00	2.82E-02
Mo-99	0.00E+00	1.46E+07	2.78E+06	0.00E+00	3.34E+07	0.00E+00	2.61E+07
Tc-99M	6.89E+00	1.92E+01	2.49E+02	0.00E+00	2.86E+02	1.07E+01	1.26E+04

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-3 (continue)
R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Vegetation

AGE GROUP = Teen

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Tc-101	1.41E-30	2.00E-30	1.97E-29	0.00E+00	3.62E-29	1.22E-30	3.42E-37
Ru-103	6.78E+06	0.00E+00	2.90E+06	0.00E+00	2.39E+07	0.00E+00	5.66E+08
Ru-105	1.24E+02	0.00E+00	4.82E+01	0.00E+00	1.57E+03	0.00E+00	1.00E+05
Ru-106	3.12E+08	0.00E+00	3.93E+07	0.00E+00	6.02E+08	0.00E+00	1.50E+10
Ag-110M	1.63E+07	1.54E+07	9.39E+06	0.00E+00	2.95E+07	0.00E+00	4.34E+09
Sn-113	1.91E+07	8.03E+05	2.02E+07	2.63E+05	5.65E+05	0.00E+00	2.29E+08
Sb-124	1.51E+08	2.78E+06	5.89E+07	3.43E+05	0.00E+00	1.32E+08	3.04E+09
Sb-125	2.11E+08	2.30E+06	4.92E+07	2.01E+05	0.00E+00	1.85E+08	1.64E+09
Te-125M	1.86E+08	6.69E+07	2.48E+07	5.19E+07	0.00E+00	0.00E+00	5.48E+08
Te-127m	7.93E+08	2.81E+08	9.44E+07	1.89E+08	3.22E+09	0.00E+00	1.98E+09
Te-127	1.38E+04	4.88E+03	2.96E+03	9.50E+03	5.58E+04	0.00E+00	1.06E+06
Te-129M	4.29E+08	1.59E+08	6.79E+07	1.38E+08	1.77E+09	0.00E+00	1.61E+09
Te-129	1.73E-03	6.46E-04	4.22E-04	1.24E-03	7.28E-03	0.00E+00	9.48E-03
Te-131M	2.20E+06	1.06E+06	8.82E+05	1.59E+06	1.10E+07	0.00E+00	8.48E+07
Te-131	3.01E-15	1.24E-15	9.40E-16	2.32E-15	1.32E-14	0.00E+00	2.47E-16
Te-132	1.03E+07	6.55E+06	6.17E+06	6.91E+06	6.29E+07	0.00E+00	2.08E+08
I-130	1.75E+05	5.07E+05	2.02E+05	4.13E+07	7.81E+05	0.00E+00	3.90E+05
I-131	7.68E+07	1.07E+08	5.77E+07	3.14E+10	1.85E+08	0.00E+00	2.13E+07
I-132	5.02E+01	1.31E+02	4.72E+01	4.43E+03	2.07E+02	0.00E+00	5.72E+01
I-133	1.96E+06	3.32E+06	1.01E+06	4.64E+08	5.83E+06	0.00E+00	2.51E+06
I-134	4.06E-05	1.08E-04	3.86E-05	1.79E-03	1.70E-04	0.00E+00	1.42E-06
I-135	3.66E+04	9.42E+04	3.49E+04	6.06E+06	1.49E+05	0.00E+00	1.04E+05
Cs-134	6.90E+09	1.62E+10	7.54E+09	0.00E+00	5.16E+09	1.97E+09	2.02E+08
Cs-136	4.28E+07	1.68E+08	1.13E+08	0.00E+00	9.16E+07	1.44E+07	1.35E+07
Cs-137	1.06E+10	1.41E+10	4.90E+09	0.00E+00	4.78E+09	1.86E+09	2.00E+08
Cs-138	7.95E-11	1.53E-10	7.63E-11	0.00E+00	1.13E-10	1.31E-11	6.93E-14
Ba-139	6.46E-02	4.54E-05	1.88E-03	0.00E+00	4.28E-05	3.13E-05	5.76E-01
Ba-140	1.38E+08	1.69E+05	8.88E+06	0.00E+00	5.72E+04	1.14E+05	2.12E+08
Ba-141	2.33E-21	1.74E-24	7.77E-23	0.00E+00	1.61E-24	1.19E-24	4.96E-27
La-140	4.62E+03	2.27E+03	6.04E+02	0.00E+00	0.00E+00	0.00E+00	1.30E+08
La-142	4.49E-04	1.99E-04	4.97E-05	0.00E+00	0.00E+00	0.00E+00	6.07E+00
Ce-141	2.77E+05	1.85E+05	2.12E+04	0.00E+00	8.70E+04	0.00E+00	5.29E+08
Ce-143	2.38E+03	1.73E+06	1.94E+02	0.00E+00	7.78E+02	0.00E+00	5.21E+07
Ce-144	5.04E+07	2.09E+07	2.71E+06	0.00E+00	1.25E+07	0.00E+00	1.27E+10
Pr-143	6.97E+04	2.78E+04	3.47E+03	0.00E+00	1.62E+04	0.00E+00	2.29E+08
Pr-144	6.02E-26	2.47E-26	3.05E-27	0.00E+00	1.41E-26	0.00E+00	6.64E-29
Nd-147	3.62E+04	3.94E+04	2.36E+03	0.00E+00	2.31E+04	0.00E+00	1.42E+08
Hf-181	1.38E+07	7.58E+04	1.54E+06	4.63E+04	6.32E+04	0.00E+00	6.90E+08
W-187	9.02E+04	7.35E+04	2.58E+04	0.00E+00	0.00E+00	0.00E+00	1.99E+07
Np-239	3.56E+03	3.36E+02	1.87E+02	0.00E+00	1.05E+03	0.00E+00	5.40E+07

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec per m}^2$ for all others.

TABLE 3.3-4
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Vegetation

AGE GROUP = Child

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	4.04E+03	4.04E+03	4.04E+03	4.04E+03	4.04E+03	4.04E+03
Na-24	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05	9.47E+05
P-32	3.67E+09	1.72E+08	1.42E+08	0.00E+00	0.00E+00	0.00E+00	1.01E+08
Cr-51	0.00E+00	0.00E+00	1.16E+05	6.44E+04	1.76E+04	1.18E+05	6.15E+06
Mn-54	0.00E+00	6.49E+08	1.73E+08	0.00E+00	1.82E+08	0.00E+00	5.44E+08
Mn-56	0.00E+00	4.70E+01	1.06E+01	0.00E+00	5.68E+01	0.00E+00	6.81E+03
Fe-55	7.63E+08	4.05E+08	1.25E+08	0.00E+00	0.00E+00	2.29E+08	7.50E+07
Fe-59	3.93E+08	6.36E+08	3.17E+08	0.00E+00	0.00E+00	1.84E+08	6.62E+08
Co-57	0.00E+00	2.88E+07	5.83E+07	0.00E+00	0.00E+00	0.00E+00	2.36E+08
Co-58	0.00E+00	6.27E+07	1.92E+08	0.00E+00	0.00E+00	0.00E+00	3.66E+08
Co-60	0.00E+00	3.76E+08	1.11E+09	0.00E+00	0.00E+00	0.00E+00	2.08E+09
Ni-63	4.55E+10	2.44E+09	1.55E+09	0.00E+00	0.00E+00	0.00E+00	1.64E+08
Ni-65	2.56E+02	2.41E+01	1.41E+01	0.00E+00	0.00E+00	0.00E+00	2.96E+03
Cu-64	0.00E+00	2.79E+04	1.69E+04	0.00E+00	6.74E+04	0.00E+00	1.31E+06
Zn-65	1.03E+09	2.74E+09	1.70E+09	0.00E+00	1.73E+09	0.00E+00	4.81E+08
Zn-69M	9.72E+04	1.66E+05	1.96E+04	0.00E+00	9.63E+04	0.00E+00	5.39E+06
Zn-69	2.23E-05	3.23E-05	2.98E-06	0.00E+00	1.96E-05	0.00E+00	2.04E-03
Br-82	0.00E+00	0.00E+00	5.29E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	1.31E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	8.50E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	4.56E+08	2.81E+08	0.00E+00	0.00E+00	0.00E+00	2.94E+07
Rb-88	0.00E+00	8.59E-22	5.97E-22	0.00E+00	0.00E+00	0.00E+00	4.21E-23
Rb-89	0.00E+00	7.33E-26	6.52E-26	0.00E+00	0.00E+00	0.00E+00	6.39E-28
Sr-89	3.62E+10	0.00E+00	1.03E+09	0.00E+00	0.00E+00	0.00E+00	1.40E+09
Sr-90	1.38E+12	0.00E+00	3.49E+11	0.00E+00	0.00E+00	0.00E+00	1.86E+10
Sr-91	1.32E+06	0.00E+00	5.00E+04	0.00E+00	0.00E+00	0.00E+00	2.92E+06
Sr-92	1.83E+03	0.00E+00	7.34E+01	0.00E+00	0.00E+00	0.00E+00	3.47E+04
Y-90	5.95E+04	0.00E+00	1.59E+03	0.00E+00	0.00E+00	0.00E+00	1.69E+08
Y-91M	2.05E-08	0.00E+00	7.48E-10	0.00E+00	0.00E+00	0.00E+00	4.02E-05
Y-91	1.83E+07	0.00E+00	4.89E+05	0.00E+00	0.00E+00	0.00E+00	2.44E+09
Y-92	3.90E+00	0.00E+00	1.12E-01	0.00E+00	0.00E+00	0.00E+00	1.13E+05
Y-93	7.41E+02	0.00E+00	2.03E+01	0.00E+00	0.00E+00	0.00E+00	1.10E+07
Zr-95	3.80E+06	8.35E+05	7.44E+05	0.00E+00	1.20E+06	0.00E+00	8.71E+08
Zr-97	1.44E+03	2.08E+02	1.23E+02	0.00E+00	2.98E+02	0.00E+00	3.15E+07
Nb-95	4.04E+05	1.57E+05	1.12E+05	0.00E+00	1.48E+05	0.00E+00	2.91E+08
Nb-97	8.67E-06	1.57E-06	7.31E-07	0.00E+00	1.74E-06	0.00E+00	4.83E-01
Mo-99	0.00E+00	1.99E+07	4.92E+06	0.00E+00	4.25E+07	0.00E+00	1.65E+07
Tc-99M	1.19E+01	2.32E+01	3.85E+02	0.00E+00	3.38E+02	1.18E+01	1.32E+04

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-4 (continue)
R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Vegetation

AGE GROUP = Child

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Tc-101	2.59E-30	2.71E-30	3.44E-29	0.00E+00	4.62E-29	1.43E-30	8.62E-30
Ru-103	1.52E+07	0.00E+00	5.86E+06	0.00E+00	3.84E+07	0.00E+00	3.94E+08
Ru-105	2.28E+02	0.00E+00	8.26E+01	0.00E+00	2.00E+03	0.00E+00	1.49E+05
Ru-106	7.52E+08	0.00E+00	9.38E+07	0.00E+00	1.02E+09	0.00E+00	1.17E+10
Ag-110M	3.46E+07	2.34E+07	1.87E+07	0.00E+00	4.35E+07	0.00E+00	2.78E+09
Sn-113	3.64E+07	1.18E+06	3.97E+07	4.82E+05	8.09E+05	0.00E+00	1.45E+08
Sb-124	3.44E+08	4.47E+06	1.21E+08	7.61E+05	0.00E+00	1.91E+08	2.16E+09
Sb-125	4.91E+08	3.79E+06	1.03E+08	4.55E+05	0.00E+00	2.74E+08	1.17E+09
Te-125M	4.39E+08	1.19E+08	5.85E+07	1.23E+08	0.00E+00	0.00E+00	4.24E+08
Te-127m	1.90E+09	5.12E+08	2.26E+08	4.55E+08	5.42E+09	0.00E+00	1.54E+09
Te-127	2.54E+04	6.85E+03	5.45E+03	1.76E+04	7.23E+04	0.00E+00	9.93E+05
Te-129M	9.98E+08	2.79E+08	1.55E+08	3.22E+08	2.93E+09	0.00E+00	1.22E+09
Te-129	3.21E-03	8.96E-04	7.62E-04	2.29E-03	9.39E-03	0.00E+00	2.00E-01
Te-131M	4.03E+06	1.39E+06	1.48E+06	2.86E+06	1.35E+07	0.00E+00	5.65E+07
Te-131	5.54E-15	1.69E-15	1.65E-15	4.24E-15	1.68E-14	0.00E+00	2.91E-14
Te-132	1.85E+07	8.20E+06	9.91E+06	1.19E+07	7.62E+07	0.00E+00	8.26E+07
I-130	3.08E+05	6.21E+05	3.20E+05	6.85E+07	9.29E+05	0.00E+00	2.91E+05
I-131	1.43E+08	1.44E+08	8.16E+07	4.75E+10	2.36E+08	0.00E+00	1.23E+07
I-132	8.91E+01	1.64E+02	7.53E+01	7.60E+03	2.51E+02	0.00E+00	1.93E+02
I-133	3.57E+06	4.42E+06	1.67E+06	8.21E+08	7.36E+06	0.00E+00	1.78E+06
I-134	7.21E-05	1.34E-04	6.16E-05	3.08E-03	2.05E-04	0.00E+00	8.88E-05
I-135	6.50E+04	1.17E+05	5.54E+04	1.04E+07	1.79E+05	0.00E+00	8.92E+04
Cs-134	1.56E+10	2.56E+10	5.40E+09	0.00E+00	7.93E+09	2.84E+09	1.38E+08
Cs-136	8.04E+07	2.21E+08	1.43E+08	0.00E+00	1.18E+08	1.76E+07	7.77E+06
Cs-137	2.49E+10	2.39E+10	3.52E+09	0.00E+00	7.78E+09	2.80E+09	1.50E+08
Cs-138	1.45E-10	2.01E-10	1.27E-10	0.00E+00	1.41E-10	1.52E-11	9.26E-11
Ba-139	1.19E-01	6.36E-05	3.45E-03	0.00E+00	5.55E-05	3.74E-05	6.87E+00
Ba-140	2.76E+08	2.42E+05	1.61E+07	0.00E+00	7.87E+04	1.44E+05	1.40E+08
Ba-141	4.29E-21	2.40E-24	1.40E-22	0.00E+00	2.08E-24	1.41E-23	2.45E-21
La-140	8.30E+03	2.90E+03	9.78E+02	0.00E+00	0.00E+00	0.00E+00	8.08E+07
La-142	8.14E-04	2.59E-04	8.12E-05	0.00E+00	0.00E+00	0.00E+00	5.14E+01
Ce-141	6.42E+05	3.20E+05	4.75E+04	0.00E+00	1.40E+05	0.00E+00	3.99E+08
Ce-143	4.39E+03	2.38E+06	3.45E+02	0.00E+00	9.98E+02	0.00E+00	3.48E+07
Ce-144	1.22E+08	3.81E+07	6.49E+06	0.00E+00	2.11E+07	0.00E+00	9.94E+09
Pr-143	1.45E+05	4.35E+04	7.18E+03	0.00E+00	2.35E+04	0.00E+00	1.56E+08
Pr-144	1.12E-25	3.46E-26	5.63E-27	0.00E+00	1.83E-26	0.00E+00	7.45E-23
Nd-147	7.15E+04	5.79E+04	4.48E+03	0.00E+00	3.18E+04	0.00E+00	9.17E+07
Hf-181	3.13E+07	1.22E+05	3.15E+06	1.03E+05	9.78E+04	0.00E+00	5.17E+08
W-187	1.64E+05	9.71E+04	4.36E+04	0.00E+00	0.00E+00	0.00E+00	1.36E+07
Np-239	6.58E+03	4.72E+02	3.32E+02	0.00E+00	1.37E+03	0.00E+00	3.49E+07

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-5
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Meat

AGE GROUP = Adult

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	3.27E+02	3.27E+02	3.27E+02	3.27E+02	3.27E+02	3.27E+02
P-32	3.05E+09	1.89E+08	1.18E+08	0.00E+00	0.00E+00	0.00E+00	3.43E+08
Cr-51	0.00E+00	0.00E+00	4.27E+03	2.56E+03	9.42E+02	5.67E+03	1.08E+06
Mn-54	0.00E+00	5.57E+06	1.06E+06	0.00E+00	1.66E+06	0.00E+00	1.71E+07
Fe-55	1.83E+08	1.26E+08	2.95E+07	0.00E+00	0.00E+00	7.05E+07	7.25E+07
Fe-59	1.59E+08	3.74E+08	1.43E+08	0.00E+00	0.00E+00	1.04E+08	1.25E+09
Co-57	0.00E+00	3.48E+06	5.79E+06	0.00E+00	0.00E+00	0.00E+00	8.84E+07
Co-58	0.00E+00	1.08E+07	2.43E+07	0.00E+00	0.00E+00	0.00E+00	2.20E+08
Co-60	0.00E+00	4.66E+07	1.03E+08	0.00E+00	0.00E+00	0.00E+00	8.76E+08
Ni-63	1.32E+10	9.13E+08	4.42E+08	0.00E+00	0.00E+00	0.00E+00	1.91E+08
Zn-65	2.49E+08	7.91E+08	3.58E+08	0.00E+00	5.29E+08	0.00E+00	4.98E+08
Br-82	0.00E+00	0.00E+00	1.38E-32	0.00E+00	0.00E+00	0.00E+00	1.58E-32
Rb-86	0.00E+00	3.04E+08	1.42E+08	0.00E+00	0.00E+00	0.00E+00	6.00E+07
Sr-89	1.82E+08	0.00E+00	5.23E+06	0.00E+00	0.00E+00	0.00E+00	2.92E+07
Sr-90	8.22E+09	0.00E+00	2.02E+09	0.00E+00	0.00E+00	0.00E+00	2.38E+08
Y-90	1.06E-17	0.00E+00	2.83E-19	0.00E+00	0.00E+00	0.00E+00	1.12E-13
Y-91	6.75E+05	0.00E+00	1.80E+04	0.00E+00	0.00E+00	0.00E+00	3.71E+08
Zr-95	1.12E+06	3.59E+05	2.43E+05	0.00E+00	5.64E+05	0.00E+00	1.14E+09
Nb-95	1.38E+06	7.66E+05	4.12E+05	0.00E+00	7.58E+05	0.00E+00	4.65E+09
Nb-97	8.25E-08	2.09E-08	7.62E-09	0.00E+00	2.43E-08	0.00E+00	7.70E-05
Mo-99	0.00E+00	4.67E-15	8.89E-16	0.00E+00	1.06E-14	0.00E+00	1.08E-14
Ru-103	6.32E+07	0.00E+00	2.72E+07	0.00E+00	2.41E+08	0.00E+00	7.38E+09
Ru-106	1.73E+09	0.00E+00	2.19E+08	0.00E+00	3.35E+09	0.00E+00	1.12E+11
Ag-110M	4.27E+06	3.95E+06	2.34E+06	0.00E+00	7.76E+06	0.00E+00	1.61E+09
Sn-113	2.97E+07	1.15E+06	2.80E+07	4.03E+05	8.40E+05	0.00E+00	5.19E+08
Sb-124	1.19E+07	2.25E+05	4.72E+06	2.88E+04	0.00E+00	9.27E+06	3.38E+08
Te-125M	2.43E+08	8.79E+07	3.25E+07	7.30E+07	9.87E+08	0.00E+00	9.69E+08
Te-127m	8.22E+08	2.94E+08	1.00E+08	2.10E+08	3.34E+09	0.00E+00	2.76E+09
Te-129M	7.40E+08	2.76E+08	1.17E+08	2.54E+08	3.09E+09	0.00E+00	3.73E+09
Te-132	4.41E-10	2.85E-10	2.68E-10	3.15E-10	2.75E-09	0.00E+00	1.35E-08
I-131	7.04E+06	1.01E+07	5.77E+06	3.30E+09	1.73E+07	0.00E+00	2.66E+06
I-133	2.85E-01	4.96E-01	1.51E-01	7.29E+01	8.66E-01	0.00E+00	4.46E-01
I-135	6.28E-17	1.64E-16	6.07E-17	1.08E-14	2.64E-16	0.00E+00	1.86E-16
Cs-134	4.01E+08	9.55E+08	7.81E+08	0.00E+00	3.09E+08	1.03E+08	1.67E+07
Cs-136	7.53E+06	2.97E+07	2.14E+07	0.00E+00	1.65E+07	2.27E+06	3.33E+06
Cs-137	5.57E+08	7.61E+08	4.99E+08	0.00E+00	2.58E+08	8.59E+07	1.47E+07
Ba-140	1.83E+07	2.30E+04	1.20E+06	0.00E+00	7.82E+03	1.32E+04	3.77E+07
La-140	7.57E-33	3.82E-33	1.01E-33	0.00E+00	0.00E+00	0.00E+00	2.80E-28
Ce-141	8.42E+03	5.69E+03	6.46E+02	0.00E+00	2.65E+03	0.00E+00	2.18E+07
Ce-144	8.75E+05	3.66E+05	4.70E+04	0.00E+00	2.17E+05	0.00E+00	2.96E+08
Pr-143	1.33E+04	5.34E+03	6.60E+02	0.00E+00	3.08E+03	0.00E+00	5.83E+07
Nd-147	4.57E+03	5.29E+03	3.16E+02	0.00E+00	3.09E+03	0.00E+00	2.54E+07
Hf-181	1.34E+07	7.57E+04	1.52E+06	4.81E+04	6.33E+04	0.00E+00	9.97E+08
Np-239	5.63E-23	5.53E-24	3.05E-24	0.00E+00	1.73E-23	0.00E+00	1.14E-18

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-6
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Meat

AGE GROUP = Teen

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	1.95E+02	1.95E+02	1.95E+02	1.95E+02	1.95E+02	1.95E+02
P-32	2.58E+09	1.60E+08	9.98E+07	0.00E+00	0.00E+00	0.00E+00	2.16E+08
Cr-51	0.00E+00	0.00E+00	3.42E+03	1.90E+03	7.49E+02	4.88E+03	5.75E+05
Mn-54	0.00E+00	4.25E+06	8.43E+05	0.00E+00	1.27E+06	0.00E+00	8.72E+06
Fe-55	1.49E+08	1.05E+08	2.46E+07	0.00E+00	0.00E+00	6.68E+07	4.56E+07
Fe-59	1.27E+08	2.97E+08	1.15E+08	0.00E+00	0.00E+00	9.36E+07	7.02E+08
Co-57	0.00E+00	2.80E+06	4.69E+06	0.00E+00	0.00E+00	0.00E+00	5.22E+07
Co-58	0.00E+00	8.36E+06	1.93E+07	0.00E+00	0.00E+00	0.00E+00	1.15E+08
Co-60	0.00E+00	3.62E+07	8.15E+07	0.00E+00	0.00E+00	0.00E+00	4.71E+08
Ni-63	1.06E+10	7.49E+08	3.59E+08	0.00E+00	0.00E+00	0.00E+00	1.19E+08
Zn-65	1.75E+08	6.07E+08	2.83E+08	0.00E+00	3.89E+08	0.00E+00	2.57E+08
Br-82	0.00E+00	0.00E+00	1.10E-32	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.54E+08	1.19E+08	0.00E+00	0.00E+00	0.00E+00	3.76E+07
Sr-89	1.54E+08	0.00E+00	4.40E+06	0.00E+00	0.00E+00	0.00E+00	1.83E+07
Sr-90	5.32E+09	0.00E+00	1.31E+09	0.00E+00	0.00E+00	0.00E+00	1.49E+08
Y-90	8.89E-18	0.00E+00	2.39E-19	0.00E+00	0.00E+00	0.00E+00	7.33E-14
Y-91	5.68E+05	0.00E+00	1.52E+04	0.00E+00	0.00E+00	0.00E+00	2.33E+08
Zr-95	8.97E+05	2.83E+05	1.95E+05	0.00E+00	4.16E+05	0.00E+00	6.53E+08
Nb-95	1.08E+06	5.97E+05	3.29E+05	0.00E+00	5.79E+05	0.00E+00	2.55E+09
Nb-97	6.83E-08	1.71E-08	6.24E-09	0.00E+00	2.00E-08	0.00E+00	4.08E-04
Mo-99	0.00E+00	3.86E-15	7.37E-16	0.00E+00	8.84E-15	0.00E+00	6.92E-15
Ru-103	5.15E+07	0.00E+00	2.20E+07	0.00E+00	1.82E+08	0.00E+00	4.30E+09
Ru-106	1.46E+09	0.00E+00	1.84E+08	0.00E+00	2.81E+09	0.00E+00	7.00E+10
Ag-110M	3.23E+06	3.06E+06	1.86E+06	0.00E+00	5.83E+06	0.00E+00	8.59E+08
Sn-113	2.09E+07	8.80E+05	2.22E+07	2.88E+05	6.19E+05	0.00E+00	2.51E+08
Sb-124	9.73E+06	1.79E+05	3.80E+06	2.21E+04	0.00E+00	8.50E+06	1.96E+08
Te-125M	2.05E+08	7.39E+07	2.74E+07	5.73E+07	0.00E+00	0.00E+00	6.05E+08
Te-127m	6.94E+08	2.46E+08	8.25E+07	1.65E+08	2.81E+09	0.00E+00	1.73E+09
Te-129M	6.20E+08	2.30E+08	9.81E+07	2.00E+08	2.59E+09	0.00E+00	2.33E+09
Te-132	3.61E-10	2.28E-10	2.15E-10	2.41E-10	2.19E-09	0.00E+00	7.23E-09
I-131	5.85E+06	8.20E+06	4.40E+06	2.39E+09	1.41E+07	0.00E+00	1.62E+06
I-133	2.39E-01	4.05E-01	1.23E-01	5.65E+01	7.10E-01	0.00E+00	3.06E-01
I-135	5.11E-17	1.32E-16	4.88E-17	8.46E-15	2.08E-16	0.00E+00	1.46E-16
Cs-134	3.19E+08	7.51E+08	3.48E+08	0.00E+00	2.39E+08	9.11E+07	9.34E+06
Cs-136	5.87E+06	2.31E+07	1.55E+07	0.00E+00	1.26E+07	1.98E+06	1.86E+06
Cs-137	4.62E+08	6.15E+08	2.14E+08	0.00E+00	2.09E+08	8.13E+07	8.75E+06
Ba-140	1.51E+07	1.86E+04	9.76E+05	0.00E+00	6.29E+03	1.25E+04	2.34E+07
La-140	6.23E-33	3.06E-33	8.14E-34	0.00E+00	0.00E+00	0.00E+00	1.76E-28
Ce-141	7.07E+03	4.72E+03	5.42E+02	0.00E+00	2.22E+03	0.00E+00	1.35E+07
Ce-144	7.37E+05	3.05E+05	3.96E+04	0.00E+00	1.82E+05	0.00E+00	1.85E+08
Pr-143	1.12E+04	4.47E+03	5.58E+02	0.00E+00	2.60E+03	0.00E+00	3.69E+07
Nd-147	4.03E+03	4.38E+03	2.63E+02	0.00E+00	2.57E+03	0.00E+00	1.58E+07
Hf-181	1.10E+07	6.05E+04	1.22E+06	3.69E+04	5.04E+04	0.00E+00	5.50E+08
Np-239	4.92E-23	4.64E-24	2.58E-24	0.00E+00	1.46E-23	0.00E+00	7.46E-19

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-7
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Meat

AGE GROUP = Child

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	2.36E+02	2.36E+02	2.36E+02	2.36E+02	2.36E+02	2.36E+02
P-32	4.86E+09	2.27E+08	1.87E+08	0.00E+00	0.00E+00	0.00E+00	1.34E+08
Cr-51	0.00E+00	0.00E+00	5.33E+03	2.96E+03	8.09E+02	5.40E+03	2.83E+05
Mn-54	0.00E+00	4.86E+06	1.30E+06	0.00E+00	1.36E+06	0.00E+00	4.08E+06
Fe-55	2.85E+08	1.51E+08	4.69E+07	0.00E+00	0.00E+00	8.56E+07	2.80E+07
Fe-59	2.25E+08	3.65E+08	1.82E+08	0.00E+00	0.00E+00	1.06E+08	3.80E+08
Co-57	0.00E+00	3.66E+06	7.41E+06	0.00E+00	0.00E+00	0.00E+00	3.00E+07
Co-58	0.00E+00	9.76E+06	2.99E+07	0.00E+00	0.00E+00	0.00E+00	5.70E+07
Co-60	0.00E+00	4.30E+07	1.27E+08	0.00E+00	0.00E+00	0.00E+00	2.38E+08
Ni-63	2.03E+10	1.09E+09	6.91E+08	0.00E+00	0.00E+00	0.00E+00	7.33E+07
Zn-65	2.62E+08	6.99E+08	4.35E+08	0.00E+00	4.40E+08	0.00E+00	1.23E+08
Br-82	0.00E+00	0.00E+00	1.72E-32	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	3.60E+08	2.21E+08	0.00E+00	0.00E+00	0.00E+00	2.32E+07
Sr-89	2.91E+08	0.00E+00	8.31E+06	0.00E+00	0.00E+00	0.00E+00	1.13E+07
Sr-90	6.87E+09	0.00E+00	1.74E+09	0.00E+00	0.00E+00	0.00E+00	9.26E+07
Y-90	1.68E-17	0.00E+00	4.50E-19	0.00E+00	0.00E+00	0.00E+00	4.79E-14
Y-91	1.07E+06	0.00E+00	2.87E+04	0.00E+00	0.00E+00	0.00E+00	1.43E+08
Zr-95	1.59E+06	3.50E+05	3.12E+05	0.00E+00	5.01E+05	0.00E+00	3.65E+08
Nb-95	1.86E+06	7.23E+05	5.17E+05	0.00E+00	6.80E+05	0.00E+00	1.34E+09
Nb-97	1.28E-07	2.31E-08	1.08E-08	0.00E+00	2.56E-08	0.00E+00	7.13E-03
Mo-99	0.00E+00	5.38E-15	1.33E-15	0.00E+00	1.15E-14	0.00E+00	4.45E-15
Ru-103	9.31E+07	0.00E+00	3.58E+07	0.00E+00	2.34E+08	0.00E+00	2.41E+09
Ru-106	2.75E+09	0.00E+00	3.43E+08	0.00E+00	3.71E+09	0.00E+00	4.27E+10
Ag-110M	5.36E+06	3.62E+06	2.89E+06	0.00E+00	6.74E+06	0.00E+00	4.30E+08
Sn-113	3.14E+07	1.01E+06	3.42E+07	4.15E+05	6.97E+05	0.00E+00	1.25E+08
Sb-124	1.76E+07	2.28E+05	6.17E+06	3.88E+04	0.00E+00	9.77E+06	1.10E+08
Te-125M	3.85E+08	1.04E+08	5.13E+07	1.08E+08	0.00E+00	0.00E+00	3.71E+08
Te-127m	1.31E+09	3.52E+08	1.55E+08	3.13E+08	3.73E+09	0.00E+00	1.06E+09
Te-129M	1.17E+09	3.26E+08	1.81E+08	3.77E+08	3.43E+09	0.00E+00	1.42E+09
Te-132	6.58E-10	2.91E-10	3.52E-10	4.24E-10	2.70E-09	0.00E+00	2.93E-09
I-131	1.09E+07	1.09E+07	6.20E+06	3.61E+09	1.79E+07	0.00E+00	9.72E+05
I-133	4.43E-01	5.48E-01	2.07E-01	1.02E+02	9.13E-01	0.00E+00	2.21E-01
I-135	9.25E-17	1.66E-16	7.87E-17	1.47E-14	2.55E-16	0.00E+00	1.27E-16
Cs-134	5.63E+08	9.23E+08	1.95E+08	0.00E+00	2.86E+08	1.03E+08	4.93E+06
Cs-136	1.01E+07	2.78E+07	1.80E+07	0.00E+00	1.48E+07	2.21E+06	9.78E+05
Cs-137	8.51E+08	8.15E+08	1.20E+08	0.00E+00	2.65E+08	9.55E+07	5.10E+06
Ba-140	2.80E+07	2.45E+04	1.63E+06	0.00E+00	7.97E+03	1.46E+04	1.42E+07
La-140	1.14E-32	3.98E-33	1.34E-33	0.00E+00	0.00E+00	0.00E+00	1.11E-28
Ce-141	1.33E+04	6.64E+03	9.86E+02	0.00E+00	2.91E+03	0.00E+00	8.28E+06
Ce-144	1.39E+06	4.36E+05	7.42E+04	0.00E+00	2.41E+05	0.00E+00	1.14E+08
Pr-143	2.12E+04	6.37E+03	1.05E+03	0.00E+00	3.45E+03	0.00E+00	2.29E+07
Nd-147	7.56E+03	6.12E+03	4.74E+02	0.00E+00	3.36E+03	0.00E+00	9.70E+06
Hf-181	2.00E+07	7.79E+04	2.02E+06	6.56E+04	6.26E+04	0.00E+00	3.31E+08
Np-239	9.26E-23	6.65E-24	4.67E-24	0.00E+00	1.92E-23	0.00E+00	4.92E-19

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-8
R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Cow Milk

AGE GROUP = Adult

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	7.69E+02	7.69E+02	7.69E+02	7.69E+02	7.69E+02	7.69E+02
P-32	1.12E+10	6.95E+08	4.32E+08	0.00E+00	0.00E+00	0.00E+00	1.26E+09
Cr-51	0.00E+00	0.00E+00	1.73E+04	1.04E+04	3.82E+03	2.30E+04	4.36E+06
Mn-54	0.00E+00	5.11E+06	9.76E+05	0.00E+00	1.52E+06	0.00E+00	1.57E+07
Fe-55	1.57E+07	1.08E+07	2.52E+06	0.00E+00	0.00E+00	6.04E+06	6.21E+06
Fe-59	1.77E+07	4.17E+07	1.60E+07	0.00E+00	0.00E+00	1.17E+07	1.39E+08
Co-57	0.00E+00	7.91E+05	1.32E+06	0.00E+00	0.00E+00	0.00E+00	2.01E+07
Co-58	0.00E+00	2.80E+06	6.28E+06	0.00E+00	0.00E+00	0.00E+00	5.68E+07
Co-60	0.00E+00	1.02E+07	2.24E+07	0.00E+00	0.00E+00	0.00E+00	1.91E+08
Ni-63	4.70E+09	3.25E+08	1.57E+08	0.00E+00	0.00E+00	0.00E+00	6.79E+07
Zn-65	9.59E+08	3.05E+09	1.38E+09	0.00E+00	2.04E+09	0.00E+00	1.92E+09
Br-82	0.00E+00	0.00E+00	2.09E-29	0.00E+00	0.00E+00	0.00E+00	2.39E-29
Rb-86	0.00E+00	1.62E+09	7.54E+08	0.00E+00	0.00E+00	0.00E+00	3.19E+08
Sr-89	8.70E+08	0.00E+00	2.50E+07	0.00E+00	0.00E+00	0.00E+00	1.40E+08
Sr-90	3.09E+10	0.00E+00	7.59E+09	0.00E+00	0.00E+00	0.00E+00	8.94E+08
Y-90	1.44E-18	0.00E+00	3.86E-20	0.00E+00	0.00E+00	0.00E+00	1.53E-14
Y-91	5.11E+03	0.00E+00	1.37E+02	0.00E+00	0.00E+00	0.00E+00	2.81E+06
Zr-95	5.62E+02	1.80E+02	1.22E+02	0.00E+00	2.83E+02	0.00E+00	5.71E+05
Nb-95	4.95E+04	2.75E+04	1.48E+04	0.00E+00	2.72E+04	0.00E+00	1.67E+08
Nb-97	1.09E-08	2.75E-09	1.00E-09	0.00E+00	3.21E-09	0.00E+00	1.01E-05
Mo-99	0.00E+00	1.83E-12	3.49E-13	0.00E+00	4.15E-12	0.00E+00	4.25E-12
Ru-103	6.11E+02	0.00E+00	2.63E+02	0.00E+00	2.33E+03	0.00E+00	7.14E+04
Ru-106	1.26E+04	0.00E+00	1.60E+03	0.00E+00	2.44E+04	0.00E+00	8.17E+05
Ag-110M	3.71E+07	3.44E+07	2.04E+07	0.00E+00	6.76E+07	0.00E+00	1.40E+10
Sn-113	1.40E+06	5.41E+04	1.32E+06	1.90E+04	3.95E+04	0.00E+00	2.44E+07
Sb-124	1.55E+07	2.92E+05	6.14E+06	3.75E+04	0.00E+00	1.20E+07	4.39E+08
Sb-125	1.30E+07	1.45E+05	3.09E+06	1.32E+04	0.00E+00	1.00E+07	1.43E+08
Te-125M	1.10E+07	3.99E+06	1.48E+06	3.31E+06	4.48E+07	0.00E+00	4.40E+07
Te-127m	3.37E+07	1.21E+07	4.11E+06	8.62E+06	1.37E+08	0.00E+00	1.13E+08
Te-129M	3.91E+07	1.46E+07	6.19E+06	1.34E+07	1.63E+08	0.00E+00	1.97E+08
Te-132	2.06E-10	1.33E-10	1.25E-10	1.47E-10	1.28E-09	0.00E+00	6.29E-09
I-131	1.94E+08	2.77E+08	1.59E+08	9.09E+10	4.76E+08	0.00E+00	7.32E+07
I-132	1.10E+01	2.93E+01	1.03E+01	1.03E+01	4.67E+01	0.00E+00	5.51E-02
I-133	2.64E+06	4.59E+06	1.40E+06	6.75E+08	8.01E+06	0.00E+00	4.13E+06
I-135	9.34E+03	2.45E+04	9.03E+03	1.61E+06	3.92E+04	0.00E+00	2.76E+04

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-8 (continue)
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Cow Milk

AGE GROUP = Adult

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Cs-134	3.45E+09	3.21E+09	6.71E+09	0.00E+00	2.66E+09	8.82E+08	1.44E+08
Cs-136	1.66E+08	6.57E+08	4.73E+08	0.00E+00	3.65E+08	5.01E+07	7.46E+07
Cs-137	4.71E+09	6.44E+09	4.22E+09	0.00E+00	2.19E+09	7.27E+08	1.25E+08
Ba-140	1.71E+07	2.15E+04	1.12E+06	0.00E+00	7.32E+03	1.23E+04	3.53E+07
La-140	7.56E-32	3.81E-32	1.01E-32	0.00E+00	0.00E+00	0.00E+00	2.80E-27
Ce-141	2.91E+03	1.97E+03	2.23E+02	0.00E+00	9.14E+02	0.00E+00	7.52E+06
Ce-144	2.15E+05	8.97E+04	1.15E+04	0.00E+00	5.32E+04	0.00E+00	7.26E+07
Pr-143	1.00E+02	4.02E+01	4.97E+00	0.00E+00	2.32E+01	0.00E+00	4.39E+05
Nd-147	6.08E+01	7.02E+01	4.20E+00	0.00E+00	4.10E+01	0.00E+00	3.37E+05
Hf-181	5.91E+03	3.33E+01	6.68E+02	2.12E+01	2.79E+01	0.00E+00	4.38E+05
Np-239	1.34E-22	1.32E-23	7.28E-24	0.00E+00	4.12E-23	0.00E+00	2.71E-18

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-9
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Cow Milk

AGE GROUP = Teen

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03
P-32	2.06E+10	1.28E+09	8.00E+08	0.00E+00	0.00E+00	0.00E+00	1.73E+09
Cr-51	0.00E+00	0.00E+00	3.02E+04	1.68E+04	6.63E+03	4.32E+04	5.08E+06
Mn-54	0.00E+00	8.52E+06	1.69E+06	0.00E+00	2.54E+06	0.00E+00	1.75E+07
Fe-55	2.78E+07	1.97E+07	4.59E+06	0.00E+00	0.00E+00	1.25E+07	8.53E+06
Fe-59	3.10E+07	7.23E+07	2.79E+07	0.00E+00	0.00E+00	2.28E+07	1.71E+08
Co-57	0.00E+00	1.39E+06	2.33E+06	0.00E+00	0.00E+00	0.00E+00	2.59E+07
Co-58	0.00E+00	4.72E+06	1.09E+07	0.00E+00	0.00E+00	0.00E+00	6.50E+07
Co-60	0.00E+00	1.72E+07	3.88E+07	0.00E+00	0.00E+00	0.00E+00	2.25E+08
Ni-63	8.25E+09	5.83E+08	2.80E+08	0.00E+00	0.00E+00	0.00E+00	9.27E+07
Zn-65	1.47E+09	5.11E+09	2.38E+09	0.00E+00	3.27E+09	0.00E+00	2.16E+09
Br-82	0.00E+00	0.00E+00	3.62E-29	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.95E+09	1.39E+09	0.00E+00	0.00E+00	0.00E+00	4.37E+08
Sr-89	1.60E+09	0.00E+00	4.59E+07	0.00E+00	0.00E+00	0.00E+00	1.91E+08
Sr-90	4.37E+10	0.00E+00	1.08E+10	0.00E+00	0.00E+00	0.00E+00	1.23E+09
Y-90	2.64E-18	0.00E+00	7.12E-20	0.00E+00	0.00E+00	0.00E+00	2.18E-14
Y-91	9.40E+03	0.00E+00	2.52E+02	0.00E+00	0.00E+00	0.00E+00	3.85E+06
Zr-95	9.83E+02	3.10E+02	2.13E+02	0.00E+00	4.56E+02	0.00E+00	7.16E+05
Nb-95	8.45E+04	4.68E+04	2.58E+04	0.00E+00	4.54E+04	0.00E+00	2.00E+08
Nb-97	1.97E-08	4.92E-09	1.80E-09	0.00E+00	5.75E-09	0.00E+00	1.17E-04
Mo-99	0.00E+00	3.31E-12	6.31E-13	0.00E+00	7.57E-12	0.00E+00	5.92E-12
Ru-103	1.09E+03	0.00E+00	4.65E+02	0.00E+00	3.83E+03	0.00E+00	9.08E+04
Ru-106	2.32E+04	0.00E+00	2.93E+03	0.00E+00	4.48E+04	0.00E+00	1.11E+06
Ag-110M	6.14E+07	5.81E+07	3.53E+07	0.00E+00	1.11E+08	0.00E+00	1.63E+10
Sn-113	2.15E+06	9.06E+04	2.28E+06	2.97E+04	6.37E+04	0.00E+00	2.58E+07
Sb-124	2.76E+07	5.08E+05	1.08E+07	6.26E+04	0.00E+00	2.41E+07	5.56E+08
Sb-125	2.32E+07	2.53E+05	5.42E+06	2.22E+04	0.00E+00	2.04E+07	1.80E+08
Te-125M	2.03E+07	7.32E+06	2.72E+06	5.68E+06	0.00E+00	0.00E+00	5.99E+07
Te-127m	6.22E+07	2.21E+07	7.39E+06	1.48E+07	2.52E+08	0.00E+00	1.55E+08
Te-129M	7.15E+07	2.65E+07	1.13E+07	2.31E+07	2.99E+08	0.00E+00	2.69E+08
Te-132	3.68E-10	2.33E-10	2.19E-10	2.45E-10	2.23E-09	0.00E+00	7.37E-09
I-131	3.52E+08	4.93E+08	2.65E+08	1.44E+11	8.48E+08	0.00E+00	9.75E+07
I-132	1.94E+01	5.09E+01	1.83E+01	1.71E+01	8.02E+01	0.00E+00	2.22E+01
I-133	4.82E+06	8.18E+06	2.49E+06	1.14E+09	1.43E+07	0.00E+00	6.19E+06
I-135	1.66E+04	4.27E+04	1.58E+04	2.75E+06	6.75E+04	0.00E+00	4.74E+04

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-9 (continue)
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Cow Milk

AGE GROUP = Teen

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Cs-134	5.99E+09	1.41E+10	6.54E+09	0.00E+00	4.48E+09	1.71E+09	1.75E+08
Cs-136	2.83E+08	1.11E+09	7.48E+08	0.00E+00	6.07E+08	9.56E+07	8.97E+07
Cs-137	8.54E+09	1.14E+10	3.96E+09	0.00E+00	3.87E+09	1.50E+09	1.62E+08
Ba-140	3.09E+07	3.79E+04	1.99E+06	0.00E+00	1.28E+04	2.55E+04	4.77E+07
La-140	1.36E-31	6.68E-32	1.78E-32	0.00E+00	0.00E+00	0.00E+00	3.83E-27
Ce-141	5.33E+03	3.56E+03	4.09E+02	0.00E+00	1.68E+03	0.00E+00	1.02E+07
Ce-144	3.95E+05	1.63E+05	2.12E+04	0.00E+00	9.76E+04	0.00E+00	9.93E+07
Pr-143	1.84E+02	7.36E+01	9.17E+00	0.00E+00	4.28E+01	0.00E+00	6.06E+05
Nd-147	1.17E+02	1.27E+02	7.61E+00	0.00E+00	7.47E+01	0.00E+00	4.59E+05
Hf-181	1.06E+04	5.82E+01	1.18E+03	3.55E+01	4.84E+01	0.00E+00	5.28E+05
Np-239	2.56E-22	2.42E-23	1.34E-23	0.00E+00	7.59E-23	0.00E+00	3.89E-18

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-10
R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Cow Milk

AGE GROUP = Child

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	1.58E+03	1.58E+03	1.58E+03	1.58E+03	1.58E+03	1.58E+03
P-32	5.09E+10	2.38E+09	1.96E+09	0.00E+00	0.00E+00	0.00E+00	1.41E+09
Cr-51	0.00E+00	0.00E+00	6.17E+04	3.42E+04	9.36E+03	6.25E+04	3.27E+06
Mn-54	0.00E+00	1.27E+07	3.39E+06	0.00E+00	3.57E+06	0.00E+00	1.07E+07
Fe-55	6.97E+07	3.70E+07	1.15E+07	0.00E+00	0.00E+00	2.09E+07	6.85E+06
Fe-59	7.18E+07	1.16E+08	5.79E+07	0.00E+00	0.00E+00	3.37E+07	1.21E+08
Co-57	0.00E+00	2.37E+06	4.80E+06	0.00E+00	0.00E+00	0.00E+00	1.94E+07
Co-58	0.00E+00	7.21E+06	2.21E+07	0.00E+00	0.00E+00	0.00E+00	4.20E+07
Co-60	0.00E+00	2.68E+07	7.90E+07	0.00E+00	0.00E+00	0.00E+00	1.48E+08
Ni-63	2.07E+10	1.11E+09	7.04E+08	0.00E+00	0.00E+00	0.00E+00	7.46E+07
Zn-65	2.89E+09	7.70E+09	4.79E+09	0.00E+00	4.85E+09	0.00E+00	1.35E+09
Br-82	0.00E+00	0.00E+00	7.42E-29	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	5.47E+09	3.36E+09	0.00E+00	0.00E+00	0.00E+00	3.52E+08
Sr-89	3.97E+09	0.00E+00	1.13E+08	0.00E+00	0.00E+00	0.00E+00	1.54E+08
Sr-90	7.38E+10	0.00E+00	1.87E+10	0.00E+00	0.00E+00	0.00E+00	9.95E+08
Y-90	6.54E-18	0.00E+00	1.75E-19	0.00E+00	0.00E+00	0.00E+00	1.86E-14
Y-91	2.32E+04	0.00E+00	6.21E+02	0.00E+00	0.00E+00	0.00E+00	3.09E+06
Zr-95	2.28E+03	5.02E+02	4.47E+02	0.00E+00	7.18E+02	0.00E+00	5.23E+05
Nb-95	1.91E+05	7.42E+04	5.31E+04	0.00E+00	6.98E+04	0.00E+00	1.37E+08
Nb-97	4.81E-08	8.70E-09	4.06E-09	0.00E+00	9.65E-09	0.00E+00	2.68E-03
Mo-99	0.00E+00	6.02E-12	1.49E-12	0.00E+00	1.29E-11	0.00E+00	4.98E-12
Ru-103	2.57E+03	0.00E+00	9.88E+02	0.00E+00	6.47E+03	0.00E+00	6.65E+04
Ru-106	5.72E+04	0.00E+00	7.14E+03	0.00E+00	7.72E+04	0.00E+00	8.90E+05
Ag-110M	1.33E+08	9.00E+07	7.19E+07	0.00E+00	1.68E+08	0.00E+00	1.07E+10
Sn-113	4.22E+05	1.36E+04	4.61E+05	5.58E+03	9.37E+03	0.00E+00	1.69E+06
Sb-124	6.53E+07	8.47E+05	2.29E+07	1.44E+05	0.00E+00	3.62E+07	4.09E+08
Sb-125	5.52E+07	4.26E+05	1.16E+07	5.11E+04	0.00E+00	3.08E+07	1.32E+08
Te-125M	4.99E+07	1.35E+07	6.65E+06	1.40E+07	0.00E+00	0.00E+00	4.81E+07
Te-127m	1.53E+08	4.13E+07	1.82E+07	3.66E+07	4.37E+08	0.00E+00	1.24E+08
Te-129M	1.76E+08	4.92E+07	2.74E+07	5.68E+07	5.18E+08	0.00E+00	2.15E+08
Te-132	8.78E-10	3.88E-10	4.69E-10	5.66E-10	3.61E-09	0.00E+00	3.91E-09
I-131	8.54E+08	8.59E+08	4.88E+08	2.84E+11	1.41E+09	0.00E+00	7.64E+07
I-132	4.60E+01	8.45E+01	3.89E+01	3.92E+01	1.29E+00	0.00E+00	9.95E+01
I-133	1.17E+07	1.45E+07	5.48E+06	2.69E+09	2.41E+07	0.00E+00	5.84E+06
I-135	3.93E+04	7.07E+04	3.35E+04	6.26E+06	1.08E+05	0.00E+00	5.39E+04

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-10 (continue)
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Cow Milk

AGE GROUP = Child

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Cs-134	1.38E+10	2.27E+10	4.78E+09	0.00E+00	7.03E+09	2.52E+09	1.22E+08
Cs-136	6.39E+08	1.76E+09	1.14E+09	0.00E+00	9.36E+08	1.40E+08	6.17E+07
Cs-137	2.06E+10	1.97E+10	2.91E+09	0.00E+00	6.42E+09	2.31E+09	1.23E+08
Ba-140	7.47E+07	6.54E+04	4.36E+06	0.00E+00	2.13E+04	3.90E+04	3.78E+07
La-140	3.25E-31	1.14E-31	3.83E-32	0.00E+00	0.00E+00	0.00E+00	3.17E-27
Ce-141	1.31E+04	6.55E+03	9.73E+02	0.00E+00	2.87E+03	0.00E+00	8.17E+06
Ce-144	9.74E+05	3.05E+05	5.20E+04	0.00E+00	1.69E+05	0.00E+00	7.96E+07
Pr-143	4.56E+02	1.37E+02	2.26E+01	0.00E+00	7.42E+01	0.00E+00	4.92E+05
Nd-147	2.87E+02	2.32E+02	1.80E+01	0.00E+00	1.27E+02	0.00E+00	3.68E+05
Hf-181	2.51E+04	9.79E+01	2.53E+03	8.24E+01	7.86E+01	0.00E+00	4.16E+05
Np-239	6.31E-22	4.53E-23	3.18E-23	0.00E+00	1.31E-22	0.00E+00	3.35E-18

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-11
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Cow Milk

AGE GROUP = Infant

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	2.40E+03	2.40E+03	2.40E+03	2.40E+03	2.40E+03	2.40E+03
P-32	1.05E+11	6.17E+09	4.06E+09	0.00E+00	0.00E+00	0.00E+00	1.42E+09
Cr-51	0.00E+00	0.00E+00	9.77E+04	6.38E+04	1.39E+04	1.24E+05	2.85E+06
Mn-54	0.00E+00	2.37E+07	5.37E+06	0.00E+00	5.25E+06	0.00E+00	8.71E+06
Fe-55	8.43E+07	5.45E+07	1.46E+07	0.00E+00	0.00E+00	2.66E+07	6.91E+06
Fe-59	1.34E+08	2.34E+08	9.23E+07	0.00E+00	0.00E+00	6.92E+07	1.12E+08
Co-57	0.00E+00	5.53E+06	9.00E+06	0.00E+00	0.00E+00	0.00E+00	1.89E+07
Co-58	0.00E+00	1.44E+07	3.60E+07	0.00E+00	0.00E+00	0.00E+00	3.59E+07
Co-60	0.00E+00	5.47E+07	1.29E+08	0.00E+00	0.00E+00	0.00E+00	1.30E+08
Ni-63	2.44E+10	1.51E+09	8.46E+08	0.00E+00	0.00E+00	0.00E+00	7.50E+07
Zn-65	3.88E+09	1.33E+10	6.14E+09	0.00E+00	6.45E+09	0.00E+00	1.12E+10
Br-82	0.00E+00	0.00E+00	1.25E-28	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.39E+10	6.86E+09	0.00E+00	0.00E+00	0.00E+00	3.55E+08
Sr-89	7.55E+09	0.00E+00	2.17E+08	0.00E+00	0.00E+00	0.00E+00	1.55E+08
Sr-90	8.04E+10	0.00E+00	2.05E+10	0.00E+00	0.00E+00	0.00E+00	1.00E+09
Y-90	1.38E-17	0.00E+00	3.71E-19	0.00E+00	0.00E+00	0.00E+00	1.91E-14
Y-91	4.36E+04	0.00E+00	1.17E+03	0.00E+00	0.00E+00	0.00E+00	3.12E+06
Zr-95	4.05E+03	9.88E+02	7.01E+02	0.00E+00	1.06E+03	0.00E+00	4.92E+05
Nb-95	3.56E+05	1.47E+05	8.48E+04	0.00E+00	1.05E+05	0.00E+00	1.24E+08
Nb-97	1.02E-07	2.17E-08	7.83E-09	0.00E+00	1.70E-08	0.00E+00	6.85E-03
Mo-99	0.00E+00	1.54E-11	3.00E-12	0.00E+00	2.30E-11	0.00E+00	5.07E-12
Ru-103	5.21E+03	0.00E+00	1.74E+03	0.00E+00	1.08E+04	0.00E+00	6.33E+04
Ru-106	1.18E+05	0.00E+00	1.47E+04	0.00E+00	1.39E+05	0.00E+00	8.95E+05
Ag-110M	2.46E+08	1.80E+08	1.19E+08	0.00E+00	2.57E+08	0.00E+00	9.32E+09
Sn-113	6.45E+06	2.45E+05	6.65E+06	9.34E+04	1.31E+05	0.00E+00	1.37E+07
Sb-124	1.26E+08	1.85E+06	3.90E+07	3.34E+05	0.00E+00	7.88E+07	3.88E+08
Sb-125	9.49E+07	9.18E+05	1.95E+07	1.19E+05	0.00E+00	5.95E+07	1.26E+08
Te-125M	1.02E+08	3.41E+07	1.38E+07	3.43E+07	0.00E+00	0.00E+00	4.86E+07
Te-127m	3.10E+08	1.03E+08	3.75E+07	8.96E+07	7.64E+08	0.00E+00	1.25E+08
Te-129M	3.62E+08	1.24E+08	5.57E+07	1.39E+08	9.05E+08	0.00E+00	2.16E+08
Te-132	1.81E-09	8.95E-10	8.35E-10	1.32E-09	5.60E-09	0.00E+00	3.31E-09
I-131	1.78E+09	2.10E+09	9.23E+08	6.90E+11	2.45E+09	0.00E+00	7.49E+07
I-132	9.55E+01	1.94E+00	6.90E+01	9.09E+01	2.16E+00	0.00E+00	1.57E+00
I-133	2.47E+07	3.60E+07	1.05E+07	6.55E+09	4.23E+07	0.00E+00	6.09E+06
I-135	8.17E+04	1.63E+05	5.93E+04	1.46E+07	1.81E+05	0.00E+00	5.88E+04

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec per m}^2$ for all others.

TABLE 3.3-11 (continue)
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Cow Milk

AGE GROUP = Infant

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Cs-134	2.23E+10	4.15E+10	4.19E+09	0.00E+00	1.07E+10	4.38E+09	1.13E+08
Cs-136	1.25E+09	3.67E+09	1.37E+09	0.00E+00	1.46E+09	2.99E+08	5.58E+07
Cs-137	3.28E+10	3.84E+10	2.72E+09	0.00E+00	1.03E+10	4.18E+09	1.20E+08
Ba-140	1.54E+08	1.54E+05	7.91E+06	0.00E+00	3.65E+04	9.43E+04	3.77E+07
La-140	6.80E-31	2.68E-31	6.89E-32	0.00E+00	0.00E+00	0.00E+00	3.15E-27
Ce-141	2.60E+04	1.59E+04	1.87E+03	0.00E+00	4.90E+03	0.00E+00	8.21E+06
Ce-144	1.40E+06	5.71E+05	7.82E+04	0.00E+00	2.31E+05	0.00E+00	8.01E+07
Pr-143	9.44E+02	3.53E+02	4.68E+01	0.00E+00	1.31E+02	0.00E+00	4.98E+05
Nd-147	5.69E+02	5.84E+02	3.58E+01	0.00E+00	2.25E+02	0.00E+00	3.70E+05
Hf-181	4.78E+04	2.26E+02	4.23E+03	1.91E+02	1.32E+02	0.00E+00	3.93E+05
Np-239	1.33E-21	1.19E-22	6.74E-23	0.00E+00	2.38E-22	0.00E+00	3.45E-18

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-12
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Goat Milk

AGE GROUP = Adult

Nuclide	T. Body	GI-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
H-3	1.57E+03	1.57E+03	0.00E+01	1.57E+03	1.57E+03	1.57E+03	1.57E+03	1.57E+03
P-32	5.19E+08	1.51E+09	1.34E+10	8.34E+08	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Cr-51	2.08E+03	5.23E+05	0.00E+01	0.00E+01	4.58E+02	1.24E+03	2.76E+03	0.00E+01
Mn-54	1.17E+05	1.88E+06	0.00E+01	6.14E+05	1.83E+05	0.00E+01	0.00E+01	0.00E+01
Fe-59	2.08E+05	1.81E+06	2.31E+05	5.42E+05	0.00E+01	0.00E+01	1.51E+05	0.00E+01
Co-58	7.54E+05	6.82E+06	0.00E+01	3.36E+05	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Co-60	2.69E+06	2.29E+07	0.00E+01	1.22E+06	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Zn-65	1.65E+08	2.31E+08	1.15E+08	3.66E+08	2.45E+08	0.00E+01	0.00E+01	0.00E+01
Rb-86	9.05E+07	3.83E+07	0.00E+01	1.94E+08	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Sr-89	5.24E+07	2.93E+08	1.83E+09	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Sr-90	1.59E+10	1.88E+09	6.49E+10	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Y-91	1.64E+01	3.37E+05	6.13E+02	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Zr-95	1.46E+01	6.85E+04	6.74E+01	2.16E+01	3.39E+01	0.00E+01	0.00E+01	0.00E+01
Nb-95	1.78E+03	2.01E+07	5.94E+03	3.31E+03	3.27E+03	0.00E+01	0.00E+01	0.00E+01
Ru-103	3.16E+01	8.56E+03	7.33E+01	0.00E+01	2.80E+02	0.00E+01	0.00E+01	0.00E+01
Ru-106	1.92E+02	9.81E+04	1.52E+03	0.00E+01	2.93E+03	0.00E+01	0.00E+01	0.00E+01
Ag-110M	2.45E+06	1.68E+09	4.46E+06	4.12E+06	8.11E+06	0.00E+01	0.00E+01	0.00E+01
Sn-113	1.32E+05	2.44E+06	1.40E+05	5.41E+03	3.96E+03	1.90E+03	0.00E+01	0.00E+01
Sb-124	7.36E+05	5.27E+07	1.86E+06	3.51E+04	0.00E+01	4.50E+03	1.44E+06	0.00E+01
Te-127M	4.93E+05	1.36E+07	4.05E+06	1.45E+06	1.64E+07	1.03E+06	0.00E+01	0.00E+01
Te-129M	7.43E+05	2.36E+07	4.69E+06	1.75E+06	1.96E+07	1.61E+06	0.00E+01	0.00E+01
I-131	1.91E+08	8.78E+07	2.33E+08	3.33E+08	5.71E+08	1.09E+11	0.00E+01	0.00E+01
I-132	1.23E+01	6.61E-02	1.32E+01	3.52E+01	5.61E+01	1.23E+01	0.00E+01	0.00E+01
I-133	1.68E+06	4.95E+06	3.17E+06	5.51E+06	9.61E+06	8.10E+08	0.00E+01	0.00E+01
I-135	1.08E+04	3.32E+04	1.12E+04	2.94E+04	4.71E+04	1.94E+06	0.00E+01	0.00E+01
Cs-134	2.01E+10	4.31E+08	1.03E+10	2.46E+10	7.97E+09	0.00E+01	2.65E+09	0.00E+01
Cs-136	1.42E+09	2.24E+08	4.99E+08	1.97E+09	1.10E+09	0.00E+01	1.50E+08	0.00E+01
Cs-137	1.27E+10	3.74E+08	1.41E+10	1.93E+10	6.56E+09	0.00E+01	2.18E+09	0.00E+01
Ba-140	1.35E+05	4.23E+06	2.06E+06	2.58E+03	8.78E+02	0.00E+01	1.48E+03	0.00E+01
Ce-141	2.68E+01	9.03E+05	3.49E+02	2.36E+02	1.10E+02	0.00E+01	0.00E+01	0.00E+01
Ce-144	1.38E+03	8.71E+06	2.58E+04	1.08E+04	6.39E+03	0.00E+01	0.00E+01	0.00E+01
Hf-181	8.02E+01	5.26E+04	7.09E+02	3.99E+00	3.34E+00	2.54E+00	0.00E+01	0.00E+01

R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-13
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Goat Milk

AGE GROUP = Teen

Nuclide	T. Body	GI-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
H-3	2.04E+03	2.04E+03	0.00E+01	2.04E+03	2.04E+03	2.04E+03	2.04E+03	2.04E+03
P-32	9.60E+08	2.08E+09	2.48E+10	1.53E+09	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Cr-51	3.63E+03	6.10E+05	0.00E+01	0.00E+01	7.95E+02	2.02E+03	5.18E+03	0.00E+01
Mn-54	2.03E+05	2.10E+06	0.00E+01	1.02E+06	3.05E+05	0.00E+01	0.00E+01	0.00E+01
Fe-59	3.63E+05	2.22E+06	4.03E+05	9.40E+05	0.00E+01	0.00E+01	2.96E+05	0.00E+01
Co-58	1.30E+06	7.80E+06	0.00E+01	5.66E+05	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Co-60	4.66E+06	2.69E+07	0.00E+01	2.07E+06	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Zn-65	2.86E+08	2.60E+08	1.77E+08	6.13E+08	3.93E+08	0.00E+01	0.00E+01	0.00E+01
Rb-86	1.66E+08	5.24E+07	0.00E+01	3.54E+08	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Sr-89	9.65E+07	4.01E+08	3.37E+09	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Sr-90	2.27E+10	2.58E+09	9.18E+10	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Y-91	3.02E+01	4.62E+05	1.13E+03	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Zr-95	2.56E+01	8.59E+04	1.18E+02	3.72E+01	5.47E+01	0.00E+01	0.00E+01	0.00E+01
Nb-95	3.09E+03	2.40E+07	1.01E+04	5.62E+03	5.45E+03	0.00E+01	0.00E+01	0.00E+01
Ru-103	5.58E+01	1.09E+04	1.30E+02	0.00E+01	4.60E+02	0.00E+01	0.00E+01	0.00E+01
Ru-106	3.51E+02	1.34E+05	2.79E+03	0.00E+01	5.38E+03	0.00E+01	0.00E+01	0.00E+01
Ag-110M	4.24E+06	1.96E+09	7.37E+06	6.97E+06	1.33E+07	0.00E+01	0.00E+01	0.00E+01
Sn-113	2.28E+05	2.58E+06	2.15E+05	9.06E+03	6.37E+03	2.97E+03	0.00E+01	0.00E+01
Sb-124	1.29E+06	6.67E+07	3.31E+06	6.10E+04	0.00E+01	7.51E+03	2.89E+06	0.00E+01
Te-127M	8.87E+05	1.86E+07	7.46E+06	2.65E+06	3.02E+07	1.77E+06	0.00E+01	0.00E+01
Te-129M	1.36E+06	3.22E+07	8.58E+06	3.19E+06	3.59E+07	2.77E+06	0.00E+01	0.00E+01
I-131	3.18E+08	1.17E+08	4.22E+08	5.91E+08	1.02E+09	1.73E+11	0.00E+01	0.00E+01
I-132	2.19E+01	2.66E+01	2.33E+01	6.11E+01	9.62E+01	2.06E+01	0.00E+01	0.00E+01
I-133	2.99E+06	7.43E+06	5.79E+06	9.81E+06	1.72E+07	1.37E+09	0.00E+01	0.00E+01
I-135	1.90E+04	5.63E+04	1.99E+04	5.13E+04	8.10E+04	3.30E+06	0.00E+01	0.00E+01
Cs-134	1.96E+10	5.26E+08	1.80E+10	4.23E+10	1.34E+10	0.00E+01	5.13E+09	0.00E+01
Cs-136	2.25E+09	2.69E+07	8.50E+08	3.34E+09	1.82E+09	0.00E+01	2.87E+08	0.00E+01
Cs-137	1.19E+10	4.85E+08	2.56E+10	3.41E+10	1.16E+10	0.00E+01	4.51E+09	0.00E+01
Ba-140	2.39E+05	5.72E+06	3.71E+06	4.55E+03	1.54E+03	0.00E+01	3.06E+03	0.00E+01
Ce-141	4.91E+01	1.22E+06	6.40E+02	4.27E+02	2.01E+02	0.00E+01	0.00E+01	0.00E+01
Ce-144	2.55E+03	1.19E+07	4.74E+04	1.96E+04	1.17E+04	0.00E+01	0.00E+01	0.00E+01
Hf-181	1.41E+02	6.34E+04	1.27E+03	6.97E+00	5.80E+00	4.26E+00	0.00E+01	0.00E+01

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^{-2} for all others.

TABLE 3.3-14
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Goat Milk

AGE GROUP = Child

Nuclide	T. Body	GI-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
H-3	3.23E+03	3.23E+03	0.00E+01	3.23E+03	3.23E+03	3.23E+03	3.23E+03	3.23E+03
P-32	2.35E+09	1.69E+09	6.11E+10	2.86E+09	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Cr-51	7.40E+03	3.93E+05	0.00E+01	0.00E+01	1.12E+03	4.11E+03	7.50E+03	0.00E+01
Mn-54	4.07E+05	1.28E+06	0.00E+01	1.53E+06	4.29E+05	0.00E+01	0.00E+01	0.00E+01
Fe-59	7.52E+05	1.57E+06	9.34E+05	1.51E+06	0.00E+01	0.00E+01	4.38E+05	0.00E+01
Co-58	2.65E+06	5.05E+06	0.00E+01	8.65E+05	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Co-60	9.48E+06	1.78E+07	0.00E+01	3.21E+06	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Zn-65	5.74E+08	1.62E+08	3.47E+08	9.24E+08	5.82E+08	0.00E+01	0.00E+01	0.00E+01
Rb-86	4.04E+08	4.22E+07	0.00E+01	6.57E+08	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Sr-89	2.38E+08	3.23E+08	8.34E+09	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Sr-90	3.93E+10	2.09E+09	1.55E+11	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Y-91	7.45E+01	3.71E+05	2.79E+03	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Zr-95	5.36E+01	6.28E+04	2.74E+02	6.02E+01	8.62E+01	0.00E+01	0.00E+01	0.00E+01
Nb-95	6.37E+03	1.65E+07	2.29E+04	8.91E+03	8.37E+03	0.00E+01	0.00E+01	0.00E+01
Ru-103	1.19E+02	7.98E+03	3.09E+02	0.00E+01	7.77E+02	0.00E+01	0.00E+01	0.00E+01
Ru-106	8.56E+02	1.07E+05	6.86E+03	0.00E+01	9.27E+03	0.00E+01	0.00E+01	0.00E+01
Ag-110M	8.63E+06	1.28E+09	1.60E+07	1.08E+07	2.01E+07	0.00E+01	0.00E+01	0.00E+01
Sn-113	4.61E+05	1.69E+06	4.22E+05	1.36E+04	9.38E+03	5.59E+03	0.00E+01	0.00E+01
Sb-124	2.75E+06	4.91E+07	7.84E+06	1.02E+05	0.00E+01	1.73E+04	4.35E+06	0.00E+01
Te-127M	2.18E+06	1.49E+07	1.84E+07	4.95E+06	5.24E+07	4.40E+06	0.00E+01	0.00E+01
Te-129M	3.28E+06	2.58E+07	2.12E+07	5.91E+06	6.21E+07	6.82E+06	0.00E+01	0.00E+01
I-131	5.85E+08	9.17E+07	1.02E+09	1.03E+09	1.69E+09	3.41E+11	0.00E+01	0.00E+01
I-132	4.67E+01	1.19E+00	5.52E+01	1.01E+00	1.55E+00	4.71E+01	0.00E+01	0.00E+01
I-133	6.58E+06	7.00E+06	1.41E+07	1.74E+07	2.90E+07	3.23E+09	0.00E+01	0.00E+01
I-135	4.01E+04	6.47E+04	4.72E+04	8.49E+04	1.30E+05	7.52E+06	0.00E+01	0.00E+01
Cs-134	1.43E+10	3.67E+08	4.14E+10	6.80E+10	2.11E+10	0.00E+01	7.56E+09	0.00E+01
Cs-136	3.41E+09	1.85E+08	1.92E+09	5.27E+09	2.81E+09	0.00E+01	4.19E+08	0.00E+01
Cs-137	8.72E+09	3.70E+08	6.17E+10	5.91E+10	1.93E+10	0.00E+01	6.93E+09	0.00E+01
Ba-140	5.23E+05	4.54E+05	8.96E+06	7.85E+03	2.56E+03	0.00E+01	4.68E+03	0.00E+01
Ce-141	1.17E+02	9.81E+05	1.53E+03	7.36E+02	3.45E+02	0.00E+01	0.00E+01	0.00E+01
Ce-144	6.24E+03	9.55E+06	1.17E+05	3.66E+04	2.03E+04	0.00E+01	0.00E+01	0.00E+01
Hf-181	3.04E+02	4.99E+04	3.02E+03	1.17E+01	9.43E+00	9.88E+00	0.00E+01	0.00E+01

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-15
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Goat Milk

AGE GROUP = Infant

Nuclide	T. Body	GI-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
H-3	4.90E+03	4.90E+03	0.00E+01	4.90E+03	4.90E+03	4.90E+03	4.90E+03	4.90E+03
P-32	4.88E+09	1.70E+09	1.26E+11	7.40E+09	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Cr-51	1.17E+04	3.42E+05	0.00E+01	0.00E+01	1.67E+03	7.65E+03	1.49E+04	0.00E+01
Mn-54	6.45E+05	1.04E+06	0.00E+01	2.84E+06	6.30E+05	0.00E+01	0.00E+01	0.00E+01
Fe-59	1.20E+06	1.45E+06	1.74E+06	3.04E+06	0.00E+01	0.00E+01	9.00E+05	0.00E+01
Co-58	4.31E+06	4.31E+06	0.00E+01	1.73E+06	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Co-60	1.55E+07	1.56E+07	0.00E+01	6.56E+06	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Zn-65	7.36E+08	1.35E+09	4.66E+08	1.60E+09	7.74E+08	0.00E+01	0.00E+01	0.00E+01
Rb-86	8.23E+08	4.26E+07	0.00E+01	1.67E+09	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Sr-89	4.55E+08	3.26E+08	1.59E+10	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Sr-90	4.30E+10	2.11E+09	1.69E+11	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Y-91	1.39E+02	3.75E+05	5.23E+03	0.00E+01	0.00E+01	0.00E+01	0.00E+01	0.00E+01
Zr-95	8.41E+01	5.90E+04	4.85E+02	1.19E+02	1.28E+02	0.00E+01	0.00E+01	0.00E+01
Nb-95	1.02E+04	1.48E+07	4.27E+04	1.76E+04	1.26E+04	0.00E+01	0.00E+01	0.00E+01
Ru-103	2.09E+02	7.60E+03	6.25E+02	0.00E+01	1.30E+03	0.00E+01	0.00E+01	0.00E+01
Ru-106	1.77E+03	1.07E+05	1.41E+04	0.00E+01	1.67E+04	0.00E+01	0.00E+01	0.00E+01
Ag-110M	1.43E+07	1.12E+09	2.95E+07	2.16E+07	3.08E+07	0.00E+01	0.00E+01	0.00E+01
Sn-113	6.66E+05	1.37E+06	6.46E+05	2.45E+04	1.32E+04	9.34E+03	0.00E+01	0.00E+01
Sb-124	4.68E+06	4.66E+07	1.51E+07	2.22E+05	0.00E+01	4.01E+04	9.46E+06	0.00E+01
Te-127M	4.51E+06	1.50E+07	3.72E+07	1.23E+07	9.16E+07	1.08E+07	0.00E+01	0.00E+01
Te-129M	6.69E+06	2.59E+07	4.34E+07	1.49E+07	1.09E+08	1.67E+07	0.00E+01	0.00E+01
I-131	1.11E+09	8.99E+07	2.14E+09	2.52E+09	2.94E+09	8.28E+11	0.00E+01	0.00E+01
I-132	8.28E+01	1.88E+00	1.15E+00	2.33E+00	2.59E+00	1.09E+02	0.00E+01	0.00E+01
I-133	1.27E+07	7.31E+06	2.97E+07	4.32E+07	5.08E+07	7.86E+09	0.00E+01	0.00E+01
I-135	7.11E+04	7.06E+04	9.81E+04	1.95E+05	2.17E+05	1.75E+07	0.00E+01	0.00E+01
Cs-134	1.26E+10	3.38E+08	6.68E+10	1.25E+11	3.21E+10	0.00E+01	1.31E+10	0.00E+01
Cs-136	4.11E+09	1.67E+08	3.75E+09	1.10E+10	4.39E+09	0.00E+01	8.98E+08	0.00E+01
Cs-137	8.17E+09	3.61E+08	9.85E+10	1.15E+11	3.10E+10	0.00E+01	1.25E+10	0.00E+01
Ba-140	9.50E+05	4.53E+06	1.84E+07	1.84E+04	4.38E+03	0.00E+01	1.13E+04	0.00E+01
Ce-141	2.24E+02	9.85E+05	3.13E+03	1.91E+03	5.88E+02	0.00E+01	0.00E+01	0.00E+01
Ce-144	9.39E+03	9.61E+06	1.67E+05	6.86E+04	2.77E+04	0.00E+01	0.00E+01	0.00E+01
Hf-181	5.08E+02	4.72E+04	5.74E+03	2.71E+01	1.58E+01	2.30E+01	0.00E+01	0.00E+01

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-16
R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Inhalation

AGE GROUP = Adult

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03
C-14	1.82E+04	3.41E+03	3.41E+03	3.41E+03	3.41E+03	3.41E+03	3.41E+03
Na-24	1.04E+04	1.04E+04	1.04E+04	1.04E+04	1.04E+04	1.04E+04	1.04E+04
P-32	1.32E+06	7.70E+04	5.00E+04	0.00E+00	0.00E+00	0.00E+00	8.63E+04
Cr-51	0.00E+00	0.00E+00	9.99E+01	5.94E+01	2.28E+01	1.44E+04	3.32E+03
Mn-54	0.00E+00	3.95E+04	6.29E+03	0.00E+00	9.83E+03	1.40E+06	7.72E+04
Mn-56	0.00E+00	1.26E+00	1.85E-01	0.00E+00	1.32E+00	9.56E+03	2.05E+04
Fe-55	2.49E+04	1.72E+04	3.99E+03	0.00E+00	0.00E+00	7.30E+04	6.11E+03
Fe-59	1.17E+04	2.77E+04	1.05E+04	0.00E+00	0.00E+00	1.01E+06	1.88E+05
Co-57	0.00E+00	7.01E+02	6.80E+02	0.00E+00	0.00E+00	3.74E+05	3.18E+04
Co-58	0.00E+00	1.58E+03	2.07E+03	0.00E+00	0.00E+00	9.27E+05	1.06E+05
Co-60	0.00E+00	1.15E+04	1.48E+04	0.00E+00	0.00E+00	5.96E+06	2.84E+05
Ni-63	4.37E+05	3.18E+04	1.47E+04	0.00E+00	0.00E+00	1.81E+05	1.35E+04
Ni-65	1.56E+00	2.12E-01	9.23E-02	0.00E+00	0.00E+00	5.67E+03	1.25E+04
Cu-64	0.00E+00	1.48E+00	6.23E-01	0.00E+00	4.68E+00	6.87E+03	4.96E+04
Zn-65	3.24E+04	1.03E+05	4.65E+04	0.00E+00	6.89E+04	8.63E+05	5.34E+04
Zn-69M	8.26E+00	1.98E+01	1.81E+00	0.00E+00	1.20E+01	1.93E+04	1.39E+05
Zn-69	3.43E-02	6.59E-02	4.58E-03	0.00E+00	4.27E-02	9.32E+02	1.65E+01
Br-82	0.00E+00	0.00E+00	1.37E+04	0.00E+00	0.00E+00	0.00E+00	1.05E+04
Br-83	0.00E+00	0.00E+00	2.44E+02	0.00E+00	0.00E+00	0.00E+00	2.35E+02
Br-84	0.00E+00	0.00E+00	3.17E+02	0.00E+00	0.00E+00	0.00E+00	1.66E-03
Br-85	0.00E+00	0.00E+00	1.30E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.35E+05	5.89E+04	0.00E+00	0.00E+00	0.00E+00	1.66E+04
Rb-88	0.00E+00	3.92E+02	1.95E+02	0.00E+00	0.00E+00	0.00E+00	3.39E-09
Rb-89	0.00E+00	2.59E+02	1.72E+02	0.00E+00	0.00E+00	0.00E+00	9.40E-12
Sr-89	3.04E+05	0.00E+00	8.71E+03	0.00E+00	0.00E+00	1.40E+06	3.49E+05
Sr-90	9.91E+07	0.00E+00	6.09E+06	0.00E+00	0.00E+00	9.59E+06	7.21E+05
Sr-91	6.27E+01	0.00E+00	2.54E+00	0.00E+00	0.00E+00	3.69E+04	1.94E+05
Sr-92	6.83E+00	0.00E+00	2.95E-01	0.00E+00	0.00E+00	1.67E+04	4.36E+04
Y-90	2.11E+03	0.00E+00	5.68E+01	0.00E+00	0.00E+00	1.72E+05	5.12E+05
Y-91M	2.64E-01	0.00E+00	1.03E-02	0.00E+00	0.00E+00	1.94E+03	1.34E+00
Y-91	4.62E+05	0.00E+00	1.24E+04	0.00E+00	0.00E+00	1.70E+06	3.84E+05
Y-92	1.04E+01	0.00E+00	3.05E-01	0.00E+00	0.00E+00	1.59E+04	7.44E+04
Y-93	9.56E+01	0.00E+00	2.64E+00	0.00E+00	0.00E+00	4.91E+04	4.27E+05
Zr-95	1.07E+05	3.44E+04	2.32E+04	0.00E+00	5.41E+04	1.77E+06	1.50E+05
Zr-97	9.80E+01	1.98E+01	9.15E+00	0.00E+00	3.01E+01	7.97E+04	5.30E+05
Nb-95	1.41E+04	7.80E+03	4.20E+03	0.00E+00	7.72E+03	5.04E+05	1.04E+05
Nb-97	2.25E-01	5.69E-02	2.07E-02	0.00E+00	6.63E-02	2.43E+03	2.45E+02
Mo-99	0.00E+00	1.22E+02	2.32E+01	0.00E+00	2.95E+02	9.23E+04	2.51E+05
Tc-99M	1.04E-03	2.95E-03	3.75E-02	0.00E+00	4.47E-02	7.74E+02	4.21E+03

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-16 (continue)
R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Inhalation

AGE GROUP = Adult

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Tc-101	4.23E-05	6.09E-05	5.98E-04	0.00E+00	1.09E-03	4.04E+02	1.10E-11
Ru-103	1.53E+03	0.00E+00	6.57E+02	0.00E+00	5.82E+03	5.04E+05	1.10E+05
Ru-105	8.00E-01	0.00E+00	3.15E-01	0.00E+00	1.03E+00	1.11E+04	4.88E+04
Ru-106	6.90E+04	0.00E+00	8.71E+03	0.00E+00	1.33E+05	9.35E+06	9.11E+05
Ag-110M	1.08E+04	9.99E+03	5.94E+03	0.00E+00	1.97E+04	4.63E+06	3.02E+05
Sn-113	6.86E+03	2.69E+02	6.48E+03	9.33E+01	1.97E+02	2.99E+05	2.48E+04
Sb-124	3.12E+04	5.88E+02	1.24E+04	7.55E+01	0.00E+00	2.48E+06	4.06E+05
Sb-125	5.40E+04	6.03E+02	1.28E+04	5.47E+01	0.00E+00	1.77E+06	1.02E+05
Te-125M	3.46E+03	1.60E+03	4.73E+02	1.06E+03	1.26E+04	3.18E+05	7.15E+04
Te-127m	1.26E+04	5.76E+03	1.57E+03	3.28E+03	4.57E+04	9.59E+05	1.49E+05
Te-127	1.42E+00	6.50E-01	3.13E-01	1.07E+00	5.16E+00	6.59E+03	5.81E+04
Te-129M	9.75E+03	4.67E+03	1.58E+03	3.44E+03	3.65E+04	1.16E+06	3.83E+05
Te-129	5.04E-02	2.42E-02	1.26E-02	3.94E-02	1.90E-01	1.96E+03	1.59E+02
Te-131M	7.08E+01	4.41E+01	2.94E+01	5.57E+01	3.13E+02	1.47E+05	5.63E+05
Te-131	1.13E-02	6.03E-03	3.64E-03	9.48E-03	4.42E-02	1.41E+03	1.86E+01
Te-132	2.63E+02	2.18E+02	1.64E+02	1.92E+02	1.47E+03	2.92E+05	5.16E+05
I-130	4.63E+03	1.36E+04	5.35E+03	1.15E+06	2.11E+04	0.00E+00	7.78E+03
I-131	2.52E+04	3.57E+04	2.05E+04	1.19E+07	6.12E+04	0.00E+00	6.27E+03
I-132	1.16E+03	3.25E+03	1.16E+03	1.14E+05	5.18E+03	0.00E+00	4.06E+02
I-133	8.63E+03	1.48E+04	4.51E+03	2.15E+06	2.58E+04	0.00E+00	8.87E+03
I-134	6.52E+02	1.75E+03	6.23E+02	3.02E+04	2.79E+03	0.00E+00	1.02E+00
I-135	2.68E+03	6.97E+03	2.56E+03	4.47E+05	1.11E+04	0.00E+00	5.24E+03
Cs-134	3.72E+05	8.47E+05	7.27E+05	0.00E+00	2.87E+05	9.75E+04	1.04E+04
Cs-136	3.90E+04	1.46E+05	1.10E+05	0.00E+00	8.55E+04	1.20E+04	1.17E+04
Cs-137	4.78E+05	6.20E+05	4.27E+05	0.00E+00	2.22E+05	7.51E+04	8.39E+03
Cs-138	3.35E+02	6.29E+02	3.28E+02	0.00E+00	4.86E+02	4.92E+01	1.89E-03
Ba-139	9.48E-01	6.74E-04	2.77E-02	0.00E+00	6.30E-04	3.81E+03	9.07E+02
Ba-140	3.90E+04	4.90E+01	2.56E+03	0.00E+00	1.67E+01	1.27E+06	2.18E+05
Ba-141	1.01E-01	7.62E-05	3.40E-03	0.00E+00	7.09E-05	1.96E+03	1.17E-07
Ba-142	2.66E-02	2.74E-05	1.68E-03	0.00E+00	2.32E-05	1.21E+03	1.59E-16
La-140	3.48E+02	1.76E+02	4.64E+01	0.00E+00	0.00E+00	1.38E+05	4.64E+05
La-142	6.92E-01	3.14E-01	7.82E-02	0.00E+00	0.00E+00	6.41E+03	2.14E+03
Ce-141	1.99E+04	1.35E+04	1.53E+03	0.00E+00	6.25E+03	3.61E+05	1.20E+05
Ce-143	1.89E+02	1.39E+02	1.55E+01	0.00E+00	6.16E+01	8.08E+04	2.29E+05
Ce-144	3.43E+06	1.43E+06	1.84E+05	0.00E+00	8.47E+05	7.76E+06	8.15E+05
Pr-143	9.48E+03	3.80E+03	4.70E+02	0.00E+00	2.19E+03	2.84E+05	2.03E+05
Pr-144	3.05E-02	1.26E-02	1.55E-03	0.00E+00	7.14E-03	1.03E+03	2.18E-08
Nd-147	5.34E+03	6.17E+03	3.69E+02	0.00E+00	3.60E+03	2.24E+05	1.75E+05
Hf-181	4.56E+04	2.57E+02	5.16E+03	1.63E+02	2.15E+02	5.99E+05	1.29E+05
W-187	8.59E+00	7.17E+00	2.51E+00	0.00E+00	0.00E+00	2.94E+04	1.57E+05
Np-239	2.32E+02	2.28E+01	1.26E+01	0.00E+00	7.09E+01	3.81E+04	1.21E+05

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-17
R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Inhalation

AGE GROUP = Teen

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	1.27E+03	1.27E+03	1.27E+03	1.27E+03	1.27E+03	1.27E+03
C-14	2.60E+04	4.87E+03	4.87E+03	4.87E+03	4.87E+03	4.87E+03	4.87E+03
Na-24	1.38E+04	1.38E+04	1.38E+04	1.38E+04	1.38E+04	1.38E+04	1.38E+04
P-32	1.89E+06	1.09E+05	7.15E+04	0.00E+00	0.00E+00	0.00E+00	9.27E+04
Cr-51	0.00E+00	0.00E+00	1.35E+02	7.49E+01	3.07E+01	2.09E+04	3.00E+03
Mn-54	0.00E+00	5.10E+04	8.39E+03	0.00E+00	1.27E+04	1.98E+06	6.67E+04
Mn-56	0.00E+00	1.70E+00	2.52E-01	0.00E+00	1.79E+00	1.52E+04	5.74E+04
Fe-55	3.34E+04	2.38E+04	5.54E+03	0.00E+00	0.00E+00	1.24E+05	6.39E+03
Fe-59	1.59E+04	3.69E+04	1.43E+04	0.00E+00	0.00E+00	1.53E+06	1.78E+05
Co-57	0.00E+00	9.44E+02	9.20E+02	0.00E+00	0.00E+00	5.86E+05	3.14E+04
Co-58	0.00E+00	2.07E+03	2.77E+03	0.00E+00	0.00E+00	1.34E+06	9.51E+04
Co-60	0.00E+00	1.51E+04	1.98E+04	0.00E+00	0.00E+00	8.71E+06	2.59E+05
Ni-63	5.80E+05	4.34E+04	1.98E+04	0.00E+00	0.00E+00	3.07E+05	1.42E+04
Ni-65	2.18E+00	2.93E-01	1.27E-01	0.00E+00	0.00E+00	9.36E+03	3.67E+04
Cu-64	0.00E+00	2.03E+00	8.48E-01	0.00E+00	6.41E+00	1.11E+04	6.14E+04
Zn-65	3.85E+04	1.33E+05	6.23E+04	0.00E+00	8.63E+04	1.24E+06	4.66E+04
Zn-69M	1.15E+01	2.71E+01	2.49E+00	0.00E+00	1.65E+01	3.14E+04	1.71E+05
Zn-69	4.83E-02	9.20E-02	6.46E-03	0.00E+00	6.02E-02	1.58E+03	2.85E+02
Br-82	0.00E+00	0.00E+00	1.82E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	3.44E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	4.33E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.83E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.90E+05	8.39E+04	0.00E+00	0.00E+00	0.00E+00	1.77E+04
Rb-88	0.00E+00	5.46E+02	2.72E+02	0.00E+00	0.00E+00	0.00E+00	2.92E-05
Rb-89	0.00E+00	3.52E+02	2.33E+02	0.00E+00	0.00E+00	0.00E+00	3.38E-07
Sr-89	4.34E+05	0.00E+00	1.25E+04	0.00E+00	0.00E+00	2.41E+06	3.71E+05
Sr-90	1.08E+08	0.00E+00	6.67E+06	0.00E+00	0.00E+00	1.65E+07	7.64E+05
Sr-91	8.80E+01	0.00E+00	3.51E+00	0.00E+00	0.00E+00	6.07E+04	2.59E+05
Sr-92	9.52E+00	0.00E+00	4.06E-01	0.00E+00	0.00E+00	2.74E+04	1.19E+05
Y-90	2.98E+03	0.00E+00	8.00E+01	0.00E+00	0.00E+00	2.93E+05	5.59E+05
Y-91M	3.70E-01	0.00E+00	1.42E-02	0.00E+00	0.00E+00	3.20E+03	3.02E+01
Y-91	6.60E+05	0.00E+00	1.77E+04	0.00E+00	0.00E+00	2.93E+06	4.08E+05
Y-92	1.47E+01	0.00E+00	4.29E-01	0.00E+00	0.00E+00	2.68E+04	1.65E+05
Y-93	1.35E+02	0.00E+00	3.72E+00	0.00E+00	0.00E+00	8.32E+04	5.79E+05
Zr-95	1.45E+05	4.58E+04	3.15E+04	0.00E+00	6.73E+04	2.68E+06	1.49E+05
Zr-97	1.38E+02	2.72E+01	1.26E+01	0.00E+00	4.12E+01	1.30E+05	6.30E+05
Nb-95	1.85E+04	1.03E+04	5.66E+03	0.00E+00	9.99E+03	7.50E+05	9.67E+04
Nb-97	3.14E-01	7.78E-02	2.84E-02	0.00E+00	9.12E-02	3.93E+03	2.17E+03
Mo-99	0.00E+00	1.69E+02	3.22E+01	0.00E+00	4.11E+02	1.54E+05	2.69E+05
Tc-99M	1.38E-03	3.86E-03	4.99E-02	0.00E+00	5.76E-02	1.15E+03	6.13E+03

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-17 (continue)
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Inhalation

AGE GROUP = Teen

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Tc-101	5.92E-05	8.40E-05	8.24E-04	0.00E+00	1.52E-03	6.67E+02	8.72E-07
Ru-103	2.10E+03	0.00E+00	8.95E+02	0.00E+00	7.42E+03	7.82E+05	1.09E+05
Ru-105	1.12E+00	0.00E+00	4.34E-01	0.00E+00	1.41E+00	1.82E+04	9.04E+04
Ru-106	9.83E+04	0.00E+00	1.24E+04	0.00E+00	1.90E+05	1.61E+07	9.59E+05
Ag-110M	1.38E+04	1.31E+04	7.98E+03	0.00E+00	2.50E+04	6.74E+06	2.72E+05
Sn-113	8.19E+03	3.44E+02	8.68E+03	1.13E+02	2.45E+02	4.27E+05	2.03E+04
Sb-124	4.30E+04	7.94E+02	1.68E+04	9.76E+01	0.00E+00	3.85E+06	3.98E+05
Sb-125	7.38E+04	8.08E+02	1.72E+04	7.04E+01	0.00E+00	2.74E+06	9.92E+04
Te-125M	4.88E+03	2.24E+03	6.67E+02	1.40E+03	0.00E+00	5.36E+05	7.50E+04
Te-127m	1.80E+04	8.15E+03	2.18E+03	4.38E+03	6.53E+04	1.65E+06	1.59E+05
Te-127	2.01E+00	9.12E-01	4.42E-01	1.42E+00	7.28E+00	1.12E+04	8.08E+04
Te-129M	1.39E+04	6.57E+03	2.24E+03	4.57E+03	5.18E+04	1.97E+06	4.04E+05
Te-129	7.10E-02	3.38E-02	1.76E-02	5.18E-02	2.66E-01	3.30E+03	1.62E+03
Te-131M	9.84E+01	6.01E+01	4.02E+01	7.25E+01	4.39E+02	2.38E+05	6.21E+05
Te-131	1.58E-02	8.32E-03	5.04E-03	1.24E-02	6.18E-02	2.34E+03	1.51E+01
Te-132	3.60E+02	2.90E+02	2.19E+02	2.46E+02	1.95E+03	4.49E+05	4.63E+05
I-130	6.24E+03	1.79E+04	7.17E+03	1.49E+06	2.75E+04	0.00E+00	9.12E+03
I-131	3.54E+04	4.90E+04	2.64E+04	1.46E+07	8.39E+04	0.00E+00	6.48E+03
I-132	1.59E+03	4.37E+03	1.57E+03	1.51E+05	6.91E+03	0.00E+00	1.27E+03
I-133	1.21E+04	2.05E+04	6.21E+03	2.92E+06	3.59E+04	0.00E+00	1.03E+04
I-134	8.88E+02	2.32E+03	8.40E+02	3.95E+04	3.66E+03	0.00E+00	2.04E+01
I-135	3.69E+03	9.43E+03	3.48E+03	6.20E+05	1.49E+04	0.00E+00	6.94E+03
Cs-134	5.02E+05	1.13E+06	5.48E+05	0.00E+00	3.75E+05	1.46E+05	9.75E+03
Cs-136	5.14E+04	1.93E+05	1.37E+05	0.00E+00	1.10E+05	1.77E+04	1.09E+04
Cs-137	6.69E+05	8.47E+05	3.11E+05	0.00E+00	3.04E+05	1.21E+05	8.48E+03
Cs-138	4.66E+02	8.56E+02	4.46E+02	0.00E+00	6.62E+02	7.87E+01	2.70E-01
Ba-139	1.34E+00	9.44E-04	3.90E-02	0.00E+00	8.88E-04	6.46E+03	6.45E+03
Ba-140	5.46E+04	6.69E+01	3.51E+03	0.00E+00	2.28E+01	2.03E+06	2.28E+05
Ba-141	1.42E-01	1.06E-04	4.74E-03	0.00E+00	9.84E-05	3.29E+03	7.46E-04
Ba-142	3.70E-02	3.70E-05	2.27E-03	0.00E+00	3.14E-05	1.91E+03	4.79E-10
La-140	4.79E+02	2.36E+02	6.26E+01	0.00E+00	0.00E+00	2.14E+05	4.87E+05
La-142	9.60E-01	4.25E-01	1.06E-01	0.00E+00	0.00E+00	1.02E+04	1.20E+04
Ce-141	2.84E+04	1.89E+04	2.16E+03	0.00E+00	8.87E+03	6.13E+05	1.26E+05
Ce-143	2.66E+02	1.94E+02	2.16E+01	0.00E+00	8.64E+01	1.30E+05	2.55E+05
Ce-144	4.88E+06	2.02E+06	2.62E+05	0.00E+00	1.21E+06	1.33E+07	8.63E+05
Pr-143	1.34E+04	5.31E+03	6.62E+02	0.00E+00	3.09E+03	4.83E+05	2.14E+05
Pr-144	4.30E-02	1.76E-02	2.18E-03	0.00E+00	1.01E-02	1.75E+03	2.35E-04
Nd-147	7.86E+03	8.56E+03	5.13E+02	0.00E+00	5.02E+03	3.72E+05	1.82E+05
Hf-181	6.32E+04	3.48E+02	7.04E+03	2.12E+02	2.90E+02	9.39E+05	1.20E+05
W-187	1.20E+01	9.76E+00	3.43E+00	0.00E+00	0.00E+00	4.74E+04	1.77E+05
Np-239	3.38E+02	3.19E+01	1.77E+01	0.00E+00	1.00E+02	6.49E+04	1.32E+05

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-18
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Inhalation

AGE GROUP = Child

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
H-3	0.00E+00	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03
C-14	3.59E+04	6.73E+03	6.73E+03	6.73E+03	6.73E+03	6.73E+03	6.73E+03
Na-24	2.39E+04	2.39E+04	2.39E+04	2.39E+04	2.39E+04	2.39E+04	2.39E+04
P-32	2.60E+06	1.14E+05	9.86E+04	0.00E+00	0.00E+00	0.00E+00	4.21E+04
Cr-51	0.00E+00	0.00E+00	1.54E+02	8.53E+01	2.43E+01	1.70E+04	1.08E+03
Mn-54	0.00E+00	4.29E+04	9.50E+03	0.00E+00	1.00E+04	1.57E+06	2.29E+04
Mn-56	0.00E+00	2.46E+00	4.64E-01	0.00E+00	2.49E+00	1.95E+04	1.83E+05
Fe-55	4.74E+04	2.52E+04	7.77E+03	0.00E+00	0.00E+00	1.11E+05	2.87E+03
Fe-59	2.07E+04	3.34E+04	1.67E+04	0.00E+00	0.00E+00	1.27E+06	7.06E+04
Co-57	0.00E+00	9.03E+02	1.07E+03	0.00E+00	0.00E+00	5.07E+05	1.32E+04
Co-58	0.00E+00	1.77E+03	3.16E+03	0.00E+00	0.00E+00	1.10E+06	3.43E+04
Co-60	0.00E+00	1.31E+04	2.26E+04	0.00E+00	0.00E+00	7.06E+06	9.61E+04
Ni-63	8.21E+05	4.63E+04	2.80E+04	0.00E+00	0.00E+00	2.75E+05	6.33E+03
Ni-65	4.44E+00	4.39E-01	2.44E-01	0.00E+00	0.00E+00	1.22E+04	1.25E+05
Cu-64	0.00E+00	2.96E+00	1.60E+00	0.00E+00	8.97E+00	1.42E+04	5.46E+04
Zn-65	4.25E+04	1.13E+05	7.02E+04	0.00E+00	7.13E+04	9.94E+05	1.63E+04
Zn-69M	2.34E+01	4.00E+01	4.72E+00	0.00E+00	2.32E+01	4.05E+04	1.49E+05
Zn-69	9.96E-02	1.44E-01	1.33E-02	0.00E+00	8.69E-02	2.11E+03	1.51E+04
Br-82	0.00E+00	0.00E+00	3.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	7.04E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	8.14E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	3.76E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.98E+05	1.14E+05	0.00E+00	0.00E+00	0.00E+00	7.98E+03
Rb-88	0.00E+00	8.36E+02	5.45E+02	0.00E+00	0.00E+00	0.00E+00	2.56E+01
Rb-89	0.00E+00	5.13E+02	4.31E+02	0.00E+00	0.00E+00	0.00E+00	2.81E+00
Sr-89	5.99E+05	0.00E+00	1.72E+04	0.00E+00	0.00E+00	2.15E+06	1.67E+05
Sr-90	1.01E+08	0.00E+00	6.43E+06	0.00E+00	0.00E+00	1.47E+07	3.43E+05
Sr-91	1.80E+02	0.00E+00	6.82E+00	0.00E+00	0.00E+00	7.92E+04	2.59E+05
Sr-92	1.95E+01	0.00E+00	7.81E-01	0.00E+00	0.00E+00	3.57E+04	3.60E+05
Y-90	6.11E+03	0.00E+00	1.64E+02	0.00E+00	0.00E+00	3.89E+05	3.98E+05
Y-91M	7.54E-01	0.00E+00	2.74E-02	0.00E+00	0.00E+00	4.18E+03	2.55E+03
Y-91	9.13E+05	0.00E+00	2.43E+04	0.00E+00	0.00E+00	2.62E+06	1.84E+05
Y-92	3.03E+01	0.00E+00	8.64E-01	0.00E+00	0.00E+00	3.55E+04	3.55E+05
Y-93	2.77E+02	0.00E+00	7.59E+00	0.00E+00	0.00E+00	1.11E+05	5.78E+05
Zr-95	1.90E+05	4.17E+04	3.69E+04	0.00E+00	5.95E+04	2.23E+06	6.10E+04
Zr-97	2.79E+02	4.04E+01	2.38E+01	0.00E+00	5.78E+01	1.68E+05	5.22E+05
Nb-95	2.35E+04	9.16E+03	6.54E+03	0.00E+00	8.61E+03	6.13E+05	3.69E+04
Nb-97	6.38E-01	1.14E-01	5.36E-02	0.00E+00	1.27E-01	5.08E+03	4.14E+04
Mo-99	0.00E+00	2.56E+02	6.33E+01	0.00E+00	5.83E+02	2.01E+05	1.88E+05
Tc-99M	2.65E-03	5.18E-03	8.58E-02	0.00E+00	7.54E-02	1.41E+03	7.15E+03

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-18 (continue)
R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Inhalation

AGE GROUP = Child

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Tc-101	1.20E-04	1.27E-04	1.60E-03	0.00E+00	2.16E-03	8.69E+02	2.43E+01
Ru-103	2.79E+03	0.00E+00	1.07E+03	0.00E+00	7.02E+03	6.61E+05	4.47E+04
Ru-105	2.27E+00	0.00E+00	8.25E-01	0.00E+00	2.00E+00	2.37E+04	1.48E+05
Ru-106	1.36E+05	0.00E+00	1.69E+04	0.00E+00	1.84E+05	1.43E+07	4.29E+05
Ag-110M	1.68E+04	1.14E+04	9.13E+03	0.00E+00	2.12E+04	5.47E+06	1.00E+05
Sn-113	9.00E+03	2.91E+02	9.83E+03	1.19E+02	2.02E+02	3.40E+05	7.45E+03
Sb-124	5.73E+04	7.40E+02	2.00E+04	1.26E+02	0.00E+00	3.24E+06	1.64E+05
Sb-125	9.84E+04	7.59E+02	2.07E+04	9.10E+01	0.00E+00	2.32E+06	4.03E+04
Te-125M	6.73E+03	2.33E+03	9.14E+02	1.92E+03	0.00E+00	4.77E+05	3.38E+04
Te-127m	2.48E+04	8.53E+03	3.01E+03	6.06E+03	6.35E+04	1.48E+06	7.13E+04
Te-127	4.12E+00	1.41E+00	9.08E-01	2.92E+00	1.05E+01	1.49E+04	8.36E+04
Te-129M	1.92E+04	6.84E+03	3.04E+03	6.32E+03	5.02E+04	1.76E+06	1.81E+05
Te-129	1.45E-01	5.20E-02	3.54E-02	1.06E-01	3.82E-01	4.36E+03	3.79E+04
Te-131M	2.00E+02	8.80E+01	7.54E+01	1.45E+02	5.94E+02	3.06E+05	4.58E+05
Te-131	3.23E-02	1.25E-02	9.79E-03	2.52E-02	8.75E-02	3.05E+03	1.98E+03
Te-132	7.15E+02	4.05E+02	3.92E+02	4.72E+02	2.63E+03	5.61E+05	2.05E+05
I-130	1.22E+04	2.44E+04	1.25E+04	2.74E+06	3.64E+04	0.00E+00	7.59E+03
I-131	4.80E+04	4.80E+04	2.72E+04	1.62E+07	7.87E+04	0.00E+00	2.84E+03
I-132	2.11E+03	4.06E+03	1.87E+03	1.93E+05	6.24E+03	0.00E+00	3.20E+03
I-133	1.66E+04	2.03E+04	7.68E+03	3.84E+06	3.37E+04	0.00E+00	5.47E+03
I-134	1.74E+03	3.21E+03	1.48E+03	7.54E+04	4.91E+03	0.00E+00	1.42E+03
I-135	4.91E+03	8.72E+03	4.14E+03	7.91E+05	1.34E+04	0.00E+00	4.43E+03
Cs-134	6.50E+05	1.01E+06	2.24E+05	0.00E+00	3.30E+05	1.21E+05	3.84E+03
Cs-136	6.50E+04	1.71E+05	1.16E+05	0.00E+00	9.53E+04	1.45E+04	4.17E+03
Cs-137	9.05E+05	8.24E+05	1.28E+05	0.00E+00	2.82E+05	1.04E+05	3.61E+03
Cs-138	9.41E+02	1.25E+03	8.25E+02	0.00E+00	9.24E+02	1.01E+02	4.01E+02
Ba-139	2.74E+00	1.46E-03	7.98E-02	0.00E+00	1.28E-03	8.58E+03	8.58E+04
Ba-140	7.39E+04	6.47E+01	4.32E+03	0.00E+00	2.11E+01	1.74E+06	1.02E+05
Ba-141	2.91E-01	1.62E-04	9.46E-03	0.00E+00	1.41E-04	4.34E+03	4.09E+02
Ba-142	7.43E-02	5.35E-05	4.15E-03	0.00E+00	4.33E-05	2.44E+03	4.08E+00
La-140	9.57E+02	3.34E+02	1.12E+02	0.00E+00	0.00E+00	2.72E+05	3.36E+05
La-142	1.93E+00	6.11E-01	1.92E-01	0.00E+00	0.00E+00	1.29E+04	1.13E+05
Ce-141	3.92E+04	1.95E+04	2.89E+03	0.00E+00	8.53E+03	5.43E+05	5.65E+04
Ce-143	5.44E+02	2.95E+02	4.27E+01	0.00E+00	1.24E+02	1.72E+05	1.89E+05
Ce-144	6.76E+06	2.11E+06	3.61E+05	0.00E+00	1.17E+06	1.19E+07	3.88E+05
Pr-143	1.85E+04	5.55E+03	9.14E+02	0.00E+00	3.00E+03	4.33E+05	9.73E+04
Pr-144	8.86E-02	2.74E-02	4.46E-03	0.00E+00	1.45E-02	2.33E+03	2.93E+02
Nd-147	1.08E+04	8.73E+03	6.81E+02	0.00E+00	4.81E+03	3.28E+05	8.21E+04
Hf-181	8.44E+04	3.28E+02	8.50E+03	2.76E+02	2.64E+02	7.95E+05	5.31E+04
W-187	2.43E+01	1.44E+01	6.44E+00	0.00E+00	0.00E+00	6.11E+04	1.35E+05
Np-239	6.93E+02	4.97E+01	3.49E+01	0.00E+00	1.45E+02	8.64E+04	9.52E+04

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-19
 R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Inhalation

AGE GROUP = Infant

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLi
H-3	0.00E+00	6.46E+02	6.46E+02	6.46E+02	6.46E+02	6.46E+02	6.46E+02
C-14	2.65E+04	5.31E+03	5.31E+03	5.31E+03	5.31E+03	5.31E+03	5.31E+03
Na-24	1.06E+04	1.06E+04	1.06E+04	1.06E+04	1.06E+04	1.06E+04	1.06E+04
P-32	2.03E+06	1.12E+05	7.73E+04	0.00E+00	0.00E+00	0.00E+00	1.61E+04
Cr-51	0.00E+00	0.00E+00	8.93E+01	5.75E+01	1.32E+01	1.28E+04	3.56E+02
Mn-54	0.00E+00	2.53E+04	4.98E+03	0.00E+00	4.98E+03	9.98E+05	7.05E+03
Mn-56	0.00E+00	1.54E+00	2.21E-01	0.00E+00	1.10E+00	1.25E+04	7.17E+04
Fe-55	1.97E+04	1.17E+04	3.33E+03	0.00E+00	0.00E+00	8.69E+04	1.09E+03
Fe-59	1.35E+04	2.35E+04	9.46E+03	0.00E+00	0.00E+00	1.01E+06	2.47E+04
Co-57	0.00E+00	6.51E+02	6.41E+02	0.00E+00	0.00E+00	3.79E+05	4.86E+03
Co-58	0.00E+00	1.22E+03	1.82E+03	0.00E+00	0.00E+00	7.76E+05	1.11E+04
Co-60	0.00E+00	8.01E+03	1.18E+04	0.00E+00	0.00E+00	4.50E+06	3.19E+04
Ni-63	3.39E+05	2.04E+04	1.16E+04	0.00E+00	0.00E+00	2.09E+05	2.42E+03
Ni-65	2.39E+00	2.84E-01	1.23E-01	0.00E+00	0.00E+00	8.12E+03	5.01E+04
Cu-64	0.00E+00	1.88E+00	7.74E-01	0.00E+00	3.98E+00	9.30E+03	1.50E+04
Zn-65	1.93E+04	6.25E+04	3.10E+04	0.00E+00	3.24E+04	6.46E+05	5.13E+04
Zn-69M	1.26E+01	2.58E+01	2.34E+00	0.00E+00	1.04E+01	2.67E+04	4.09E+04
Zn-69	5.39E-02	9.67E-02	7.18E-03	0.00E+00	4.02E-02	1.47E+03	1.32E+04
Br-82	0.00E+00	0.00E+00	1.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	3.81E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	4.00E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	2.04E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.90E+05	8.81E+04	0.00E+00	0.00E+00	0.00E+00	3.03E+03
Rb-88	0.00E+00	5.57E+02	2.87E+02	0.00E+00	0.00E+00	0.00E+00	3.39E+02
Rb-89	0.00E+00	3.21E+02	2.06E+02	0.00E+00	0.00E+00	0.00E+00	6.82E+01
Sr-89	3.97E+05	0.00E+00	1.14E+04	0.00E+00	0.00E+00	2.03E+06	6.39E+04
Sr-90	4.08E+07	0.00E+00	2.59E+06	0.00E+00	0.00E+00	1.12E+07	1.31E+05
Sr-91	9.56E+01	0.00E+00	3.46E+00	0.00E+00	0.00E+00	5.26E+04	7.34E+04
Sr-92	1.05E+01	0.00E+00	3.91E-01	0.00E+00	0.00E+00	2.38E+04	1.40E+05
Y-90	3.29E+03	0.00E+00	8.82E+01	0.00E+00	0.00E+00	2.69E+05	1.04E+05
Y-91M	4.07E-01	0.00E+00	1.39E-02	0.00E+00	0.00E+00	2.79E+03	2.35E+03
Y-91	5.87E+05	0.00E+00	1.57E+04	0.00E+00	0.00E+00	2.45E+06	7.02E+04
Y-92	1.64E+01	0.00E+00	4.61E-01	0.00E+00	0.00E+00	2.45E+04	1.27E+05
Y-93	1.50E+02	0.00E+00	4.07E+00	0.00E+00	0.00E+00	7.64E+04	1.67E+05
Zr-95	1.15E+05	2.78E+04	2.03E+04	0.00E+00	3.10E+04	1.75E+06	2.17E+04
Zr-97	1.50E+02	2.56E+01	1.17E+01	0.00E+00	2.59E+01	1.10E+05	1.40E+05
Nb-95	1.57E+04	6.42E+03	3.77E+03	0.00E+00	4.71E+03	4.78E+05	1.27E+04
Nb-97	3.42E-01	7.29E-02	2.63E-02	0.00E+00	5.70E-02	3.32E+03	2.69E+04
Mo-99	0.00E+00	1.65E+02	3.23E+01	0.00E+00	2.65E+02	1.35E+05	4.87E+04
Tc-99M	1.40E-03	2.88E-03	3.72E-02	0.00E+00	3.11E-02	8.11E+02	2.03E+03

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

TABLE 3.3-19 (continue)
R VALUES FOR THE SHEARON HARRIS NUCLEAR POWER PLANT*

PATHWAY = Inhal

AGE GROUP = Infant

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	Gi-LLi
Tc-101	6.51E-05	8.23E-05	8.12E-04	0.00E+00	9.79E-04	5.84E+02	8.44E+02
Ru-103	2.01E+03	0.00E+00	6.78E+02	0.00E+00	4.24E+03	5.51E+05	1.61E+04
Ru-105	1.22E+00	0.00E+00	4.10E-01	0.00E+00	8.99E-01	1.57E+04	4.84E+04
Ru-106	8.67E+04	0.00E+00	1.09E+04	0.00E+00	1.06E+05	1.15E+07	1.64E+05
Ag-110M	9.97E+03	7.21E+03	4.99E+03	0.00E+00	1.09E+04	3.66E+06	3.30E+04
Sn-113	4.67E+03	1.74E+02	4.89E+03	6.73E+01	9.94E+01	2.30E+05	2.29E+03
Sb-124	3.79E+04	5.56E+02	1.20E+04	1.00E+02	0.00E+00	2.64E+06	5.91E+04
Sb-125	5.17E+04	4.77E+02	1.09E+04	6.23E+01	0.00E+00	1.64E+06	1.47E+04
Te-125M	4.76E+03	1.99E+03	6.58E+02	1.62E+03	0.00E+00	4.47E+05	1.29E+04
Te-127m	1.66E+04	6.89E+03	2.07E+03	4.86E+03	3.75E+04	1.31E+06	2.73E+04
Te-127	2.23E+00	9.53E-01	4.89E-01	1.85E+00	4.86E+00	1.03E+04	2.44E+04
Te-129M	1.41E+04	6.08E+03	2.22E+03	5.47E+03	3.17E+04	1.68E+06	6.89E+04
Te-129	7.88E-02	3.47E-02	1.88E-02	6.75E-02	1.75E-01	3.00E+03	2.63E+04
Te-131M	1.07E+02	5.50E+01	3.63E+01	8.93E+01	2.65E+02	1.99E+05	1.19E+05
Te-131	1.74E-02	8.22E-03	5.00E-03	1.58E-02	3.99E-02	2.06E+03	8.22E+03
Te-132	3.72E+02	2.37E+02	1.76E+02	2.79E+02	1.03E+03	3.40E+05	4.41E+04
I-130	6.36E+03	1.39E+04	5.57E+03	1.60E+06	1.53E+04	0.00E+00	1.99E+03
I-131	3.79E+04	4.43E+04	1.96E+04	1.48E+07	5.17E+04	0.00E+00	1.06E+03
I-132	1.69E+03	3.54E+03	1.26E+03	1.69E+05	3.94E+03	0.00E+00	1.90E+03
I-133	1.32E+04	1.92E+04	5.59E+03	3.55E+06	2.24E+04	0.00E+00	2.15E+03
I-134	9.21E+02	1.88E+03	6.65E+02	4.45E+04	2.09E+03	0.00E+00	1.29E+03
I-135	3.86E+03	7.59E+03	2.77E+03	6.95E+05	8.46E+03	0.00E+00	1.83E+03
Cs-134	3.96E+05	7.02E+05	7.44E+04	0.00E+00	1.90E+05	7.95E+04	1.33E+03
Cs-136	4.82E+04	1.34E+05	5.28E+04	0.00E+00	5.63E+04	1.17E+04	1.43E+03
Cs-137	5.48E+05	6.11E+05	4.54E+04	0.00E+00	1.72E+05	7.12E+04	1.33E+03
Cs-138	5.05E+02	7.81E+02	3.98E+02	0.00E+00	4.10E+02	6.54E+01	8.76E+02
Ba-139	1.48E+00	9.84E-04	4.30E-02	0.00E+00	5.92E-04	5.95E+03	5.10E+04
Ba-140	5.59E+04	5.59E+01	2.89E+03	0.00E+00	1.34E+01	1.59E+06	3.83E+04
Ba-141	1.57E-01	1.08E-04	4.97E-03	0.00E+00	6.50E-05	2.97E+03	4.75E+03
Ba-142	3.98E-02	3.30E-05	1.96E-03	0.00E+00	1.90E-05	1.55E+03	6.93E+02
La-140	5.05E+02	2.00E+02	5.15E+01	0.00E+00	0.00E+00	1.68E+05	8.48E+04
La-142	1.03E+00	3.77E-01	9.04E-02	0.00E+00	0.00E+00	8.22E+03	5.95E+04
Ce-141	2.77E+04	1.66E+04	1.99E+03	0.00E+00	5.24E+03	5.16E+05	2.15E+04
Ce-143	2.93E+02	1.93E+02	2.21E+01	0.00E+00	5.64E+01	1.16E+05	4.97E+04
Ce-144	3.19E+06	1.21E+06	1.76E+05	0.00E+00	5.37E+05	9.83E+06	1.48E+05
Pr-143	1.40E+04	5.24E+03	6.99E+02	0.00E+00	1.97E+03	4.33E+05	3.72E+04
Pr-144	4.79E-02	1.85E-02	2.41E-03	0.00E+00	6.72E-03	1.61E+03	4.28E+03
Nd-147	7.94E+03	8.13E+03	5.00E+02	0.00E+00	3.15E+03	3.22E+05	3.12E+04
Hf-181	5.65E+04	2.66E+02	5.05E+03	2.25E+02	1.59E+02	6.73E+05	1.90E+04
W-187	1.30E+01	9.02E+00	3.12E+00	0.00E+00	0.00E+00	3.96E+04	3.56E+04
Np-239	3.71E+02	3.32E+01	1.88E+01	0.00E+00	6.62E+01	5.95E+04	2.49E+04

*R Values in units of mrem/yr per $\mu\text{Ci}/\text{m}^3$ for inhalation and tritium and in units of mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 for all others.

Table 3.3-20

Recommended Values for U_{ap} to be used for the Maximum Exposed Individual
 in Lieu of Site Specific Data (Table E-5 Regulatory Guide 1.109 Rev 1)

Pathway	Infant	Child	Teen	Adult
Fruits, vegetables & grain (kg/yr) ¹	-	520	630	520
Leafy Vegetables (kg/yr)	-	26	42	64
Milk (L/yr)	330	330	400	310
Meat & poultry (kg/yr)	-	41	65	110
Inhalation (m ³ /yr)	1400	3700	8000	8000

Note 1 – Consists of the following (on a mass basis): 22% fruit, 54% vegetables (including leafy vegetables), and 24% grain

Table 3.3-21

Inhalation Dose Factors from Carbon-14 for organ to an individual from
 Tables E-7 to E-10 Regulatory Guide 1.109 Rev 1
 (mrem/pCi inhaled)

Individual	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Infant	1.89E-05	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06
Child	9.70E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06
Teen	3.25E-06	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07
Adult	2.27E-06	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07

Table 3.3-22

Ingestion Dose Factors from Carbon-14 for organ to an individual from
 Tables E-11 to E-14 Regulatory Guide 1.109 Rev 1
 (mrem/pCi ingested)

Individual	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Infant	2.37E-05	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06
Child	1.21E-05	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06
Teen	4.06E-06	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07
Adult	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07

Figure 3.1

SHNPP Gaseous Waste Streams



Figure 3.2

Schematic of Airborne Effluent Release Points

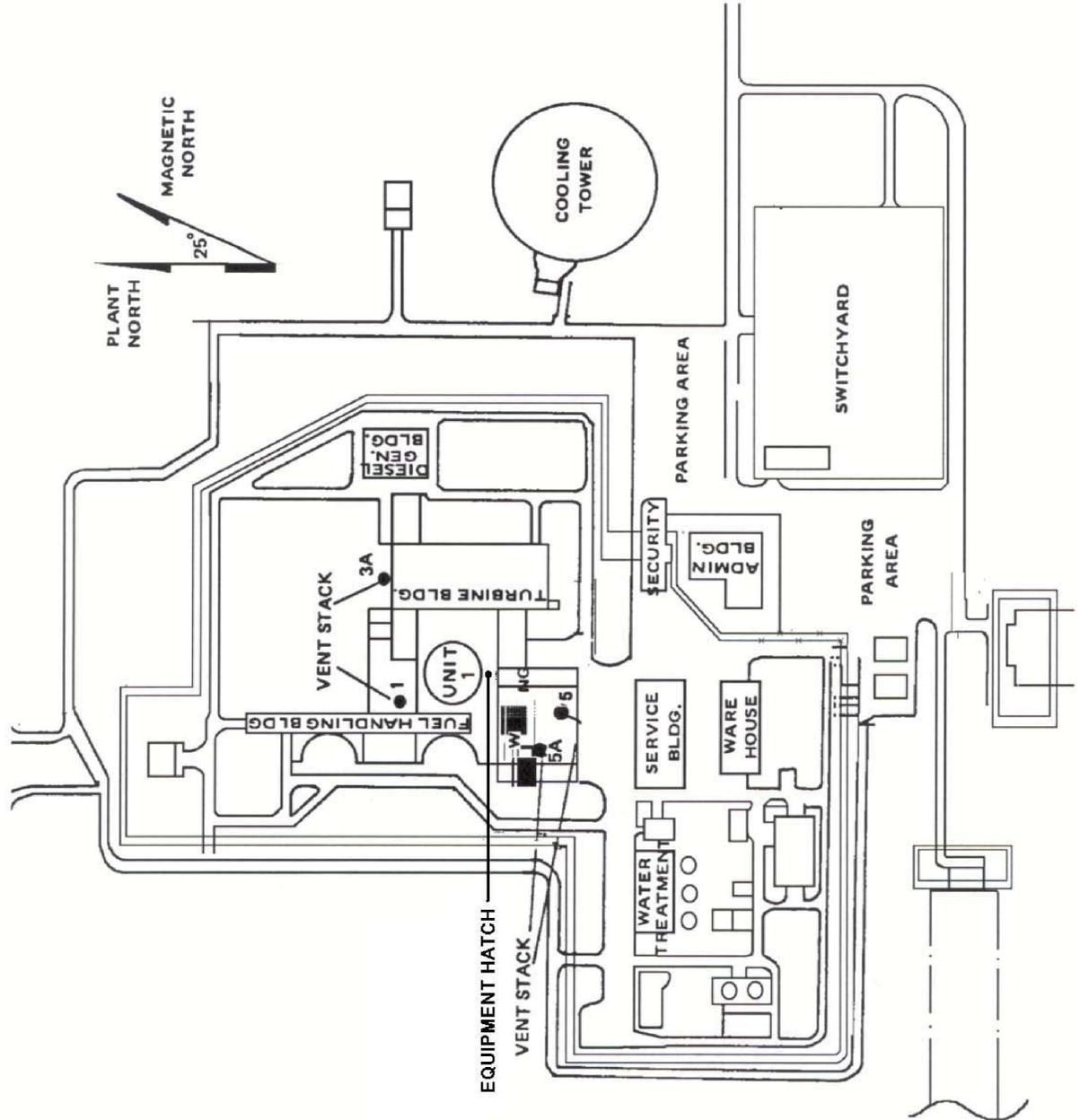
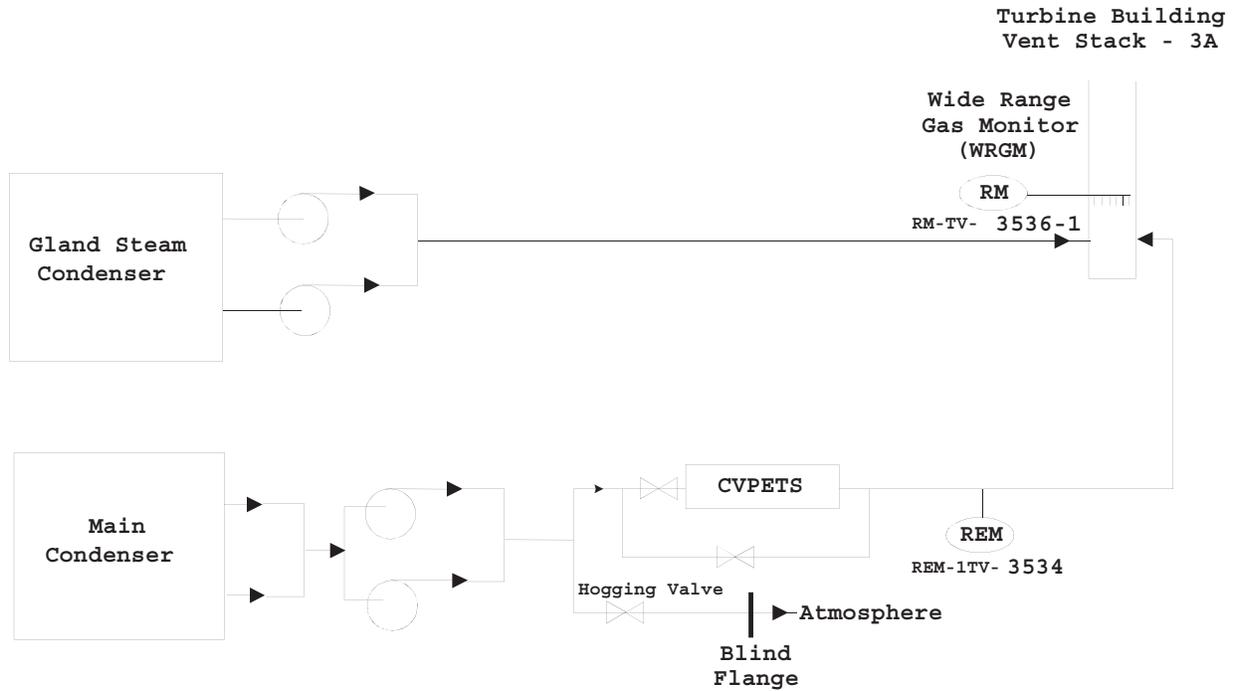


Figure 3.3

SHNPP Condenser Off-Gas System



4.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

The purpose of the radiological monitoring program is to measure radioactivity in the environment, to determine whether measured radioactivity is the result of operation of the Shearon Harris Nuclear Power Plant, and to assess the potential dose to the offsite population based on the cumulative measurements of radioactivity of plant origin. The program provides representative measurements of radioactivity in the highest potential exposure pathways and verification of the accuracy of the effluent monitoring program and modeling of environmental exposure pathways (i.e. air, surface water, groundwater.)

Table 4.1 contains the sample point description, sampling and collection frequency, analysis type, and frequency for various exposure pathways in the vicinity of the SHNPP for the radiological monitoring program.

Figure 4.1-1 shows the exclusion boundary surrounding SHNPP. Figures 4.1-2 and 4.1-3 show the locations of the various sampling points and TLD locations.

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Airborne Particulates and Radioiodine
Sampling and Collection Frequency:		Continuous operating sampler with sample collection as required by dust loading but at least once per 7 days.
Analysis Frequency and Required Analysis:		Weekly Gross Beta ² Weekly I-131 (charcoal canisters) Quarterly Gamma Isotopic ^{4,5} (Composited by location)
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
2	1.4 mi. S on SR 1134 from SR 1011 intersection. NNE sector, 1.4 mi. from site.	
4	0.7 mi. N on SR 1127 from intersection with US 1. NNE sector, 3.1 mi. from site.	
5	Pittsboro (Control Station) ³ WNW sector from site, > 12 mi. from site	
26	Harris Lake Spillway S sector, 4.7 mi. from site	
63	SHNPP site. SW sector, 0.6 mi. from site.	
90	SHNPP site. SSW sector, 0.5 mi. from site.	
91	HE&EC, Sewage Treatment Facility ENE Sector, 1.6 mi. from site.	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Direct Radiation (TLD)
Sampling and Collection Frequency:		Continuous measurement with an integrated readout at least once per quarter.
Analysis Frequency and Required Analysis:		Quarterly Gamma Dose
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
1	0.1 mi. S on SR 1134 from SR 1011 intersection. N sector, 2.6 mi. from site.	
2	1.4 mi. S on SR 1134 from SR 1011 intersection. NNE sector, 1.4 mi. from site.	
3	HE&EC Visitor Center (Population Center) ENE sector, 1.9 mi. from site.	
4	New Hill (Population Center) 0.7 mi. N on SR 1127 from intersection with US 1 NNE sector, 3.1 mi. from site.	
5	Pittsboro (Control Station) ³ WNW sector from site, >12 mi. (13.3 mi.) from site	
6	Intersection of SR 1134 & SR 1135. ENE sector, 0.8 mi. from site.	
7	Extension of SR 1134. E sector 0.7 mi. from site.	
8	Dead end of road. Extension of SR 1134. ESE sector, 0.6 mi. from site.	
9	1 mi. S on SR 1130 from intersection of SR 1127, 1115, and 1130. SE sector, 2.2 mi. from site.	
10	SR 1130 S of intersection of SR 1127, 1115, and 1130. SSE sector, 2.2 mi. from site.	
11	SHNPP site. S sector, 0.6 mi. from site	
12	SHNPP site. SSW sector, 0.9 mi. from site.	
13	SHNPP site. WSW sector 0.7 mi. from site.	
14	SHNPP site. Access road to aux. reservoir. W sector, 1.5 mi. from site.	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Direct Radiation (TLD)
Sampling and Collection Frequency:		Continuous measurement with an integrated readout at least once per quarter.
Analysis Frequency and Required Analysis:		Quarterly Gamma Dose
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
15	SR 1911. W sector, 2.0 mi. from site.	
19	0.6 mi. E on SR 1142 from intersection of SR 1141. NNE sector 5.0 mi. from site.	
20	US 1 at intersection SR 1149. NE sector 4.5 mi. from site.	
21	1.2 mi. W on SR 1152 from intersection SR 1153. ENE sector, 4.8 mi. from site.	
22	Formerly Ragan's Dairy on SR 1115. E sector, 4.3 mi. from site.	
23	Intersection of SR 1127 and SR 1116. ESE sector, 4.8 mi. from site.	
24	Sweet Springs Church on SR 1116. SE sector 4.0 mi. from site.	
25	0.2 mi. W on SR 1402 from intersection of SR 1400 SSE sector, 4.7 mi. from site	
26	Harris Lake Spillway S sector, 4.7 mi. from site	
27	NC 42 @ Buckhorn United Methodist Church SSW sector, 4.8 mi. from site.	
28	0.6 mi. on SR 1924 from intersection of SR 1916. SW sector, 4.8 mi. from site.	
29	Parking lot on SR 1916. WSW sector, 5.7 mi. from site.	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Direct Radiation (TLD)
Sampling and Collection Frequency:		Continuous measurement with an integrated readout at least once per quarter.
Analysis Frequency and Required Analysis:		Quarterly Gamma Dose
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
31	At intersection of SR 1908, 1909, 1910. WNW sector, 4.7 mi. from site.	
32	Jordan Lake (Population Center) SR 1008. NNW sector 6.4 mi. from site.	
33	SR 1142. 1.7 mi. from intersection of SR 1141. NNW sector, 4.5 mi. from site.	
48	SR 1142. 1.5 mi. from intersection of SR 1141. N sector, 4.5 mi. from site.	
49	SR 1127. 0.3 mi. S from intersection with US 1. NE sector, 2.5 mi. from site.	
50	Holleman Crossroad (Population Center) SR 1127 W from intersection SR 1115 and 1130. ESE sector, 2.6 mi. from site.	
56	SR 1912 at intersection of SR 1912 and SR 1924. WSW sector, 3.0 mi. from site.	
63	SHNPP Site. SW sector, 0.6 mi. from site.	
93	SR 1911. WNW sector, 2.2 mi. from site.	
94	Old US HWY 1 NW sector, 2.0 mi. from site	
95	Bonsal Rd NNW sector, 2.0 mi. from site	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Direct Radiation (TLD)
Sampling and Collection Frequency:		Continuous measurement with an integrated readout at least once per quarter.
Analysis Frequency and Required Analysis:		Quarterly Gamma Dose
98	Holly Springs School Complex (Population Center) E sector, 5.9 mi. from site	
99	Friendship High School (Population Center) NNE sector, 5.5 mi. from site	
130	Old US HWY 1 W sector, 3.9 mi. from site	
153	Beaver Creek Road NW sector, 4.5 mi from site	

Exposure Pathway and/or Sample:		Waterborne, Surface Water
Sampling and Collection Frequency:		Composite sample ⁵ collected over a monthly period.
Analysis Frequency and Required Analysis:		Monthly Gamma Isotopic ⁴ Quarterly Tritium
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
26	Harris Lake Spillway S sector, 4.7 mi. from site	
40	NE Harnett Metro Water Treatment Plant Intake Building Duncan Street, Lillington, N.C. SSE sector, 17.2 mi. from site.	
43	Sanford Water Treatment Plant (Control Station) ³ Poplar Springs Church Road, Sanford, NC SW sector, 8.5 miles from site	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Waterborne, Groundwater
Sampling and Collection Frequency:		Grab sample collected quarterly
Analysis Frequency and Required Analysis:		Quarterly Gamma Isotopic ⁴ Quarterly Tritium
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
57	SHNPP Site (LP-13) N. side of Aux Res Intake canal SSW sector, 0.4 mi. from site.	
59	SHNPP Site (W-13) N. side of Old Construction Road. NNE sector, 0.5 mi. from site	
60	SHNPP Site (W-9A) W. bank of Harris Lake SE of Cooling Tower. ESE sector, 0.5 mi. from site	
68	SHNPP Site (LP-6) N. of old Steam Generator Storage Building W sector, 0.2 mi. from site	
69	SHNPP Site (LP-7) S. side of Warehouse 9. NNE sector, 0.2 mi. from site	
70	SHNPP Site (LP-9) N. side of Plant Entrance Road. E sector, 0.4 mi. from site	
71	SHNPP Site (LP-16) S. of Switch Yard SE sector, 0.3 mi. from site	
72	SHNPP Site (MWA-12) N. of Cooling Tower Makeup Water Intake Structures. SE sector, 0.2 mi. from site	
73	SHNPP Site N. of Emergency Service Water Screening Structure. S sector, 0.2 mi. from site	
74	SHNPP Site N. of helicopter landing pad. SSE sector, 0.2 mi. from site	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Waterborne, Groundwater
Sampling and Collection Frequency:		Grab sample collected quarterly
Analysis Frequency and Required Analysis:		Quarterly Gamma Isotopic ⁴ Quarterly Tritium
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
75	SHNPP Site W. of Security Building Entrance ESE sector, 0.1 mi. from site	
77	SHNPP Site (BD-MW1) Along the Cooling Tower Blowdown Line S sector, 0.4 mi. from site	
78	SHNPP Site (BD-MW2) Along the Cooling Tower Blowdown Line S sector, 0.5 mi. from site	
79	SHNPP Site (BD-MW3) Along the Cooling Tower Blowdown Line S sector, 0.5 mi. from site	
80	SHNPP Site (BD-MW5) Along the Cooling Tower Blowdown Line S sector, 0.6 mi. from site	
81	SHNPP Site (BD-MW7) Along the Cooling Tower Blowdown Line S sector, 0.6 mi. from site	
82	SHNPP Site (BD-MW8) Along the Cooling Tower Blowdown Line S sector, 0.6 mi. from site	
83	SHNPP Site (BD-MW16) Along the Cooling Tower Blowdown Line SSW sector, 1.6 mi. from site	
84	SHNPP Site (MW-14) N. of Emergency Service Water Screening Structure. SSW sector, 0.2 mi. from site	
85	SHNPP Site (MW-13) W. of site near Settling Basin SSW sector, 0.2 mi. from site	
86	SHNPP Site (MW-12) W. of site near Old Reactor Head Storage Building SW sector, 0.2 mi. from site	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Waterborne, Drinking Water
Sampling and Collection Frequency:		Composite sample ⁵ collected over a two-week period if I-131 analysis is performed; monthly composite otherwise.
Analysis Frequency and Required Analysis:		I-131 on each composite when the dose ⁶ calculated for the consumption of the water is greater than 1 mrem per yr. Monthly Gross Beta Monthly Gamma Isotopic ⁴ Quarterly Tritium
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
38	Deleted	
40	Deleted	
46	NE Harnett Metro Water Treatment Plant Intake Building Duncan Street, Lillington, N.C. SSE sector, 17.2 mi. from site.	
51	SHNPP Water Treatment Building On Site	
58	Sanford Water Treatment Plant (Control Station) ³ Poplar Springs Church Road, Sanford, NC SW sector, 8.5 miles from site	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Waterborne, Sediment from Shoreline
Sampling and Collection Frequency:		Shoreline Sediment sample collected semiannually.
Analysis Frequency and Required Analysis:		Each Sample Gamma Isotopic ⁴
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
26	Harris Lake Spillway S sector, 4.6 mi. from site	
41	Shoreline of Mixing Zone of Cooling Tower Blowdown Line S sector, 3.8 miles from site.	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Waterborne, Bottom Sediment
Sampling and Collection Frequency:		Bottom Sediment sample collected semiannually.
Analysis Frequency and Required Analysis:		Each Sample Gamma Isotopic ⁴
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
52	Harris Lake in the vicinity of the mixing zone of the cooling tower S sector, 3.8 miles from site.	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Ingestion – Milk ^{8, 17}
Sampling and Collection Frequency:		Grab samples semi-monthly when animals are on pasture; monthly at other times. ⁹
Analysis Frequency and Required Analysis:		Each Sample I-131 Each Sample Gamma Isotopic ⁴
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
5	Manco's Dairy, Pittsboro (Control Station) ³ WNW sector from site, > 12 mi. from site	
102	Goat Farm, W sector, 2.82 miles from site.	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Ingestion - Fish
Sampling and Collection Frequency:		One sample of each of the following semiannually: 1. Catfish (bottom feeders) 2. Sunfish & Largemouth Bass (free swimmers)
Analysis Frequency and Required Analysis:		Each sample - Gamma Isotopic ⁴ on edible portion for each
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
44	Site varies within the Harris Lake.	
45	Site varies above Buckhorn Dam on Cape Fear River (Control Station) ³	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Ingestion – Food Products ^{7,10}
Sampling and Collection Frequency:		Samples of 3 different kinds of broadleaf vegetation monthly during the growing season ¹⁶
Analysis Frequency and Required Analysis:		Each sample - Gamma Isotopic ⁴ on edible portion for each
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
5	Deleted	
97	Granite Springs Farm (Control Station) ³ NW sector, 19.1 miles from site	

TABLE 4.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample:		Aquatic Vegetation
Sampling and Collection Frequency:		Annually
Analysis Frequency and Required Analysis:		Each sample - Gamma Isotopic ⁴
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
26	Harris Lake Spillway S sector, 4.7 mi. from site	
41	Shoreline of Mixing Zone of Cooling Tower Blowdown Line S sector, 3.8 miles from site.	
61	Harris Lake East of New Hill- Holleman Rd (Control Location) E sector, 2.5 mi. from site	

Exposure Pathway and/or Sample:		Broadleaf Vegetation ⁸
Sampling and Collection Frequency:		Monthly, during growing season ¹⁵
Analysis Frequency and Required Analysis:		Each sample - Gamma Isotopic ⁴
Sample Point ID No.	Sample Point, Description ¹ , Distance, and Direction	
5	Pittsboro (Control Station) ³ NNW sector, > 12 mi. from site	
12	SHNPP Site SSW sector, 0.9 mi. from site	
63	SHNPP Site SW sector, 0.6 mi from site	

NOTES TO TABLE 4.1

SHNPP Radiological Environmental Monitoring Program

1. Sample locations are shown on Figures 4.1-2 and 4.1-3. Tables 4.2 and 4.3 lists the sample locations and frequencies.
2. Particulate samples will be analyzed for gross beta radioactivity 24 hours or more following filter change to allow for radon and thorium daughter decay. If gross beta activity is greater than ten times the yearly mean of the control sample station activity, a gamma isotopic analysis will be performed on the individual samples.
3. Control sample stations (or background stations) are located in areas that are unaffected by plant operations. All other sample stations that have the potential to be affected by radioactive emissions from plant operations are considered indicator stations.
4. Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to effluents from plant operations.
5. Composite samples will be collected with equipment which is capable of collecting an aliquot at time intervals which are very short (e.g., every 2 hours) relative to the compositing period (e.g., monthly).
6. The dose will be calculated for the maximum organ and age group, using the methodology contained in ODCM Equation 2.3-1.
7. Based on historical meteorology (1976-1987), food product Locations 54 and 55 were added in the summer of 1988 as the off-site locations with the highest predicted D/Q values. Food product locations 43 and 46 were deleted after the 1988 growing season.
8. If milk animals are not present or unavailable for sampling at indicator locations per page 4-11, sampling of Broadleaf Vegetation per page 4-14 can be substituted.
9. When no milk animals are available at indicator locations, milk sampling of the control location can be reduced to once per month to maintain historical data.
10. Sample Locations 54, 55, 62, 64 were deleted from food product sampling in Revision 18 as crops are not irrigated with water in which plant wastes have been discharged or crops are no longer being grown at a location. Sample Location 5 was deleted in Revision 26. The owner of this control location no longer gardens in sufficient quantity provide three different kinds of broadleaf vegetation. The new control location 97 is a commercial operation and satisfies the food crop requirement. Currently there are no food product locations irrigated by water containing plant discharges.
11. Sample Location 58 was deleted from groundwater monitoring in Revision 18 since being shown to have direct communication with lake/surface water. Sample Locations 68 through 72 were added to the groundwater monitoring in Revision 19 based on evaluation of data from bedrock wells.
12. Locations 39 deleted the groundwater monitoring in Revision 20 based on evaluation of data from bedrock wells.
13. Sample Locations 65 & 66 deleted Broad Leaf vegetation samples and added Broad Leaf vegetation to Sample Locations 12 and 63 in Revision 20 based on new meteorology data.
14. Location 57 was removed from the groundwater monitoring in Revision 19 but was reinstated in Revision 21 after new site hydrogeology study. In Revision 21, Sample Locations 73 through 76 were added to the groundwater monitoring in Revision 21 in order to provide a more complete picture of the site's hydrology. Sample Location 76 was removed from the groundwater monitoring in Revision 26 because within the protected area it is not used as a source of drinking water or irrigation.
15. Broadleaf vegetation refers to any natural vegetation, plants, shrubs or trees that have wide, flat leaves or leaves with veins which branch from a main vein. Typically leaves are only present during the growing season May through October.
16. Attention shall be paid to including samples of tuberous and root food products.
17. Goat milk is seasonally available. Typically goats lactate during the spring, summer and early fall (April through October).

TABLE 4.2

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SAMPLING LOCATIONS

Site#	Type	Location Description*	AC & AP	SW	DW	SS	SB	AV	FP ^(a)	Fish (FI)	Milk (Mk)	BLV ^(b)	GW
2	I	1.4 miles NNE	W/Q										
4	I	3.1 miles NNE	W/Q										
5	C	>12 miles WNW – Pittsboro >12 Miles NNW – Pittsboro (BLV)	W/Q								SM/M	M ^(b)	
12	I	0.9 miles SSW										M ^(b)	
26	I	4.7 miles S	W/Q	BW/M		SA		A					
40	I	17.2 miles SSE -- Lillington		M/Q									
41	I	3.8 miles S				SA		A					
43	C	8.5 miles SW		M/Q									
44	I	Site varies in Harris Lake								SA			
45	C	Site varies in Cape Fear River above Buckhorn Dam								SA			
46	I	17.2 miles SSE -- Lillington			M/Q								
51	I	Water Treatment Building (On Site)			BW/M								
52	I	3.8 miles S					SA						
57	I	0.4 miles SSW											Q
58	C	8.5 miles SW			M/Q								
59	I	0.5 miles NNE											Q
60	I	0.5 miles ESE											Q
61	C	2.5 miles E						A					
63	I	0.6 miles SW	W/Q									M ^(b)	
68	I	0.2 miles W											Q
69	I	0.2 miles NNE											Q
70	I	0.4 miles E											Q
71	I	0.3 miles SE											Q
72	I	0.2 miles SE											Q
73	I	0.2 miles S											Q
74	I	0.2 miles SSE											Q
75	I	0.1 miles ESE											Q
77	I	0.4 miles S											Q
78	I	0.5 miles S											Q
79	I	0.5 miles S											Q
80	I	0.6 miles S											Q
81	I	0.6 miles S											Q
82	I	0.6 miles S											Q
83	I	1.6 miles SSW											Q
84	I	0.2 miles SSW											Q
85	I	0.2 miles SSW											Q
86	I	0.2 miles SW											Q
90	I	0.5 miles SSW	W/Q										
91	I	1.6 miles ENE	W/Q										
97	C	19.1 miles NW Granite Springs Farm							M ^(a)				
102	I	2.8 miles W									SM ^(c)		

- (a) When Available, during Harvest/Growing Season
- (b) During Growing Season per ODCM – May through October
- (c) When goats are lactating

* GPS data reflect approximate accuracy to within 2-5 meters. GPS field measurements were taken as close as possible to the item of interest.

W	Weekly	SM	Semimonthly	AC	Air Cartridge	SB	Sediment Bottom	FI	Fish
BW	BiWeekly	Q	Quarterly	AP	Air Particulate	AV	Aquatic Vegetation	MK	Milk
M	Monthly	SA	Semiannually	SW	Surface Water	FP	Food Product		
A	Annual			DW	Drinking Water	BLV	Broadleaf Vegetation		
C	Control	I	Indicator	SS	Sediment Shoreline	GW	Ground Water		

TABLE 4.3

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SAMPLING LOCATIONS
 (TLD Sites)

Site #	Measure Type	Location*	Distance (miles)	Sector	Site #	Measure Type	Location*	Distance (miles)	Sector
1	IR		2.6	N	26	OR		4.7	S
2	IR		1.4	NNE	27	OR		4.8	SSW
3	SI	HE&EC Visitor Center (Population Center)	1.9	ENE	28	OR		4.8	SW
4	SI	New Hill (Population Center)	3.1	NNE	29	OR		5.7	WSW
5	C	Pittsboro (Control Station)	13.3	WNW	31	OR		4.7	WNW
6	IR		0.8	ENE	32	SI	Jordan Lake (Population Center)	6.4	NNW
7	IR		0.7	E	33	OR		4.5	NNW
8	IR		0.6	ESE	48	OR		4.5	N
9	IR		2.2	SE	49	IR		2.5	NE
10	IR		2.2	SSE	50	SI	Holleman Crossroads (Population Center)	2.6	ESE
11	IR		0.6	S	56	IR		3.0	WSW
12	IR		0.9	SSW	63	IR		0.6	SW
13	IR		0.7	WSW	93	IR		2.2	WNW
14	IR		1.5	W	94	IR		2.0	NW
15	IR		2.0	W	95	IR		2.0	NNW
19	OR		5.0	NNE	98	SI	Holly Springs School Complex (Population Center)	5.9	E
20	OR		4.5	NE	99	SI	Friendship School (Population Center)	5.5	NNE
21	OR		4.8	ENE	130	OR		3.9	W
22	OR		4.3	E	153	OR		4.5	NW
23	OR		4.8	ESE					
24	OR		4.0	SE					
25	OR		4.7	SSE					

* GPS data reflect approximate accuracy to within 2-5 meters. GPS field measurements were taken as close as possible to the item of interest.

IR	Inner Ring	OR	Outer Ring
C	Control	SI	Special Interest/ Population Center

Figure 4.1-1
 Map of the Site Boundary

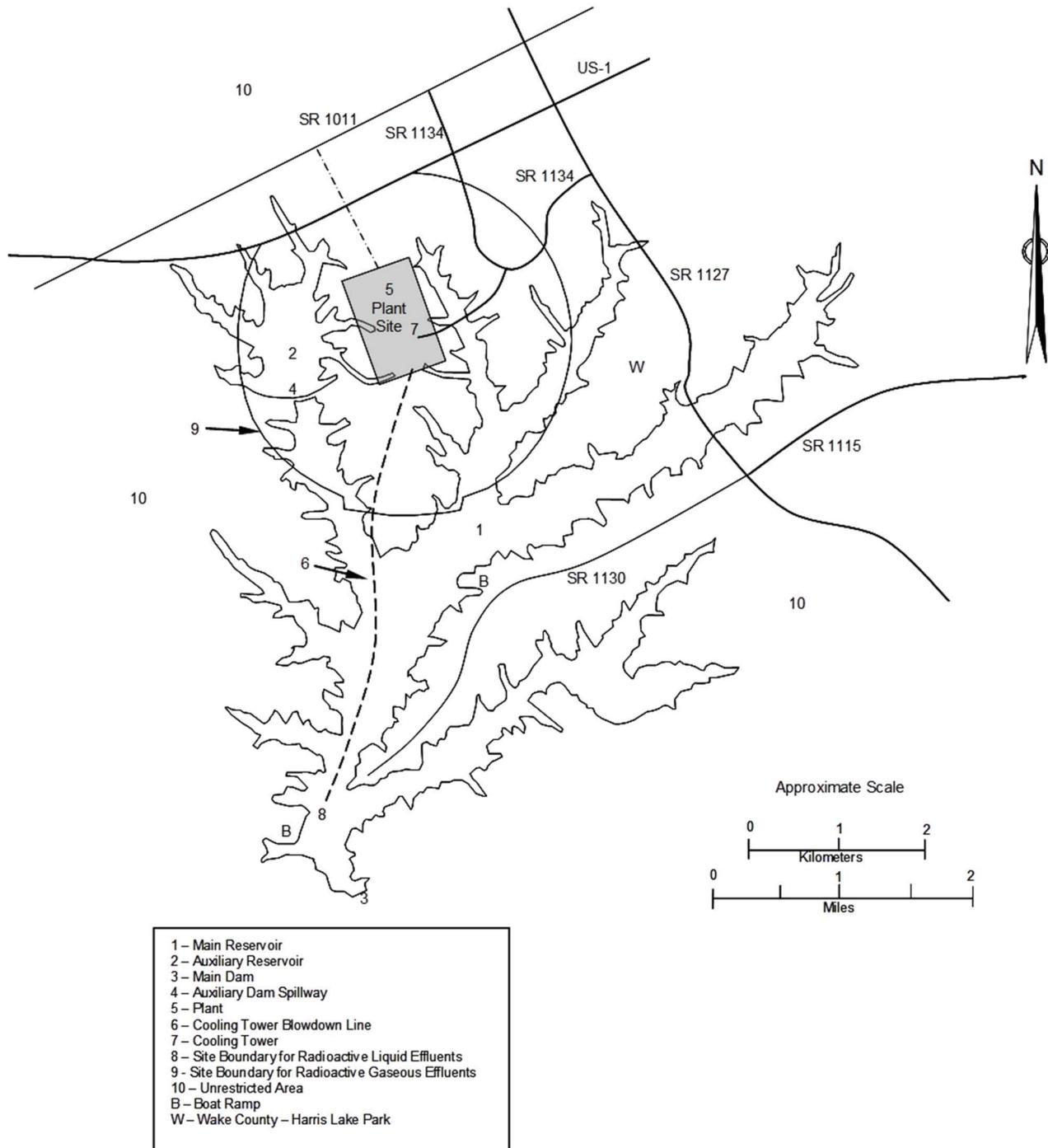


Figure 4.1-2
 Environmental Radiological Sampling Points
 (One Mile Radius)

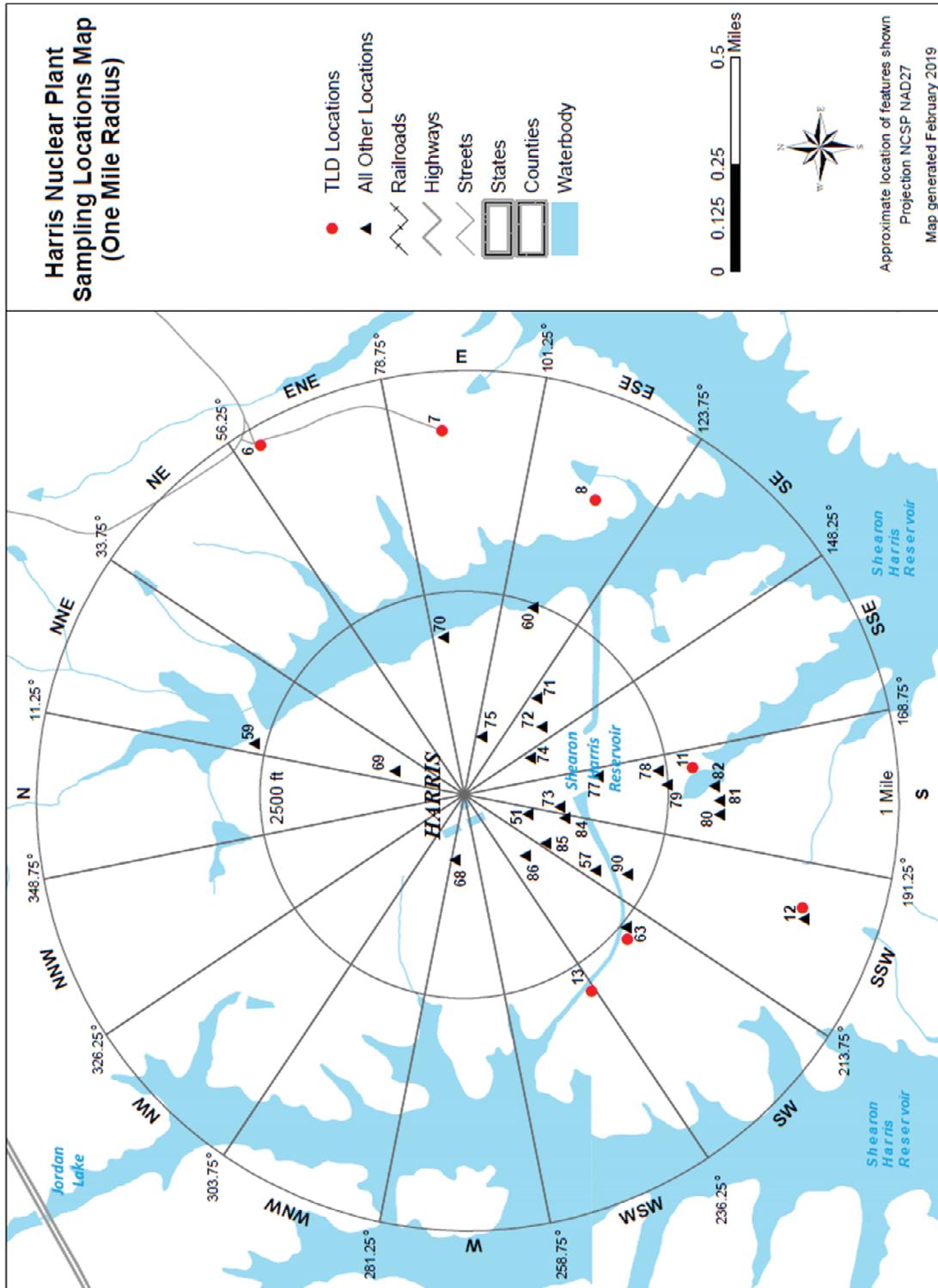
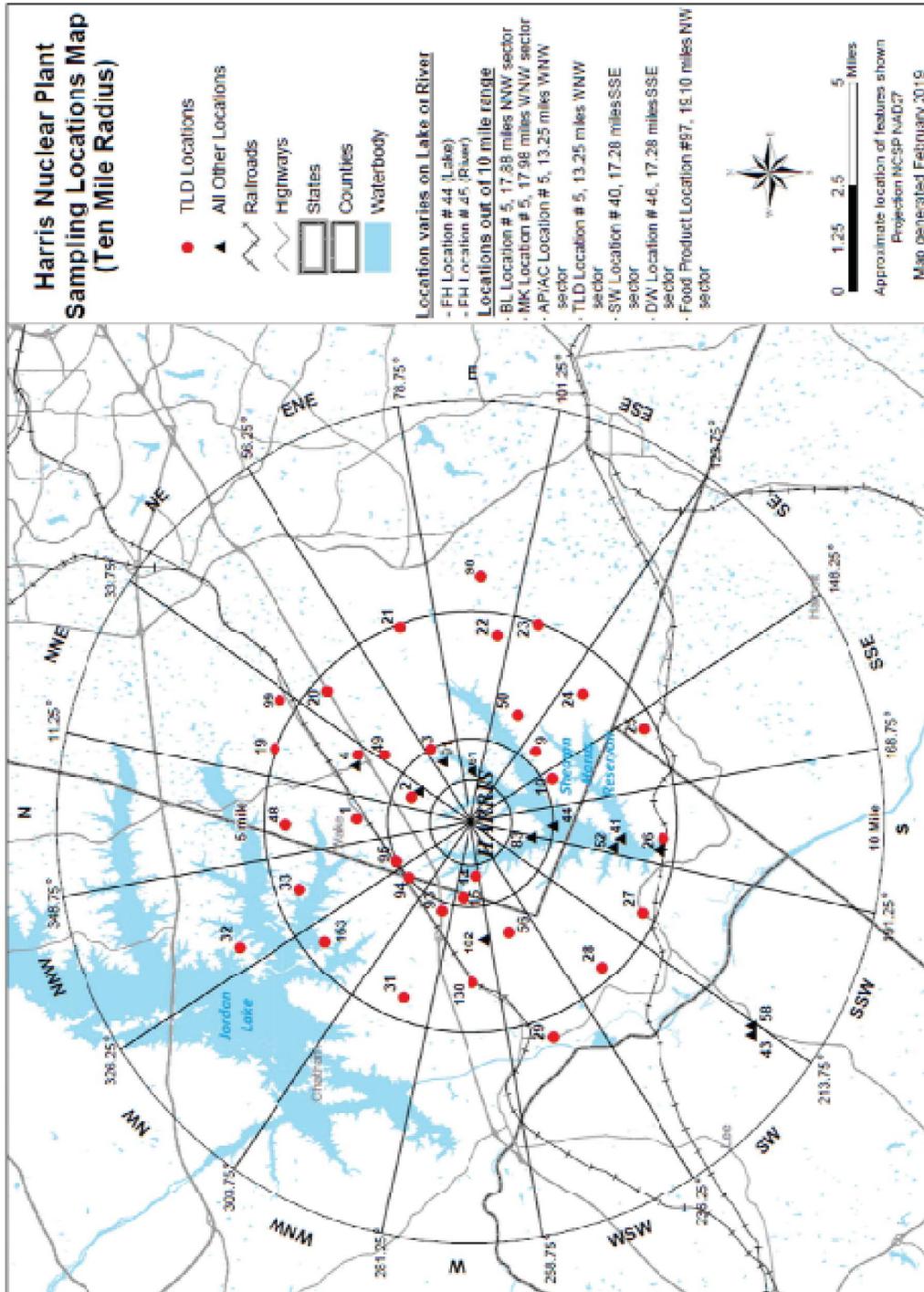


Figure 4.1-3
 Environmental Radiological Sampling Points
 (10 mile Radius)



5.0 INTERLABORATORY COMPARISON STUDIES

The objective of this program is to evaluate the total laboratory analysis process by comparing results for an equivalent sample with those obtained by an independent laboratory or laboratories.

Environmental samples from the SHNPP environs are to be analyzed by a qualified laboratory. These laboratories will participate at least annually in a nationally recognized interlaboratory comparison study. The results of the laboratories' performances in the study will be included in the Annual Radiological Environmental Operating Report (see SHNPP ODCM Operational Requirement 4.12.3).

Radiochemical analyses of composite samples required by ODCM Operational Requirements Tables 4.11-1 and 4.11-2 will be performed by a qualified laboratory. The qualified radiochemistry laboratory will participate annually in a corporate interlaboratory comparison study or an equivalent study.

The qualified laboratory results shall be compared to the criteria established in the NRC Inspection Manual (Procedure 84750) for Radioactive Waste Treatment, Effluent, and Environmental Monitoring. The referenced criteria is as follows:

- a) Divide each standard result by its associated uncertainty to obtain resolution (the uncertainty is defined as the relative standard deviation, one sigma, of the standard result as calculated from counting statistics).
- b) Divide each laboratory result by the corresponding standard result to obtain the ratio (laboratory result/standard).
- c) The laboratory measurement is in agreement if the value of the ratio falls within the limits shown below for the corresponding resolution:

<u>Resolution</u>	<u>Ratio</u>
<4	0.4 – 2.5
4 - 7	0.5 - 2.0
8 - 15	0.6 - 1.66
16 - 50	0.75 - 1.33
51 -200	0.80 - 1.25
>200	0.85 - 1.28

If the qualified laboratory results lay outside the ratio criteria, an evaluation will be performed to identify any recommended remedial actions to reduce anomalous errors. Complete documentation of the evaluation will be available to HNP and will be provided to the NRC upon request.

6.0 TOTAL DOSE (COMPLIANCE WITH 40 CFR 190) for ODCM OR 3.11.4

Compliance with 40 CFR 190 as prescribed in ODCM Operational Requirement 3.11.4 must be demonstrated only when one or more of ODCM Operational Requirements 3.11.1.2a, 3.11.1.2b, 3.11.2.2a, 3.11.2.2b, 3.11.2.3a, or 3.11.2.3b is exceeded by a factor of two. Once this occurs, the company has 30 days to submit this report in accordance with Technical Specification 6.9.2.

ODCM Operational Requirement 3.11.4 requires that the annual dose or dose commitment to a member of the public from uranium fuel cycle sources be limited to 25 mrem for the whole body and any organ except the thyroid which is limited to 75 mrem. In addition, assessment of radiation doses to the likely most exposed member of the public from primary effluent pathways, direct radiation, and any other nearby uranium fuel cycle sources are to be included.

The dose estimates from the gas and liquid effluent pathways to the likely most exposed member of the public can be obtained by using the Regulatory Guide 1.109 and WASH 1258-based NRC codes LADTAP II and GASPAR. This will allow the use of current annual average meteorology X/Q and D/Q values derived from the NRC XOQDOQ (NUREG/CR-2919) Code that is appropriate for the specific location of the receptor and the applicable exposure pathways.

Radiation exposures of members of the public from direct radiation sources (the reactor unit and other primary system components, radwaste, radioactivity in auxiliary systems such as storage tanks, transportation of radioactive material, etc.) will be determined from TLD measurements. Quarterly TLD measurements at locations within three miles of the plant center (inner ring) will be compared with the four-year, pre-operational TLD measurements using methods contained in NBS Handbook 91, "Experimental Statistics," to determine any significant contribution from direct radiation associated with plant operation.

If there is a significant direct radiation component at the TLD location in the sector containing the likely most exposed member of the public then this dose will be added to the doses from effluent pathways derived from LADTAP II and GASPAR.

6.1 Total Dose (COMPLIANCE WITH 40 CFR 190) for ODCM OR F.2

To demonstrate compliance with ODCM Operational Requirement F.2, the ODCM dose equations for noble gases, iodines, particulates, and tritium are used. They provide conservative dose estimates. The X/Q and D/Q values are based on historical data for the exclusion boundary distances. The liquid dose estimates also use the ODCM equations for dose determination which are added together for demonstration of compliance with 40 CFR 190.

7.0 LICENSEE-INITIATED CHANGES TO THE ODCM

Changes to the ODCM:

- a. Shall be documented and records of reviews performed shall be retained as required by Technical Specification 6.14. This documentation shall contain:
 - 1) Sufficient information to support the change together with the appropriate analyses or evaluations justifying the change(s) and
 - 2) A determination that the change will maintain the level of radioactive effluent control required by 10 CFR 20.1302, 40 CFR 190, 10 CFR 50.36a, and Appendix I to 10 CFR Part 50 and not adversely impact the accuracy or reliability of effluent, dose, or setpoint calculations.
- b. Shall become effective after review and acceptance by the ORC (previously known as PNSC) and the approval of the Plant General Manager.
- c. Shall be submitted to the Commission in the form of a complete, legible copy of the entire ODCM as a part of or concurrent with the Annual Radioactive Effluent Release Report for the period of the report in which any change to the ODCM was made. Each change shall be identified by markings in the margin of the affected pages, clearly indicating the areas of the page that was changed, and shall indicate the date (e.g., month/year) the change was implemented.

A.0 Appendix A

Duke Energy has performed the assessment of the transport and dispersion of the effluent in the atmosphere as outlined in Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants, NUREG 0133 (USNRC,1978). The methodology for this assessment was based on guidelines presented in Regulatory Guide 1.111, Revision 1 (USNRC,1977). The results of the assessment were to provide the relative deposition flux and relative concentrations (undepleted and depleted) based on numerical models acceptable for use in Appendix I evaluations.

Regulatory Guide 1.111 presented three acceptable diffusion models for use in estimating deposition flux and concentrations. These are:

1. Particle-in-cell model (a variable trajectory model based on the gradient-transport theory),
2. Puff-advection model (a variable trajectory model based on the statistical approach to diffusion), and
3. The constant mean wind direction model referred to here as the straight-line trajectory Gaussian diffusion model (the most widely used model based on a statistical approach). It was resolved that for operational efficiency, the straight-line method described in XOQDOQ Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations, NUREG/CRG-2919 (USNRC, September 1982) would be used for generating the required analysis of Appendix I to provide a more realistic accounting of the variability of wind around the plant site, standard open-terrain recirculation factors were used.

A five-year record of meteorological data was used from the on-site meteorological program at the Shearon Harris Nuclear Power Plant. This data consisted of all collected parameters from the 12.5 meter level for years 2010-2014. The description of the model used and computations are presented in NUREG/CRC-2919. The following tables provide the meteorological dispersion factors (i.e. concentration (X/Q) and deposition (D/Q) values) utilized to show compliance with ODCM Operational Requirement 3/4.11.2 for noble gases, radioiodines and particulates.

A.1 Changes to X/Q and D/Q modeling

Along with updating the ODCM with X/Q and D/Q values using 2010-2014 meteorological data, there were some changes to the XOQDOQ modeling setup based on interpretations of Regulatory Guide 1.111 and NUREG/CRC-2919. The most notable of these changes was to increase the number of wind speed classes from 7 to 13, concentrating more classes for lower wind speeds.

Wind speed classes:

Previous:

- 1) Calm
- 2) 0.45-0.75 mph
- 3) 0.75-3.50 mph
- 4) 3.50-7.50 mph
- 5) 7.50-12.50 mph
- 6) 12.50-18.50 mph
- 7) 18.50-25.00 mph
- 8) 25.00 + mph

Current:

- 1) Calm
- 2) 0.45-0.75 m/s
- 3) 0.75-1.00 m/s
- 4) 1.00-1.25 m/s
- 5) 1.25-1.50 m/s
- 6) 1.50-2.00 m/s
- 7) 2.00-3.00 m/s
- 8) 3.00-4.00 m/s
- 9) 4.00-5.00 m/s
- 10) 5.00-6.00 m/s
- 11) 6.00-8.00 m/s
- 12) 8.00-10.00 m/s
- 13) 10.00+ m/s

Tables A-1 through A-4

Relative undepleted concentration, relative depleted concentration, and relative deposition flux estimates for the ground level releases for special receptors for long-term releases.

Tables A-5 through A-12

Relative undepleted concentration, relative depleted concentration, and relative deposition flux estimates for the ground level releases for standard and segmented distance locations for long-term releases.

Table A-13

SHNPP on-site Joint Wind Frequency Distributions for years 2010-2014.

Table A-14

The NRC XOQDOQ program input is presented. XOQDOQ was obtained and installed on Duke Energy's computer system. This model is part of the NRC's NRCDOSE program, version 2.3.20. The program was run with appropriate physical plant data and included special receptor locations noted by the annual landuse census. The open-terrain recirculation factors were applied within the model.

Tables A-1 through A-4
X/Q and D/Q Values for Routine Ground Level Releases (Special Receptor Locations)

Model: XOQDOQ – SHNP 10 meter Meteorological Data, 2010-2014

Corrected using Standard Open-Terrain factors

Type of Receptor	Direction From Site	Distance (miles)	TABLE A-1	TABLE A-2	TABLE A-3	TABLE A-4
			X/Q	X/Q	X/Q	D/Q
			sec m ⁻³	sec m ⁻³	sec m ⁻³	1/m ²
			No Decay Undepleted	2.3 Day Decay Undepleted	8 Day Decay Depleted	
SITE BOUNDARY	S	1.36	9.4E-06	9.1E-06	8.0E-06	7.7E-09
SITE BOUNDARY	SSW	1.33	1.0E-05	1.0E-05	8.7E-06	9.0E-09
SITE BOUNDARY	SW	1.33	1.8E-05	1.7E-05	1.5E-05	9.0E-09
SITE BOUNDARY	WSW	1.33	1.1E-05	1.1E-05	9.5E-06	6.1E-09
SITE BOUNDARY	W	1.33	5.3E-06	5.1E-06	4.5E-06	3.2E-09
SITE BOUNDARY	WNW	1.33	2.6E-06	2.6E-06	2.3E-06	2.4E-09
SITE BOUNDARY	NW	1.26	3.6E-06	3.5E-06	3.1E-06	3.3E-09
SITE BOUNDARY	NNW	1.26	3.5E-06	3.4E-06	3.0E-06	4.2E-09
SITE BOUNDARY	N	1.32	3.8E-06	3.7E-06	3.3E-06	5.9E-09
SITE BOUNDARY	NNE	1.33	5.1E-06	5.0E-06	4.3E-06	8.3E-09
SITE BOUNDARY	NE	1.33	5.6E-06	5.4E-06	4.7E-06	7.5E-09
SITE BOUNDARY	ENE	1.33	5.4E-06	5.3E-06	4.6E-06	7.2E-09
SITE BOUNDARY	E	1.33	4.5E-06	4.4E-06	3.9E-06	4.6E-09
SITE BOUNDARY	ESE	1.33	3.4E-06	3.3E-06	2.9E-06	4.3E-09
SITE BOUNDARY	SE	1.33	4.0E-06	3.9E-06	3.4E-06	4.9E-09
SITE BOUNDARY	SSE	1.33	5.8E-06	5.7E-06	5.0E-06	5.7E-09
RESIDENT	SSW	3.82	1.4E-06	1.3E-06	1.0E-06	7.3E-10
RESIDENT	SW	2.76	4.4E-06	4.1E-06	3.4E-06	1.5E-09
RESIDENT	WSW	4.29	1.3E-06	1.1E-06	9.4E-07	3.8E-10
RESIDENT	W	2.75	1.3E-06	1.2E-06	1.0E-06	5.6E-10
RESIDENT	WNW	2.13	1.0E-06	9.7E-07	8.2E-07	7.5E-10
RESIDENT	NW	2.24	1.1E-06	1.0E-06	8.8E-07	8.0E-10
RESIDENT	NNW	1.55	2.2E-06	2.2E-06	1.9E-06	2.5E-09
RESIDENT	N	2.21	1.3E-06	1.3E-06	1.1E-06	1.7E-09
RESIDENT	NNE	1.81	2.6E-06	2.6E-06	2.2E-06	3.9E-09
RESIDENT	NE	2.43	1.6E-06	1.6E-06	1.3E-06	1.7E-09
RESIDENT	ENE	1.78	3.0E-06	2.9E-06	2.5E-06	3.5E-09
RESIDENT	E	1.98	2.0E-06	1.9E-06	1.6E-06	1.7E-09
RESIDENT	ESE	2.73	8.1E-07	7.7E-07	6.4E-07	7.6E-10
RESIDENT	SE	4.11	4.6E-07	4.2E-07	3.4E-07	3.4E-10
RESIDENT	SSE	4.26	6.4E-07	5.9E-07	4.8E-07	3.6E-10

Tables A-1 through A-4
X/Q and D/Q Values for Routine Ground Level Releases (Special Receptor Locations)

Model: XOQDOQ – SHNP 10 meter Meteorological Data, 2010-2014

Corrected using Standard Open-Terrain factors

Type of Receptor	Direction From Site	Distance (miles)	<u>TABLE A-1</u>	<u>TABLE A-2</u>	<u>TABLE A-3</u>	<u>TABLE A-4</u>
			X/Q	X/Q	X/Q	D/Q
			sec m ⁻³	sec m ⁻³	sec m ⁻³	1/m ²
			No Decay	2.3 Day Decay	8 Day Decay	
			Undepleted	Undepleted	Depleted	
GARDEN	SSW	4.20	1.2E-06	1.1E-06	8.8E-07	5.9E-10
GARDEN	SW	2.80	4.2E-06	4.0E-06	3.3E-06	1.5E-09
GARDEN	WSW	4.29	1.3E-06	1.1E-06	9.4E-07	3.8E-10
GARDEN	W	3.73	7.4E-07	6.8E-07	5.6E-07	2.8E-10
GARDEN	WNW	3.39	4.2E-07	3.9E-07	3.2E-07	2.5E-10
GARDEN	NW	3.17	5.7E-07	5.3E-07	4.4E-07	3.6E-10
GARDEN	NNW	1.82	1.6E-06	1.5E-06	1.3E-06	1.7E-09
GARDEN	N	2.21	1.3E-06	1.3E-06	1.1E-06	1.7E-09
GARDEN	NNE	1.91	2.4E-06	2.3E-06	2.0E-06	3.4E-09
GARDEN	NE	3.22	9.7E-07	9.1E-07	7.5E-07	9.0E-10
GARDEN	ENE	2.06	2.2E-06	2.1E-06	1.8E-06	2.5E-09
GARDEN	ESE	4.76	3.0E-07	2.8E-07	2.2E-07	2.2E-10
GARDEN	SE	4.11	4.6E-07	4.2E-07	3.4E-07	3.4E-10
GARDEN	SSE	4.26	6.4E-07	5.9E-07	4.8E-07	3.6E-10
MEAT ANIMAL	SSW	3.93	1.3E-06	1.2E-06	9.9E-07	6.9E-10
MEAT ANIMAL	SW	2.80	4.2E-06	4.0E-06	3.3E-06	1.5E-09
MEAT ANIMAL	WSW	4.29	1.3E-06	1.1E-06	9.4E-07	3.8E-10
MEAT ANIMAL	W	3.26	9.4E-07	8.7E-07	7.2E-07	3.8E-10
MEAT ANIMAL	WNW	2.13	1.0E-06	9.7E-07	8.2E-07	7.5E-10
MEAT ANIMAL	NW	2.24	1.1E-06	1.0E-06	8.8E-07	8.0E-10
MEAT ANIMAL	NNW	1.82	1.6E-06	1.5E-06	1.3E-06	1.7E-09
MEAT ANIMAL	N	2.21	1.3E-06	1.3E-06	1.1E-06	1.7E-09
MEAT ANIMAL	NNE	1.91	2.4E-06	2.3E-06	2.0E-06	3.4E-09
MEAT ANIMAL	NE	3.22	9.7E-07	9.1E-07	7.5E-07	9.0E-10
MEAT ANIMAL	ENE	2.01	2.3E-06	2.2E-06	1.9E-06	2.6E-09
MEAT ANIMAL	ESE	2.74	8.1E-07	7.7E-07	6.4E-07	7.6E-10
MEAT ANIMAL	SE	4.11	4.6E-07	4.2E-07	3.4E-07	3.4E-10
MEAT ANIMAL	SSE	4.57	5.7E-07	5.2E-07	4.2E-07	3.1E-10

Table A-5

Undepleted, no decay, X/Q values for Ground Level Routine Release at standard distances in sec⁻³

Annual Average X/Q	Distance in miles from the site											
	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4	4.5	
Sector												
S	2.611E-04	7.818E-05	3.882E-05	1.920E-05	7.644E-06	4.346E-06	2.856E-06	2.050E-06	1.563E-06	1.243E-06	1.021E-06	
SSW	2.698E-04	8.112E-05	4.041E-05	1.998E-05	7.945E-06	4.509E-06	2.959E-06	2.122E-06	1.616E-06	1.284E-06	1.054E-06	
SW	4.894E-04	1.442E-04	7.057E-05	3.460E-05	1.372E-05	7.874E-06	5.207E-06	3.758E-06	2.876E-06	2.295E-06	1.890E-06	
WSW	3.013E-04	8.921E-05	4.401E-05	2.172E-05	8.656E-06	4.945E-06	3.260E-06	2.347E-06	1.792E-06	1.428E-06	1.174E-06	
W	1.375E-04	4.124E-05	2.060E-05	1.021E-05	4.072E-06	2.311E-06	1.517E-06	1.088E-06	8.284E-07	6.584E-07	5.403E-07	
WNW	6.379E-05	1.967E-05	1.009E-05	5.083E-06	2.043E-06	1.142E-06	7.407E-07	5.265E-07	3.979E-07	3.142E-07	2.564E-07	
NW	7.673E-05	2.375E-05	1.221E-05	6.115E-06	2.443E-06	1.366E-06	8.861E-07	6.299E-07	4.762E-07	3.761E-07	3.070E-07	
NNW	7.313E-05	2.287E-05	1.182E-05	5.951E-06	2.383E-06	1.326E-06	8.572E-07	6.076E-07	4.581E-07	3.611E-07	2.942E-07	
N	8.759E-05	2.771E-05	1.446E-05	7.266E-06	2.897E-06	1.604E-06	1.033E-06	7.301E-07	5.493E-07	4.322E-07	3.515E-07	
NNE	1.163E-04	3.682E-05	1.924E-05	9.723E-06	3.897E-06	2.156E-06	1.388E-06	9.805E-07	7.373E-07	5.797E-07	4.713E-07	
NE	1.350E-04	4.174E-05	2.136E-05	1.073E-05	4.295E-06	2.402E-06	1.558E-06	1.108E-06	8.374E-07	6.614E-07	5.399E-07	
ENE	1.342E-04	4.128E-05	2.100E-05	1.050E-05	4.189E-06	2.346E-06	1.524E-06	1.085E-06	8.210E-07	6.490E-07	5.302E-07	
E	1.133E-04	3.465E-05	1.757E-05	8.770E-06	3.502E-06	1.969E-06	1.282E-06	9.145E-07	6.932E-07	5.488E-07	4.488E-07	
ESE	8.409E-05	2.601E-05	1.329E-05	6.638E-06	2.646E-06	1.480E-06	9.609E-07	6.834E-07	5.168E-07	4.084E-07	3.334E-07	
SE	9.933E-05	3.054E-05	1.549E-05	7.730E-06	3.082E-06	1.729E-06	1.124E-06	8.009E-07	6.064E-07	4.797E-07	3.921E-07	
SSE	1.492E-04	4.526E-05	2.272E-05	1.130E-05	4.507E-06	2.545E-06	1.664E-06	1.190E-06	9.038E-07	7.168E-07	5.872E-07	
Annual Average X/Q	Distance in miles from the site											
Sector	5	7.5	10	15	20	25	30	35	40	45	50	
S	8.590E-07	4.697E-07	3.175E-07	1.928E-07	1.357E-07	1.035E-07	8.298E-08	6.890E-08	5.868E-08	5.095E-08	4.491E-08	
SSW	8.867E-07	4.840E-07	3.268E-07	1.982E-07	1.394E-07	1.062E-07	8.514E-08	7.067E-08	6.016E-08	5.222E-08	4.602E-08	
SW	1.595E-06	8.806E-07	5.990E-07	3.667E-07	2.595E-07	1.987E-07	1.598E-07	1.331E-07	1.136E-07	9.879E-08	8.722E-08	
WSW	9.896E-07	5.437E-07	3.686E-07	2.247E-07	1.586E-07	1.211E-07	9.731E-08	8.089E-08	6.896E-08	5.993E-08	5.286E-08	
W	4.546E-07	2.481E-07	1.675E-07	1.015E-07	7.135E-08	5.436E-08	4.357E-08	3.615E-08	3.077E-08	2.671E-08	2.353E-08	
WNW	2.146E-07	1.150E-07	7.670E-08	4.573E-08	3.179E-08	2.402E-08	1.912E-08	1.578E-08	1.337E-08	1.155E-08	1.014E-08	
NW	2.571E-07	1.379E-07	9.202E-08	5.493E-08	3.822E-08	2.889E-08	2.302E-08	1.900E-08	1.611E-08	1.393E-08	1.223E-08	
NNW	2.459E-07	1.311E-07	8.712E-08	5.170E-08	3.583E-08	2.701E-08	2.146E-08	1.768E-08	1.496E-08	1.292E-08	1.133E-08	
N	2.934E-07	1.556E-07	1.031E-07	6.090E-08	4.209E-08	3.166E-08	2.512E-08	2.067E-08	1.747E-08	1.507E-08	1.321E-08	
NNE	3.932E-07	2.082E-07	1.376E-07	8.114E-08	5.598E-08	4.204E-08	3.332E-08	2.739E-08	2.313E-08	1.993E-08	1.745E-08	
NE	4.520E-07	2.424E-07	1.617E-07	9.652E-08	6.714E-08	5.075E-08	4.042E-08	3.337E-08	2.828E-08	2.445E-08	2.147E-08	
ENE	4.443E-07	2.389E-07	1.598E-07	9.564E-08	6.669E-08	5.051E-08	4.029E-08	3.330E-08	2.825E-08	2.445E-08	2.149E-08	
E	3.764E-07	2.032E-07	1.362E-07	8.178E-08	5.713E-08	4.333E-08	3.460E-08	2.863E-08	2.430E-08	2.105E-08	1.851E-08	
ESE	2.793E-07	1.500E-07	1.002E-07	5.987E-08	4.170E-08	3.156E-08	2.516E-08	2.078E-08	1.762E-08	1.525E-08	1.340E-08	
SE	3.286E-07	1.770E-07	1.185E-07	7.102E-08	4.957E-08	3.756E-08	2.998E-08	2.479E-08	2.104E-08	1.821E-08	1.601E-08	
SSE	4.932E-07	2.676E-07	1.800E-07	1.086E-07	7.609E-08	5.783E-08	4.627E-08	3.834E-08	3.259E-08	2.825E-08	2.487E-08	

Table A-6

Undepleted, no decay, X/Q values for Ground Level Routine Release at standard distances in sec m⁻³

Annual Average X/Q	Segment Boundaries (miles from site)									
	0.5-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-10.0	10.0-20.0	20.0-30.0	30.0-40.0	40.0-50.0
Sector										
S	3.884E-05	8.746E-06	2.931E-06	1.580E-06	1.027E-06	4.885E-07	1.951E-07	1.039E-07	6.903E-08	5.100E-08
SSW	4.038E-05	9.092E-06	3.037E-06	1.634E-06	1.060E-06	5.036E-07	2.006E-07	1.066E-07	7.080E-08	5.228E-08
SW	7.093E-05	1.576E-05	5.339E-06	2.907E-06	1.901E-06	9.143E-07	3.707E-07	1.994E-07	1.333E-07	9.888E-08
WSW	4.415E-05	9.911E-06	3.344E-06	1.812E-06	1.181E-06	5.650E-07	2.273E-07	1.216E-07	8.104E-08	5.999E-08
W	2.057E-05	4.654E-06	1.557E-06	8.378E-07	5.436E-07	2.581E-07	1.028E-07	5.457E-08	3.622E-08	2.673E-08
WNW	9.993E-06	2.318E-06	7.620E-07	4.027E-07	2.581E-07	1.201E-07	4.642E-08	2.413E-08	1.582E-08	1.157E-08
NW	1.207E-05	2.780E-06	9.115E-07	4.820E-07	3.090E-07	1.440E-07	5.575E-08	2.903E-08	1.905E-08	1.395E-08
NNW	1.167E-05	2.706E-06	8.824E-07	4.639E-07	2.962E-07	1.371E-07	5.252E-08	2.714E-08	1.773E-08	1.294E-08
N	1.421E-05	3.293E-06	1.064E-06	5.563E-07	3.539E-07	1.629E-07	6.191E-08	3.182E-08	2.072E-08	1.509E-08
NNE	1.892E-05	4.418E-06	1.430E-06	7.467E-07	4.745E-07	2.179E-07	8.251E-08	4.227E-08	2.746E-08	1.996E-08
NE	2.116E-05	4.883E-06	1.603E-06	8.476E-07	5.433E-07	2.531E-07	9.796E-08	5.099E-08	3.345E-08	2.448E-08
ENE	2.084E-05	4.772E-06	1.568E-06	8.309E-07	5.336E-07	2.494E-07	9.703E-08	5.074E-08	3.338E-08	2.448E-08
E	1.745E-05	3.991E-06	1.318E-06	7.014E-07	4.516E-07	2.119E-07	8.292E-08	4.352E-08	2.869E-08	2.107E-08
ESE	1.316E-05	3.015E-06	9.884E-07	5.231E-07	3.356E-07	1.566E-07	6.075E-08	3.170E-08	2.083E-08	1.527E-08
SE	1.539E-05	3.513E-06	1.156E-06	6.137E-07	3.945E-07	1.847E-07	7.203E-08	3.773E-08	2.484E-08	1.824E-08
SSE	2.265E-05	5.145E-06	1.709E-06	9.143E-07	5.908E-07	2.788E-07	1.100E-07	5.807E-08	3.841E-08	2.829E-08

Table A-7

Undepleted, 2.26 Day Decay, X/Q values for Ground Level Routine Release at standard distances in sec⁻³

Annual Average X/Q		Distance in miles from the site									
Sector	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4	4.5
S	2.596E-04	7.730E-05	3.818E-05	1.878E-05	7.397E-06	4.158E-06	2.701E-06	1.917E-06	1.444E-06	1.136E-06	9.217E-07
SSW	2.683E-04	8.021E-05	3.975E-05	1.954E-05	7.687E-06	4.312E-06	2.797E-06	1.983E-06	1.493E-06	1.173E-06	9.512E-07
SW	4.863E-04	1.424E-04	6.927E-05	3.375E-05	1.323E-05	7.493E-06	4.893E-06	3.487E-06	2.635E-06	2.077E-06	1.689E-06
WSW	2.994E-04	8.813E-05	4.322E-05	2.121E-05	8.351E-06	4.712E-06	3.069E-06	2.182E-06	1.646E-06	1.295E-06	1.052E-06
W	1.367E-04	4.075E-05	2.025E-05	9.980E-06	3.933E-06	2.206E-06	1.430E-06	1.014E-06	7.628E-07	5.990E-07	4.857E-07
WNW	6.345E-05	1.947E-05	9.932E-06	4.981E-06	1.981E-06	1.096E-06	7.033E-07	4.945E-07	3.697E-07	2.888E-07	2.332E-07
NW	7.631E-05	2.351E-05	1.202E-05	5.991E-06	2.369E-06	1.310E-06	8.412E-07	5.916E-07	4.424E-07	3.457E-07	2.791E-07
NNW	7.276E-05	2.265E-05	1.165E-05	5.840E-06	2.317E-06	1.276E-06	8.167E-07	5.731E-07	4.277E-07	3.337E-07	2.691E-07
N	8.719E-05	2.747E-05	1.428E-05	7.142E-06	2.823E-06	1.548E-06	9.882E-07	6.920E-07	5.157E-07	4.019E-07	3.239E-07
NNE	1.158E-04	3.651E-05	1.900E-05	9.562E-06	3.800E-06	2.084E-06	1.330E-06	9.307E-07	6.935E-07	5.403E-07	4.353E-07
NE	1.343E-04	4.133E-05	2.106E-05	1.053E-05	4.175E-06	2.311E-06	1.485E-06	1.045E-06	7.817E-07	6.112E-07	4.938E-07
ENE	1.335E-04	4.087E-05	2.070E-05	1.030E-05	4.069E-06	2.256E-06	1.450E-06	1.022E-06	7.650E-07	5.985E-07	4.838E-07
E	1.127E-04	3.429E-05	1.730E-05	8.590E-06	3.395E-06	1.888E-06	1.216E-06	8.581E-07	6.433E-07	5.037E-07	4.074E-07
ESE	8.366E-05	2.576E-05	1.309E-05	6.510E-06	2.570E-06	1.423E-06	9.143E-07	6.435E-07	4.816E-07	3.766E-07	3.043E-07
SE	9.880E-05	3.022E-05	1.526E-05	7.576E-06	2.990E-06	1.659E-06	1.068E-06	7.525E-07	5.636E-07	4.410E-07	3.566E-07
SSE	1.483E-04	4.477E-05	2.236E-05	1.106E-05	4.367E-06	2.439E-06	1.577E-06	1.115E-06	8.375E-07	6.568E-07	5.320E-07
Annual Average X/Q		Distance in miles from the site									
Sector	5	7.5	10	15	20	25	30	35	40	45	50
S	7.669E-07	3.957E-07	2.525E-07	1.367E-07	8.591E-08	5.860E-08	4.213E-08	3.142E-08	2.409E-08	1.887E-08	1.505E-08
SSW	7.909E-07	4.072E-07	2.593E-07	1.400E-07	8.780E-08	5.976E-08	4.287E-08	3.190E-08	2.441E-08	1.908E-08	1.518E-08
SW	1.407E-06	7.292E-07	4.657E-07	2.514E-07	1.571E-07	1.063E-07	7.569E-08	5.585E-08	4.232E-08	3.274E-08	2.575E-08
WSW	8.760E-07	4.525E-07	2.885E-07	1.557E-07	9.735E-08	6.600E-08	4.712E-08	3.487E-08	2.652E-08	2.059E-08	1.627E-08
W	4.037E-07	2.074E-07	1.319E-07	7.092E-08	4.429E-08	3.002E-08	2.145E-08	1.589E-08	1.210E-08	9.412E-09	7.449E-09
WNW	1.931E-07	9.804E-08	6.195E-08	3.319E-08	2.077E-08	1.416E-08	1.019E-08	7.616E-09	5.860E-09	4.611E-09	3.694E-09
NW	2.312E-07	1.175E-07	7.425E-08	3.980E-08	2.491E-08	1.697E-08	1.220E-08	9.119E-09	7.011E-09	5.512E-09	4.414E-09
NNW	2.227E-07	1.128E-07	7.119E-08	3.816E-08	2.393E-08	1.635E-08	1.180E-08	8.859E-09	6.844E-09	5.408E-09	4.353E-09
N	2.678E-07	1.355E-07	8.556E-08	4.604E-08	2.903E-08	1.997E-08	1.452E-08	1.099E-08	8.556E-09	6.819E-09	5.537E-09
NNE	3.599E-07	1.820E-07	1.149E-07	6.190E-08	3.909E-08	2.694E-08	1.964E-08	1.489E-08	1.163E-08	9.296E-09	7.571E-09
NE	4.093E-07	2.085E-07	1.322E-07	7.131E-08	4.491E-08	3.081E-08	2.232E-08	1.681E-08	1.302E-08	1.032E-08	8.336E-09
ENE	4.011E-07	2.046E-07	1.298E-07	6.998E-08	4.403E-08	3.015E-08	2.180E-08	1.637E-08	1.265E-08	9.996E-09	8.045E-09
E	3.380E-07	1.726E-07	1.095E-07	5.893E-08	3.696E-08	2.521E-08	1.815E-08	1.356E-08	1.043E-08	8.198E-09	6.562E-09
ESE	2.522E-07	1.285E-07	8.141E-08	4.384E-08	2.756E-08	1.886E-08	1.362E-08	1.023E-08	7.898E-09	6.238E-09	5.018E-09
SE	2.956E-07	1.508E-07	9.558E-08	5.142E-08	3.226E-08	2.201E-08	1.586E-08	1.186E-08	9.130E-09	7.185E-09	5.758E-09
SSE	4.419E-07	2.266E-07	1.441E-07	7.774E-08	4.879E-08	3.328E-08	2.394E-08	1.788E-08	1.373E-08	1.078E-08	8.614E-09

Table A-8

Undepleted, 2.26 Day Decay, X/Q values for Ground Level Routine Release at standard distances in sec m⁻³

Sector	Segment Boundaries (miles from site)									
	0.5-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-10.0	10.0-20.0	20.0-30.0	30.0-40.0	40.0-50.0
S	3.825E-05	8.487E-06	2.776E-06	1.462E-06	9.277E-07	4.145E-07	1.399E-07	5.930E-08	3.169E-08	1.900E-08
SSW	3.976E-05	8.822E-06	2.876E-06	1.511E-06	9.574E-07	4.267E-07	1.433E-07	6.048E-08	3.218E-08	1.921E-08
SW	6.973E-05	1.524E-05	5.024E-06	2.666E-06	1.699E-06	7.627E-07	2.571E-07	1.076E-07	5.637E-08	3.299E-08
WSW	4.342E-05	9.591E-06	3.152E-06	1.666E-06	1.059E-06	4.737E-07	1.593E-07	6.680E-08	3.519E-08	2.075E-08
W	2.024E-05	4.509E-06	1.471E-06	7.721E-07	4.889E-07	2.174E-07	7.263E-08	3.040E-08	1.603E-08	9.481E-09
WNW	9.851E-06	2.254E-06	7.244E-07	3.745E-07	2.348E-07	1.031E-07	3.406E-08	1.433E-08	7.682E-09	4.641E-09
NW	1.189E-05	2.704E-06	8.665E-07	4.482E-07	2.811E-07	1.235E-07	4.083E-08	1.718E-08	9.197E-09	5.550E-09
NNW	1.151E-05	2.637E-06	8.418E-07	4.334E-07	2.711E-07	1.187E-07	3.918E-08	1.655E-08	8.933E-09	5.443E-09
N	1.404E-05	3.216E-06	1.019E-06	5.227E-07	3.262E-07	1.427E-07	4.726E-08	2.021E-08	1.107E-08	6.859E-09
NNE	1.869E-05	4.318E-06	1.371E-06	7.029E-07	4.385E-07	1.917E-07	6.355E-08	2.726E-08	1.501E-08	9.349E-09
NE	2.088E-05	4.758E-06	1.529E-06	7.919E-07	4.973E-07	2.192E-07	7.311E-08	3.117E-08	1.694E-08	1.039E-08
ENE	2.056E-05	4.647E-06	1.494E-06	7.749E-07	4.871E-07	2.150E-07	7.174E-08	3.051E-08	1.650E-08	1.006E-08
E	1.720E-05	3.880E-06	1.252E-06	6.515E-07	4.102E-07	1.813E-07	6.041E-08	2.552E-08	1.368E-08	8.253E-09
ESE	1.298E-05	2.936E-06	9.416E-07	4.878E-07	3.064E-07	1.350E-07	4.496E-08	1.909E-08	1.031E-08	6.278E-09
SE	1.517E-05	3.418E-06	1.099E-06	5.709E-07	3.590E-07	1.584E-07	5.271E-08	2.228E-08	1.196E-08	7.233E-09
SSE	2.232E-05	4.998E-06	1.622E-06	8.479E-07	5.356E-07	2.378E-07	7.962E-08	3.368E-08	1.803E-08	1.085E-08

Table A-9

Depleted, 8 Day Decay, X/Q values for Ground Level Routine Release at standard distances in sec m⁻³

Annual Average X/Q		Distance in miles from the site									
Sector	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4	4.5
S	2.467E-04	7.116E-05	3.443E-05	1.670E-05	6.431E-06	3.554E-06	2.277E-06	1.598E-06	1.192E-06	9.299E-07	7.496E-07
SSW	2.550E-04	7.384E-05	3.584E-05	1.738E-05	6.685E-06	3.687E-06	2.359E-06	1.653E-06	1.233E-06	9.608E-07	7.740E-07
SW	4.624E-04	1.312E-04	6.256E-05	3.007E-05	1.153E-05	6.429E-06	4.144E-06	2.922E-06	2.189E-06	1.713E-06	1.384E-06
WSW	2.847E-04	8.119E-05	3.902E-05	1.889E-05	7.277E-06	4.039E-06	2.596E-06	1.826E-06	1.365E-06	1.066E-06	8.606E-07
W	1.299E-04	3.753E-05	1.827E-05	8.882E-06	3.425E-06	1.889E-06	1.208E-06	8.470E-07	6.315E-07	4.921E-07	3.964E-07
WNW	6.028E-05	1.791E-05	8.949E-06	4.424E-06	1.720E-06	9.346E-07	5.913E-07	4.108E-07	3.040E-07	2.355E-07	1.887E-07
NW	7.250E-05	2.163E-05	1.083E-05	5.322E-06	2.057E-06	1.118E-06	7.072E-07	4.915E-07	3.639E-07	2.819E-07	2.259E-07
NNW	6.911E-05	2.083E-05	1.049E-05	5.182E-06	2.008E-06	1.086E-06	6.849E-07	4.746E-07	3.506E-07	2.710E-07	2.169E-07
N	8.279E-05	2.524E-05	1.284E-05	6.329E-06	2.442E-06	1.315E-06	8.263E-07	5.712E-07	4.210E-07	3.249E-07	2.596E-07
NNE	1.099E-04	3.354E-05	1.708E-05	8.471E-06	3.286E-06	1.768E-06	1.111E-06	7.673E-07	5.653E-07	4.362E-07	3.483E-07
NE	1.276E-04	3.801E-05	1.896E-05	9.339E-06	3.619E-06	1.967E-06	1.245E-06	8.654E-07	6.407E-07	4.964E-07	3.979E-07
ENE	1.268E-04	3.759E-05	1.864E-05	9.138E-06	3.528E-06	1.921E-06	1.217E-06	8.472E-07	6.279E-07	4.869E-07	3.905E-07
E	1.071E-04	3.155E-05	1.559E-05	7.632E-06	2.948E-06	1.611E-06	1.023E-06	7.134E-07	5.295E-07	4.111E-07	3.301E-07
ESE	7.947E-05	2.369E-05	1.179E-05	5.778E-06	2.229E-06	1.212E-06	7.674E-07	5.336E-07	3.952E-07	3.063E-07	2.456E-07
SE	9.387E-05	2.780E-05	1.375E-05	6.728E-06	2.595E-06	1.415E-06	8.975E-07	6.250E-07	4.635E-07	3.595E-07	2.885E-07
SSE	1.410E-04	4.120E-05	2.016E-05	9.832E-06	3.794E-06	2.082E-06	1.327E-06	9.278E-07	6.901E-07	5.368E-07	4.317E-07
Annual Average X/Q		Distance in miles from the site									
Sector	5	7.5	10	15	20	25	30	35	40	45	50
S	6.200E-07	3.153E-07	1.998E-07	1.086E-07	6.939E-08	4.848E-08	3.584E-08	2.755E-08	2.180E-08	1.763E-08	1.451E-08
SSW	6.398E-07	3.248E-07	2.055E-07	1.115E-07	7.118E-08	4.968E-08	3.670E-08	2.819E-08	2.229E-08	1.801E-08	1.481E-08
SW	1.148E-06	5.884E-07	3.746E-07	2.047E-07	1.312E-07	9.180E-08	6.790E-08	5.220E-08	4.128E-08	3.336E-08	2.742E-08
WSW	7.126E-07	3.638E-07	2.309E-07	1.258E-07	8.047E-08	5.623E-08	4.156E-08	3.193E-08	2.525E-08	2.040E-08	1.677E-08
W	3.276E-07	1.662E-07	1.051E-07	5.695E-08	3.631E-08	2.532E-08	1.868E-08	1.434E-08	1.132E-08	9.143E-09	7.511E-09
WNW	1.552E-07	7.746E-08	4.846E-08	2.592E-08	1.640E-08	1.137E-08	8.364E-09	6.404E-09	5.051E-09	4.075E-09	3.347E-09
NW	1.859E-07	9.285E-08	5.813E-08	3.112E-08	1.970E-08	1.367E-08	1.005E-08	7.700E-09	6.073E-09	4.900E-09	4.025E-09
NNW	1.782E-07	8.852E-08	5.522E-08	2.943E-08	1.858E-08	1.288E-08	9.462E-09	7.241E-09	5.710E-09	4.606E-09	3.784E-09
N	2.131E-07	1.054E-07	6.561E-08	3.489E-08	2.202E-08	1.526E-08	1.122E-08	8.594E-09	6.784E-09	5.480E-09	4.508E-09
NNE	2.858E-07	1.412E-07	8.776E-08	4.660E-08	2.938E-08	2.035E-08	1.495E-08	1.145E-08	9.040E-09	7.303E-09	6.008E-09
NE	3.275E-07	1.637E-07	1.025E-07	5.495E-08	3.483E-08	2.421E-08	1.783E-08	1.368E-08	1.080E-08	8.731E-09	7.183E-09
ENE	3.216E-07	1.611E-07	1.011E-07	5.431E-08	3.448E-08	2.399E-08	1.768E-08	1.357E-08	1.072E-08	8.662E-09	7.125E-09
E	2.721E-07	1.367E-07	8.595E-08	4.625E-08	2.939E-08	2.045E-08	1.507E-08	1.156E-08	9.128E-09	7.372E-09	6.061E-09
ESE	2.022E-07	1.011E-07	6.340E-08	3.401E-08	2.157E-08	1.499E-08	1.105E-08	8.470E-09	6.690E-09	5.405E-09	4.445E-09
SE	2.377E-07	1.192E-07	7.483E-08	4.022E-08	2.553E-08	1.775E-08	1.308E-08	1.003E-08	7.921E-09	6.397E-09	5.259E-09
SSE	3.563E-07	1.799E-07	1.135E-07	6.131E-08	3.904E-08	2.721E-08	2.008E-08	1.541E-08	1.218E-08	9.844E-09	8.096E-09

Table A-10

Depleted, 8 Day Decay, X/Q values for Ground Level Routine Release at standard distances in sec m⁻³

Sector	Segment Boundaries (miles from site)									
	0.5-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-10.0	10.0-20.0	20.0-30.0	30.0-40.0	40.0-50.0
S	3.471E-05	7.435E-06	2.346E-06	1.208E-06	7.550E-07	3.316E-07	1.114E-07	4.900E-08	2.773E-08	1.771E-08
SSW	3.608E-05	7.729E-06	2.431E-06	1.249E-06	7.796E-07	3.418E-07	1.145E-07	5.022E-08	2.837E-08	1.809E-08
SW	6.337E-05	1.339E-05	4.265E-06	2.217E-06	1.394E-06	6.176E-07	2.098E-07	9.276E-08	5.253E-08	3.351E-08
WSW	3.944E-05	8.418E-06	2.673E-06	1.383E-06	8.667E-07	3.822E-07	1.290E-07	5.683E-08	3.214E-08	2.049E-08
W	1.838E-05	3.955E-06	1.245E-06	6.399E-07	3.992E-07	1.749E-07	5.847E-08	2.560E-08	1.443E-08	9.185E-09
WNW	8.930E-06	1.972E-06	6.106E-07	3.084E-07	1.902E-07	8.186E-08	2.670E-08	1.151E-08	6.448E-09	4.094E-09
NW	1.078E-05	2.365E-06	7.304E-07	3.691E-07	2.277E-07	9.810E-08	3.204E-08	1.383E-08	7.753E-09	4.923E-09
NNW	1.043E-05	2.304E-06	7.078E-07	3.557E-07	2.186E-07	9.365E-08	3.034E-08	1.303E-08	7.292E-09	4.628E-09
N	1.270E-05	2.805E-06	8.545E-07	4.273E-07	2.617E-07	1.116E-07	3.600E-08	1.545E-08	8.654E-09	5.506E-09
NNE	1.691E-05	3.764E-06	1.149E-06	5.738E-07	3.512E-07	1.496E-07	4.810E-08	2.060E-08	1.153E-08	7.338E-09
NE	1.892E-05	4.156E-06	1.286E-06	6.499E-07	4.010E-07	1.729E-07	5.658E-08	2.449E-08	1.377E-08	8.772E-09
ENE	1.863E-05	4.061E-06	1.257E-06	6.368E-07	3.936E-07	1.701E-07	5.590E-08	2.426E-08	1.366E-08	8.702E-09
E	1.560E-05	3.395E-06	1.056E-06	5.369E-07	3.326E-07	1.442E-07	4.758E-08	2.068E-08	1.164E-08	7.407E-09
ESE	1.176E-05	2.566E-06	7.925E-07	4.009E-07	2.475E-07	1.068E-07	3.501E-08	1.517E-08	8.528E-09	5.430E-09
SE	1.375E-05	2.989E-06	9.265E-07	4.700E-07	2.907E-07	1.258E-07	4.138E-08	1.796E-08	1.010E-08	6.427E-09
SSE	2.024E-05	4.375E-06	1.369E-06	6.996E-07	4.349E-07	1.896E-07	6.300E-08	2.751E-08	1.552E-08	9.890E-09

Table A-11

Deposition values (D/Q) for Ground Level Routine Release at standard distances in per m²

Sector	Distance in miles from the site										
	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4	4.5
S	2.043E-07	6.909E-08	3.547E-08	1.687E-08	6.058E-09	3.004E-09	1.769E-09	1.158E-09	8.150E-10	6.040E-10	4.655E-10
SSW	2.243E-07	7.584E-08	3.894E-08	1.851E-08	6.649E-09	3.298E-09	1.942E-09	1.271E-09	8.946E-10	6.630E-10	5.109E-10
SW	2.249E-07	7.606E-08	3.905E-08	1.857E-08	6.669E-09	3.307E-09	1.947E-09	1.275E-09	8.973E-10	6.650E-10	5.124E-10
WSW	1.520E-07	5.141E-08	2.640E-08	1.255E-08	4.508E-09	2.235E-09	1.316E-09	8.619E-10	6.065E-10	4.494E-10	3.464E-10
W	8.074E-08	2.730E-08	1.402E-08	6.665E-09	2.394E-09	1.187E-09	6.990E-10	4.577E-10	3.221E-10	2.387E-10	1.839E-10
WNW	5.925E-08	2.003E-08	1.029E-08	4.890E-09	1.757E-09	8.712E-10	5.130E-10	3.359E-10	2.363E-10	1.752E-10	1.350E-10
NW	7.104E-08	2.402E-08	1.233E-08	5.864E-09	2.106E-09	1.045E-09	6.151E-10	4.027E-10	2.834E-10	2.100E-10	1.618E-10
NNW	9.208E-08	3.114E-08	1.599E-08	7.601E-09	2.730E-09	1.354E-09	7.973E-10	5.220E-10	3.673E-10	2.722E-10	2.098E-10
N	1.450E-07	4.905E-08	2.518E-08	1.197E-08	4.300E-09	2.133E-09	1.256E-09	8.223E-10	5.786E-10	4.288E-10	3.304E-10
NNE	2.084E-07	7.048E-08	3.619E-08	1.720E-08	6.180E-09	3.065E-09	1.805E-09	1.182E-09	8.315E-10	6.162E-10	4.749E-10
NE	1.864E-07	6.302E-08	3.236E-08	1.538E-08	5.526E-09	2.740E-09	1.614E-09	1.057E-09	7.434E-10	5.509E-10	4.246E-10
ENE	1.809E-07	6.118E-08	3.141E-08	1.493E-08	5.364E-09	2.660E-09	1.566E-09	1.026E-09	7.217E-10	5.348E-10	4.121E-10
E	1.151E-07	3.892E-08	1.999E-08	9.501E-09	3.413E-09	1.693E-09	9.966E-10	6.526E-10	4.592E-10	3.403E-10	2.622E-10
ESE	1.081E-07	3.655E-08	1.877E-08	8.922E-09	3.205E-09	1.589E-09	9.358E-10	6.128E-10	4.312E-10	3.195E-10	2.462E-10
SE	1.221E-07	4.129E-08	2.120E-08	1.008E-08	3.620E-09	1.795E-09	1.057E-09	6.922E-10	4.871E-10	3.610E-10	2.782E-10
SSE	1.413E-07	4.778E-08	2.453E-08	1.166E-08	4.189E-09	2.078E-09	1.223E-09	8.010E-10	5.636E-10	4.177E-10	3.219E-10

Sector	Distance in miles from the site										
	5	7.5	10	15	20	25	30	35	40	45	50
S	3.698E-10	1.643E-10	9.951E-11	5.030E-11	3.044E-11	2.041E-11	1.463E-11	1.098E-11	8.539E-12	6.821E-12	5.567E-12
SSW	4.059E-10	1.803E-10	1.092E-10	5.521E-11	3.341E-11	2.240E-11	1.605E-11	1.205E-11	9.373E-12	7.487E-12	6.111E-12
SW	4.071E-10	1.809E-10	1.096E-10	5.537E-11	3.351E-11	2.247E-11	1.610E-11	1.209E-11	9.401E-12	7.509E-12	6.129E-12
WSW	2.752E-10	1.222E-10	7.404E-11	3.743E-11	2.265E-11	1.519E-11	1.088E-11	8.172E-12	6.354E-12	5.075E-12	4.143E-12
W	1.461E-10	6.492E-11	3.932E-11	1.988E-11	1.203E-11	8.066E-12	5.779E-12	4.340E-12	3.374E-12	2.695E-12	2.200E-12
WNW	1.072E-10	4.763E-11	2.886E-11	1.458E-11	8.827E-12	5.919E-12	4.241E-12	3.185E-12	2.476E-12	1.978E-12	1.614E-12
NW	1.286E-10	5.712E-11	3.460E-11	1.749E-11	1.058E-11	7.097E-12	5.085E-12	3.818E-12	2.969E-12	2.372E-12	1.936E-12
NNW	1.667E-10	7.404E-11	4.485E-11	2.267E-11	1.372E-11	9.199E-12	6.592E-12	4.950E-12	3.848E-12	3.074E-12	2.509E-12
N	2.625E-10	1.166E-10	7.064E-11	3.570E-11	2.161E-11	1.449E-11	1.038E-11	7.796E-12	6.062E-12	4.842E-12	3.952E-12
NNE	3.772E-10	1.676E-10	1.015E-10	5.131E-11	3.106E-11	2.082E-11	1.492E-11	1.120E-11	8.711E-12	6.958E-12	5.680E-12
NE	3.373E-10	1.498E-10	9.076E-11	4.588E-11	2.777E-11	1.862E-11	1.334E-11	1.002E-11	7.788E-12	6.221E-12	5.078E-12
ENE	3.274E-10	1.455E-10	8.811E-11	4.453E-11	2.695E-11	1.807E-11	1.295E-11	9.724E-12	7.561E-12	6.039E-12	4.930E-12
E	2.083E-10	9.255E-11	5.606E-11	2.834E-11	1.715E-11	1.150E-11	8.240E-12	6.187E-12	4.811E-12	3.843E-12	3.137E-12
ESE	1.956E-10	8.691E-11	5.264E-11	2.661E-11	1.610E-11	1.080E-11	7.737E-12	5.810E-12	4.517E-12	3.608E-12	2.945E-12
SE	2.210E-10	9.817E-11	5.947E-11	3.006E-11	1.819E-11	1.220E-11	8.740E-12	6.563E-12	5.103E-12	4.076E-12	3.327E-12
SSE	2.557E-10	1.136E-10	6.882E-11	3.478E-11	2.105E-11	1.412E-11	1.011E-11	7.595E-12	5.905E-12	4.717E-12	3.850E-12

Table A-12

Deposition values (D/Q) for Ground Level Routine Release at standard distances in per m²

Sector	Segment Boundaries (miles from site)									
	0.5-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-10.0	10.0-20.0	20.0-30.0	30.0-40.0	40.0-50.0
S	3.467E-08	7.102E-09	1.854E-09	8.327E-10	4.711E-10	1.812E-10	5.241E-11	2.077E-11	1.109E-11	6.866E-12
SSW	3.806E-08	7.796E-09	2.035E-09	9.140E-10	5.171E-10	1.988E-10	5.753E-11	2.280E-11	1.218E-11	7.536E-12
SW	3.817E-08	7.819E-09	2.041E-09	9.168E-10	5.186E-10	1.994E-10	5.770E-11	2.287E-11	1.221E-11	7.559E-12
WSW	2.580E-08	5.285E-09	1.380E-09	6.196E-10	3.505E-10	1.348E-10	3.900E-11	1.546E-11	8.254E-12	5.109E-12
W	1.370E-08	2.807E-09	7.327E-10	3.291E-10	1.862E-10	7.159E-11	2.071E-11	8.208E-12	4.383E-12	2.713E-12
WNW	1.005E-08	2.059E-09	5.376E-10	2.415E-10	1.366E-10	5.253E-11	1.520E-11	6.023E-12	3.216E-12	1.991E-12
NW	1.206E-08	2.469E-09	6.447E-10	2.895E-10	1.638E-10	6.299E-11	1.822E-11	7.222E-12	3.857E-12	2.387E-12
NNW	1.563E-08	3.201E-09	8.356E-10	3.753E-10	2.123E-10	8.165E-11	2.362E-11	9.362E-12	4.999E-12	3.094E-12
N	2.461E-08	5.042E-09	1.316E-09	5.911E-10	3.344E-10	1.286E-10	3.720E-11	1.475E-11	7.874E-12	4.874E-12
NNE	3.537E-08	7.245E-09	1.891E-09	8.495E-10	4.806E-10	1.848E-10	5.346E-11	2.119E-11	1.132E-11	7.004E-12
NE	3.163E-08	6.478E-09	1.691E-09	7.595E-10	4.297E-10	1.652E-10	4.780E-11	1.895E-11	1.012E-11	6.262E-12
ENE	3.070E-08	6.289E-09	1.642E-09	7.373E-10	4.171E-10	1.604E-10	4.640E-11	1.839E-11	9.822E-12	6.079E-12
E	1.953E-08	4.001E-09	1.045E-09	4.691E-10	2.654E-10	1.021E-10	2.953E-11	1.170E-11	6.249E-12	3.868E-12
ESE	1.834E-08	3.757E-09	9.809E-10	4.405E-10	2.492E-10	9.584E-11	2.773E-11	1.099E-11	5.868E-12	3.632E-12
SE	2.072E-08	4.244E-09	1.108E-09	4.976E-10	2.815E-10	1.083E-10	3.132E-11	1.241E-11	6.629E-12	4.103E-12
SSE	2.398E-08	4.912E-09	1.282E-09	5.759E-10	3.258E-10	1.253E-10	3.624E-11	1.436E-11	7.671E-12	4.748E-12

Table A-13

Joint Wind Frequency Distribution by Pasquill Stability Classes at SHNP (2010-2014 meteorological data, 12.5 meter level)

Stability Class A																	
Umax	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0	0	0.002
1	0	0	0	0.002	0.005	0	0	0	0	0	0	0	0	0	0	0	0.007
1.25	0.002	0	0.005	0.002	0	0.002	0	0	0	0.002	0.002	0	0	0.002	0	0	0.018
1.5	0	0	0.005	0.002	0	0	0.005	0.002	0	0.002	0.002	0	0.005	0	0.005	0	0.028
2	0.002	0	0	0.009	0	0.002	0	0.007	0.002	0	0.005	0.009	0.005	0.002	0.002	0.002	0.048
3	0	0.014	0.028	0.035	0.012	0.002	0	0.007	0.007	0.012	0.012	0.025	0.012	0.005	0.005	0.002	0.175
4	0.005	0.018	0.023	0.018	0.002	0	0.002	0.012	0.023	0.009	0.007	0.037	0.016	0.002	0.009	0.002	0.186
5	0.002	0.014	0.007	0.002	0.005	0	0	0	0.007	0.007	0.012	0.007	0.002	0.002	0.005	0.002	0.074
6	0	0.002	0	0	0	0	0	0	0	0	0.005	0.007	0.002	0	0.002	0.002	0.021
8	0	0	0	0	0	0	0	0	0	0	0.002	0.002	0	0	0	0	0.005
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0.01	0.05	0.07	0.07	0.02	0.01	0.01	0.03	0.04	0.03	0.05	0.09	0.04	0.02	0.03	0.01	0.56
Stability Class B																	
Umax	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.75	0	0	0	0.002	0.002	0.002	0.002	0	0	0	0	0	0	0	0	0	0.009
1	0	0	0	0	0	0	0	0	0	0.002	0.002	0.002	0	0.002	0	0.005	0.014
1.25	0.002	0	0.002	0.002	0.002	0	0	0	0	0	0.002	0.005	0	0	0.005	0.005	0.025
1.5	0.002	0.005	0.009	0.009	0.005	0.002	0.002	0.005	0	0	0.002	0.005	0.005	0.005	0.002	0.002	0.06
2	0.007	0.012	0.023	0.03	0.021	0.018	0.005	0.012	0.018	0.014	0.007	0.016	0.012	0.007	0.009	0.007	0.216
3	0.044	0.071	0.134	0.076	0.025	0.007	0.018	0.032	0.046	0.044	0.035	0.076	0.028	0.028	0.028	0.016	0.707
4	0.005	0.067	0.041	0.032	0.005	0.009	0.005	0.009	0.085	0.067	0.062	0.104	0.023	0.021	0.023	0.016	0.573
5	0.009	0.018	0.012	0.009	0	0.002	0	0	0.021	0.016	0.032	0.032	0.016	0.007	0.012	0.012	0.198
6	0.009	0.002	0.002	0.002	0	0	0	0	0.005	0.005	0.023	0.007	0.005	0.016	0.005	0.005	0.085
8	0	0	0.002	0	0	0	0	0	0	0	0.002	0.002	0.002	0.002	0.002	0	0.014
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0.08	0.17	0.23	0.16	0.06	0.04	0.03	0.06	0.17	0.15	0.17	0.25	0.09	0.09	0.09	0.07	1.9

Table A-13 (continue)

Joint Wind Frequency Distribution by Pasquill Stability Classes at SHNP (2010-2014 meteorological data, 12.5 meter level)

Stability Class C																	
Umax	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.45	0.003	0.001	0	0	0	0.001	0.002	0	0.001	0.001	0.001	0.001	0.002	0	0.004	0	0.016
0.75	0.007	0.002	0	0	0	0.002	0.005	0	0.002	0.002	0.002	0.002	0.005	0	0.009	0	0.039
1	0.007	0.005	0.007	0.002	0.007	0.007	0.005	0.009	0.005	0.007	0.005	0.007	0.005	0.014	0.005	0.002	0.097
1.25	0.012	0.012	0.014	0.007	0.012	0.018	0.009	0.007	0.016	0.009	0.007	0.014	0.014	0.005	0.002	0	0.157
1.5	0.023	0.018	0.037	0.032	0.012	0.018	0.018	0.005	0.03	0.016	0.009	0.023	0.016	0.03	0.016	0.023	0.327
2	0.046	0.051	0.064	0.099	0.039	0.032	0.039	0.037	0.048	0.046	0.055	0.069	0.062	0.037	0.067	0.053	0.845
3	0.087	0.26	0.191	0.157	0.074	0.053	0.048	0.113	0.219	0.175	0.11	0.322	0.129	0.099	0.145	0.127	2.309
4	0.085	0.127	0.087	0.03	0.005	0.012	0.009	0.023	0.124	0.131	0.127	0.292	0.099	0.11	0.124	0.09	1.476
5	0.028	0.039	0.014	0	0	0	0	0.002	0.023	0.062	0.046	0.062	0.023	0.032	0.046	0.039	0.417
6	0.002	0.014	0.005	0	0	0	0	0.002	0	0.012	0.018	0.005	0.007	0.012	0.009	0.002	0.087
8	0	0	0	0	0	0	0	0	0	0	0.002	0	0.002	0.007	0.005	0	0.016
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0.3	0.53	0.42	0.33	0.15	0.14	0.14	0.2	0.47	0.46	0.38	0.8	0.36	0.35	0.43	0.34	5.78
Stability Class D																	
Umax	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.45	0.038	0.063	0.082	0.058	0.042	0.034	0.047	0.041	0.047	0.08	0.055	0.041	0.054	0.051	0.042	0.055	0.831
0.75	0.067	0.11	0.143	0.101	0.074	0.06	0.083	0.071	0.083	0.14	0.097	0.071	0.094	0.09	0.074	0.097	1.455
1	0.207	0.226	0.237	0.198	0.152	0.11	0.129	0.12	0.117	0.161	0.122	0.129	0.127	0.12	0.099	0.154	2.408
1.25	0.23	0.216	0.207	0.138	0.122	0.092	0.115	0.163	0.173	0.157	0.163	0.159	0.108	0.122	0.127	0.163	2.456
1.5	0.311	0.279	0.272	0.193	0.122	0.157	0.143	0.182	0.209	0.292	0.274	0.244	0.189	0.175	0.182	0.258	3.481
2	0.693	0.799	0.571	0.405	0.251	0.244	0.304	0.389	0.504	0.661	0.573	0.615	0.329	0.237	0.352	0.456	7.382
3	1.462	1.563	0.882	0.433	0.26	0.209	0.343	0.64	1.091	1.16	1.128	1.186	0.61	0.453	0.829	0.937	13.186
4	0.605	0.734	0.401	0.166	0.023	0.078	0.076	0.189	0.467	0.737	0.757	0.702	0.371	0.465	0.603	0.506	6.881
5	0.163	0.209	0.087	0.018	0.012	0.007	0.005	0.044	0.115	0.421	0.357	0.299	0.15	0.336	0.311	0.134	2.668
6	0.028	0.067	0.021	0.002	0	0.002	0	0.023	0.048	0.182	0.152	0.113	0.055	0.147	0.076	0.023	0.939
8	0.005	0.009	0	0	0	0	0	0.009	0.03	0.06	0.064	0.035	0.018	0.064	0.021	0.012	0.327
10	0	0	0	0	0	0	0	0	0	0	0	0.002	0	0.012	0	0	0.014
13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3.81	4.28	2.9	1.71	1.06	0.99	1.24	1.87	2.89	4.05	3.74	3.6	2.1	2.27	2.71	2.79	42.03

Table A-13 (continue)

Joint Wind Frequency Distribution by Pasquill Stability Classes at SHNP (2010-2014 meteorological data, 12.5 meter level)

Stability Class E																	
Umax	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.45	0.164	0.207	0.302	0.249	0.169	0.103	0.149	0.106	0.169	0.166	0.156	0.156	0.136	0.108	0.116	0.128	2.585
0.75	0.15	0.189	0.276	0.228	0.154	0.094	0.136	0.097	0.154	0.152	0.143	0.143	0.124	0.099	0.106	0.117	2.362
1	0.205	0.239	0.244	0.209	0.145	0.129	0.161	0.184	0.198	0.182	0.182	0.166	0.198	0.161	0.122	0.134	2.859
1.25	0.221	0.258	0.18	0.173	0.136	0.099	0.113	0.154	0.12	0.228	0.154	0.198	0.177	0.124	0.106	0.127	2.567
1.5	0.32	0.304	0.203	0.237	0.136	0.11	0.203	0.182	0.2	0.306	0.256	0.256	0.138	0.124	0.12	0.173	3.266
2	0.472	0.467	0.237	0.163	0.15	0.157	0.168	0.315	0.479	0.559	0.474	0.387	0.239	0.196	0.219	0.279	4.961
3	0.336	0.419	0.244	0.145	0.076	0.076	0.048	0.161	0.472	1.054	0.741	0.35	0.228	0.246	0.232	0.348	5.177
4	0.046	0.053	0.046	0.021	0.007	0.009	0.012	0.009	0.134	0.447	0.193	0.078	0.046	0.081	0.062	0.11	1.354
5	0.005	0.014	0.002	0	0	0.002	0.002	0	0.016	0.081	0.069	0.023	0.021	0.016	0.012	0.007	0.269
6	0.005	0.005	0	0	0	0	0	0	0.005	0.028	0.009	0.012	0	0.002	0.005	0	0.069
8	0.007	0	0	0	0	0	0	0	0	0.007	0.005	0	0	0	0	0.002	0.021
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1.93	2.15	1.73	1.43	0.97	0.78	0.99	1.21	1.95	3.21	2.38	1.77	1.31	1.16	1.1	1.42	25.49
Stability Class F																	
Umax	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.45	0.281	0.286	0.44	0.367	0.168	0.132	0.095	0.127	0.091	0.195	0.227	0.181	0.159	0.095	0.136	0.2	3.179
0.75	0.143	0.145	0.223	0.186	0.085	0.067	0.048	0.064	0.046	0.099	0.115	0.092	0.081	0.048	0.069	0.101	1.614
1	0.173	0.122	0.152	0.152	0.062	0.074	0.058	0.039	0.083	0.076	0.099	0.11	0.074	0.092	0.071	0.11	1.547
1.25	0.11	0.087	0.048	0.101	0.053	0.023	0.046	0.03	0.051	0.081	0.06	0.078	0.064	0.055	0.053	0.081	1.022
1.5	0.154	0.094	0.03	0.048	0.025	0.014	0.039	0.044	0.055	0.069	0.078	0.101	0.058	0.058	0.062	0.058	0.988
2	0.12	0.074	0.039	0.03	0.014	0.009	0.012	0.025	0.051	0.131	0.069	0.074	0.032	0.023	0.025	0.051	0.778
3	0.018	0.021	0.005	0.007	0.005	0	0.005	0.002	0.018	0.037	0.025	0.028	0.012	0.009	0.002	0.007	0.2
4	0	0.002	0	0	0	0	0	0	0	0	0	0.002	0.002	0.005	0	0.005	0.016
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	0.83	0.94	0.89	0.41	0.32	0.3	0.33	0.39	0.69	0.67	0.67	0.48	0.39	0.42	0.61	9.34

Table A-13 (continue)

Joint Wind Frequency Distribution by Pasquill Stability Classes at SHNP (2010-2014 meteorological data, 12.5 meter level)

Stability Class G	Umax	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.45	1.23	1.266	2.698	1.504	0.633	0.191	0.263	0.215	0.239	0.275	0.43	0.478	0.43	0.298	0.37	0.621	11.139	
0.75	0.237	0.244	0.52	0.29	0.122	0.037	0.051	0.041	0.046	0.053	0.083	0.092	0.083	0.058	0.071	0.12	2.148	
1	0.092	0.085	0.136	0.134	0.037	0.037	0.016	0.012	0.028	0.046	0.058	0.041	0.035	0.032	0.035	0.048	0.87	
1.25	0.041	0.039	0.048	0.03	0.009	0.007	0.016	0.007	0.018	0.018	0.044	0.018	0.021	0.009	0.007	0.03	0.364	
1.5	0.044	0.016	0.016	0.009	0.007	0	0.005	0.005	0.009	0.009	0.025	0.016	0.009	0.005	0.007	0.025	0.207	
2	0.048	0.018	0.009	0.002	0.007	0.002	0.005	0.002	0.009	0.007	0.012	0.002	0.005	0	0.005	0.012	0.145	
3	0.002	0.002	0	0.002	0	0	0	0	0.005	0.002	0	0	0	0	0	0	0.014	
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL	1.69	1.67	3.43	1.97	0.81	0.27	0.35	0.28	0.35	0.41	0.65	0.65	0.58	0.4	0.49	0.86	14.89	

TOTAL HOURS CONSIDERED: 43441 hours from January 2010 to December 2014
 WIND MEASURED AT 12.5 METERS

OVERALL WIND DIRECTION FREQUENCY

DIRECTION:	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
FREQUENCY(%):	8.8	9.7	9.7	6.6	3.5	2.6	3.1	4.0	6.3	9.0	8.0	7.8	5.0	4.7	5.3	6.1

WIND SPEED CLASS DETAILS

MAX WIND SPEED (UMAX) (M/S):	.450	.750	1.000	1.250	1.500	2.000	3.000	4.000	5.000	6.000	8.000	10.000	13.900
AVE WIND SPEED (M/S):	.225	.600	.875	1.125	1.375	1.750	2.500	3.500	4.500	5.500	7.000	9.000	11.950
WIND SPEED FREQUENCY %:	17.75	7.63	7.80	6.61	8.36	14.38	21.77	10.49	3.63	1.20	.38	.01	.00

Table A-14
Shearon Harris Plant Site XOQDOQ Model Input Information for Continuous Ground Level Releases

Card Type	Columns	Variable Name	Format	Description	Value used in XOQDOQ
<p>Card Type 1 is an array (KOPT) of options, such that 1 = DO, 0 = BYPASS. These options remain in effect for all release points run. Thus, all release points must have the same assumptions.</p>					
1	1	KOPT(1)	I1	Option to distribute calms as the first wind-speed class (if calms are already distributed by direction in Card Type 6, KOPT(1) = 0, and Card Type 5 is blank). If KOPT(1) = 1, the calm values of Card Type 5 are distributed by direction in the same proportion as the direction frequency of wind-speed class two.	1
1	2	KOPT(2)	I1	Option to input joint frequency distribution data as percent frequency.	0
1	3	KOPT(3)	I1	Option to compute a sector spread for comparison with centerline value in purge calculation (Normally = 1).	0
1	4	KOPT(4)	I1	Option to plot short-term X/Q values versus probability of occurrence (Normally = 0).	0
1	5	KOPT(5)	I1	Option to use cubic spline in lieu of least square function for fitting intermittent release distribution (Normally = 1).	0
1	6	KOPT(6)	I1	Option to punch radial segment X/Q and D/Q values (Normally = 1).	1
1	7	KOPT(7)	I1	Option to punch output of X/Q and D/Q values of the points of interest (Normally = 1).	1
1	8	KOPT(8)	I1	Option to correct X/Q and D/Q values for open terrain recirculation.	1
1	9	KOPT(9)	I1	Option to correct X/Q and D/Q values using site specific terrain recirculation data.	0

Table A-14
Shearon Harris Plant Site XOQDOQ Model Input Information for Continuous Ground Level Releases

Card Type	Columns	Variable Name	Format	Description	Value used in XOQDOQ
1	10	KOPT(10)	I1	Option to use desert sigma curves (Normally = 0)	0
1	11	KOPT(11)	I1	Option to calculate annual X/Q with 30 degree sectors for North, East, South and West and 20 degree sectors for all others. (Normally = 0, and the code will use 22-1/2 degree sectors)	0
2	1 - 80	TITLM	20A4	The main title printed at the beginning of the output.	N/A
3	1 - 5	NVEL	I5	The number of velocity categories (maximum of 14).	13
3	6 - 10	NSTA	I5	The number of stability categories (maximum of 7) (1 always equals Pasquill stability class A, 2 = B, ..., 7 = G).	7
3	11 - 15	NDIS	I5	The number of distances with terrain data for each sector. The number of distances must be the same for each sector (Card Type 10) (maximum of 10).	0
3	16 - 20	INC	I5	The increment in percent for which plotted results are printed out (Normally = 15).	15
3	21 - 25	NPTYPE	I5	The number of titles of receptor types (cow, garden, etc.) (Card Type 13) (maximum of eight)	4
3	26 - 30	NEXIT	I5	The number of release exit points (maximum of five).	1
3	31 - 35	NCOR	I5	The number of distances of site specific correction factors for recirculation (maximum of 10).	0
4	1 - 5	PLEV	F5.0	The height (in meters, above ground level) of the measured wind presented in the joint frequency data (Card Type 7). (For elevated/ground-level mixed release, use the lower level winds).	12.5

Table A-14
Shearon Harris Plant Site XOQDOQ Model Input Information for Continuous Ground Level Releases

Card Type	Columns	Variable Name	Format	Description	Value used in XOQDOQ
4	6 - 20	DECAYS(I) I = 1,3	3F5.0	For each I: The half-life (days) used in the X/Q calculations: if DECAYS > 100, no decay will occur; if DECAYS < 0, depletion factor will be used in the X/Q calculations; if DECAYS = 0, X/Q will not be calculated. (Normally, DECAYS(1) = 101, (2) = 2.26, (3) = -8.00.)	101.00 2.26 -8.00
4	21 - 25	PLGRAD	F5.0	Plant grade elevation (feet above sea level). If PLGRAD = 0.0, DIST and HT data Card Type 10 and 11 must be in meters. If PLGRAD < 0.0, DIST in miles and HT data in feet above plant grade. If PLGRAD > 0.0 above DIST in miles and HT data in feet above sea level.	0
5	1 - 35	CALM(I) I = 1,NSTA	7F5.0	The number of hours, or percent, of calm for each stability category; if KOPT(1) = 0, insert blank card. (Note: I = 1 is stability class A, 2 = B, ..., 7 = G).	Determined by onsite MET Data
6	1 - 80	FREQ(K,I,J) K = 1,16 I = 1,NVEL (if KOPT(1)=0) I = 2,NVEL (if KOPT(1)=1) J = 1,NSTA		The joint frequency distribution in hours (or percent). The values for 16 (K) sectors are read on each card for each combination of wind-speed class (I) and stability class (J). The loop to read these value cycles first on direction continuing in a clockwise fashion), then on wind class and finally on stability class.	JFD
7	1 - 5	UCOR	F5.0	A correction factor applied to wind-speed classes. If UCOR < 0: no corrections will be made. If UCOR > 100: the wind-speed classes will be converted from miles/hour to meters/second.	-1

Table A-14
Shearon Harris Plant Site Input Information for Continuous Ground Level Releases

Card Type	Columns	Variable Name	Format	Description	Value used in XOQDOQ
7	6 - 75	UMAX(I)	14F5.0	The maximum wind speed in each wind-speed class, in either miles/hour or meters/second. (If given in miles/hour, set UCOR > 100.)	See Table A-13 (UMAX)
Card Types 8 and 9 are read in for each correction factor and distance given, I = 1,NCOR					
8	1 - 80	VRDIST(K,I) K = 1,16	16F5.0	The distance in meters at which correction factors are given. These values are read in beginning with south and proceeding in a clockwise direction (maximum of 10).	SKIP
9	1 - 80	VRCD(K,I) K = 1,16	16F5.0	Correction factor to be applied to X/Q and D/Q values corresponds to distances specified in VRDIST.	SKIP
Card Types 8 and 9 are repeated for the remaining distances and correction factors.					
Card Types 10 and 11 are read in for each terrain distance and height given, I = 1,NDIS					
10	1 - 80	DIST(K,I) K = 1,16	16F5.0	The distance in meters at which terrain heights are given. These values are read in beginning with south and proceeding in a clockwise direction (maximum of ten distances).	SKIP
11	1 - 80	HT(K,I) K = 1,16	16F5.0	The terrain heights (in meters, above plant grade level) corresponding to the distances specified in the DIST array (Card Type 10). These values are read in the same order as the DIST array. For a given direction and distance, the terrain height should be the highest elevation between the source and that distance anywhere within the direction sector.	SKIP
Card Types 10 and 11 are repeated for the remaining distances and heights.					

Table A-14
Shearon Harris Plant Site Input Information for Continuous Ground Level Releases

Card Type	Columns	Variable Name	Format	Description	Value used in XOQDOQ
12	1 - 25	NPOINT(I) I = 1,NPTYPE	5I5	The number (maximum of 30) of receptor locations for a particular receptor type (such as the number of cows, gardens, or site boundaries).	16,15,14,14
Card Types 13 and 14 are read in for each receptor type, thus I = 1,NPTYPE					
13	1 - 16	TITLPT(I,J)	4A4	The title (cows, gardens, etc.) of the receptor type for the receptor locations (Card Type 14) (a maximum of 16 spaces).	Site Boundary = 16 Nearest Resident = 15 Garden = 14 Meat Animal = 14
14	1 - 80	KDIR(I,N) PTDIST(I,N) N = 1,NPOINT(I)	8(I5,F5.0)	The receptor direction and distance. KDIR is the direction of interest, such that 1 = South, 2 = SSW....., 16 = SSE, PTDIST is the distance, in meters, to the receptor location.	See Table A-1
Card Types 13 and 14 are repeated for the remaining receptor types (See annual Land Use Census).					
Card Types 15, 16 and 17 are read in for each plant release point, thus I = 1,NEXIT.					
15	1 - 80	TITLE(I,J)	20A4	The title for the release point whose characteristics are described on Card Types 16 and 17.	Turbine Building
16	1 - 5	EXIT(I)	F5.0	The vent average velocity (meters/second). (Note: if a 100% ground-level release is assumed, set EXIT = 0, DIAMTR = 0, and SLEV = 10 meters).	0
16	6 - 10	DIAMTR	F5.0	The vent inside diameter (meters).	0
16	11 - 15	HSTACK(I)	F5.0	The height of the vent release point (meters, plant grade level). If release is 100% elevated, input negative of height.	0.0
16	16 - 20	HBLDG(I)	F5.0	The height of the vent's building (meters, above plant grade level).	55.0

Table A-14

Card Type	Columns	Variable Name	Format	Description	Value used in XOQDOQ
16	21 - 25	CRSEC(I)	F5.0	The minimum cross-sectional area for the vent's building (square meters).	2161.0
16	26 - 30	SLEV(I)	F5.0	The wind height used for the vent elevated release (meters, above plant grade level).	12.5
16	31 - 35	HEATR(I)	F5.0	The vent heat emission rate (cal/sec) (Normally = 0).	0.0
17	1	RLSID(I)	A1	A one letter identification for the release point.	G
17	2 - 5	IPURGE(I)	I4	IPURGE = 1, 2 or 3 if the vent has intermittent releases. The 1, 2, or 3 corresponds to DECAYS(1), DECAYS(2), or DECAYS(3) (Card Type 4), respectively, whichever is used as the base for intermittent release calculations (normally no decay/no deplete X/Q, such that IPURGE(I) = 1; if a vent has no intermittent releases, IPURGE = 0.	0
17	6 - 10	NPURGE(I)	I5	The number of intermittent releases per year for this release point.	0
17	11 - 15	NPRGHR(I)	I5	The average number of hours per intermittent release.	0
Card Types 15, 16, and 17 are repeated for the remaining release points.					
Card Types 1 - 17 may be repeated for the next case.					

B.0 APPENDIX B

DOSE PARAMETERS FOR RADIOIODINES, PARTICULATES, AND TRITIUM

This appendix contains the methodology which was used to calculate the dose parameters for radioiodines, particulates, and tritium to show compliance with ODCM Operational Requirement 3.11.2.1.b and Appendix I of 10CFR50 for gaseous effluents. These dose parameters, P_i and R_i , were calculated using the methodology outlined in NUREG 0133 along with Regulatory Guide 1.109, Revision 1. The following sections provide the specific methodology which was utilized in calculating the P_i and R_i values for the various exposure pathways (Tables 3.2-4 and 3.3-1 through 3.3-19, respectively).

B.1 Calculation of P_i

The dose parameter, P_i , contained in the radioiodine and particulates portion of Section 3.2 includes only the inhalation pathway transport parameter of the "i" radionuclide, the receptor's usage of the pathway media, and the dosimetry of the exposure. Inhalation rates and the internal dosimetry are functions of the receptor's age; however, under the exposure conditions for ODCM Operational Requirement 3.11.2.1b, the child is considered to receive the highest dose. The following sections provide in detail the methodology which was used in calculating the P_i values for inclusion into this ODCM.

The age group considered is the child because the bases for the ODCM Operational Requirement 3.11.2.1.b is to restrict the dose to the child's thyroid via inhalation to ≤ 1500 mrem/yr. The child's breathing rate is taken as 3700 m^3/yr from Table E-5 of Regulatory Guide 1.109, Revision 1. The inhalation dose factors for the child, DFA_i , are presented in Table E-9 of Regulatory Guide 1.109 in units of mrem/pCi.

The dose factor from the inhalation pathway is calculated by

$$P_{ii} = K'(BR) DFA_i \tag{B.1-1}$$

where:

P_{ii} = Dose factor for radionuclide "i" for the inhalation pathway, mrem/yr per $\mu Ci/m^3$, per organ of interest

K' = A constant of unit conversion;
 = 10^6 pCi/ μCi ;

BR = The breathing rate of the children's age group, m^3/yr ;

DFA_i = The organ inhalation dose factor for the children's age group for radionuclide "i," mrem/pCi.

The incorporation of breathing rate of a child (3700 m^3/yr) and the unit conversion factor results in the following equation:

$$P_{ii} = 3.7 E+09 DFA_i \tag{B.1-2}$$

B.2 Calculation of R_i

The basis for ODCM Operational Requirement 3.11.2.3 states that conformance with the guidance in Appendix I should be shown by calculational procedures based on models and data such that the actual exposure of a member of the public through appropriate pathways is unlikely to be substantially underestimated. Underestimation of the dose can be avoided by assigning a theoretical individual to the exclusion boundary in the sector with the highest X/Q and D/Q values and employing all of the likely exposure pathways, e.g., inhalation, cow milk, meat, vegetation, and ground plane. R_i values have been calculated for the adult, teen, child, and infant age groups for the inhalation, ground plane, cow milk, goat milk, vegetable, and beef ingestion pathways. The methodology which was utilized to calculate these values is presented below.

B.2.1 Inhalation Pathway

The dose factor from the inhalation pathway is calculated by:

$$R_{iI} = K' (BR)_a (DFA_i)_a \quad (B.2-1)$$

where:

R_{iI} = Dose factor for each identified radionuclide "i" of the organ of interest, mrem/yr per μCi/m³;

K' = A constant of unit conversion;

= 10⁶ pCi/μCi;

(BR)_a = Breathing rate of the receptor of age group "a," m³/yr;

(DFA_i)_a = Organ inhalation dose factor for radionuclide "i" for the receptor of age group "a", mrem/pCi.

The breathing rates (BR)_a for the various age groups are tabulated below, as given in Table E-5 of Regulatory Guide 1.109, Revision 1.

<u>Age Group (a)</u>	<u>Breathing Rate (m³/yr)</u>
Infant	1400
Child	3700
Teen	8000
Adult	8000

Inhalation dose factors (DFA_i)_a for the various age groups are given in Tables E-7 through E-10 of Regulatory Guide 1.109, Revision 1.

B.2.2 Ground Plane Pathway

The ground plane pathway dose factor is calculated by:

$$R_{iG} = I_i K' K'' (SF) DFG_i (1 - e^{-\lambda_i t}) / \lambda_i \quad (B.2-2)$$

where:

- R_{iG} = Dose factor for the ground plane pathway for each identified radionuclide "i" for the organ of interest, mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 ;
- K' = A constant of unit conversion;
 = 10^6 pCi/ μCi ;
- K'' = A constant of unit conversion;
 = 8760 hr/year;
- SF = The shielding factor (dimensionless);
 (A shielding factor of 0.7 is suggested in Table E-15 of Regulatory Guide 1.109, Revision 1.)
- DFG_i = The ground plane dose conversion factor for radionuclide "i," mrem/hr per pCi/ m^2 ;
 (A tabulation of DFG_i values is presented in Table E-6 of Regulatory Guide 1.109, Revision 1.)
- λ_i = The radiological decay constant for radionuclide "i," sec^{-1} ;
- t = The exposure time, sec;
 = $4.73 \text{ E}+08$ sec (15 years);
- I_i = Factor to account for fractional deposition of radionuclide "i."

For radionuclides other than iodine, the factor I_i is equal to one. For radioiodines, the value of I_i may vary. However, a value of 1.0 was used in calculating the R values in Table 3.3-2. (Reference NUREG 0133)

B.2.3 Grass Cow or Goat Milk Pathway

The dose factor for the cow milk or goat milk pathway for each radionuclide for each organ is calculated by:

$$R_{iM} = I_i K' Q_F U_{ap} F_m (DFL_i)_a e^{-\lambda_i t_f} \left(\frac{r(1 - e^{-\lambda_{E_i} t_e})}{Y_p \lambda_{E_i}} + \frac{B_{iv} (1 - e^{-\lambda_i t_b})}{P \lambda_i} \right) + \frac{B_{iv} (1 - e^{-\lambda_i t_b})}{P \lambda_i} + (1 - \frac{f_f}{p_s}) \left(\frac{r(1 - e^{-\lambda_{E_i} t_e})}{Y_s \lambda_{E_i}} + \frac{B_{iv} (1 - e^{-\lambda_i t_b})}{P \lambda_i} \right) e^{-\lambda_i t_h}$$

(B.2-3)

where:

- R_{iM} = Dose factor for the cow milk or goat milk pathway, for each identified radionuclide "i" for the organ of interest, mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^{-2} ;
- K' = A constant of unit conversion;
= 10^6 pCi/ μCi ;
- Q_F = The cow's or goat's feed consumption rate, kg/day (wet weight);
- U_{ap} = The receptor's milk consumption rate for age group "a," liters/yr;
- Y_p = The agricultural productivity by unit area of pasture feed grass, kg/ m^2 ;
- Y_s = The agricultural productivity by unit area of stored feed, kg/ m^2 ;
- F_m = The stable element transfer coefficients, pCi/liter per pCi/day;
- r = Fraction of deposited activity retained on cow's feed grass;
- $(DFL_i)_a$ = The organ ingestion dose for radionuclide "i" for the receptor in age group "a," mrem/pCi;

B.2.3 Grass Cow or Goat Milk Pathway (continued)

- λ_{E_T} = $\lambda_i + \lambda_w$;
- λ_i = The radiological decay constant for radionuclide "i," sec⁻¹;
- λ_w = The decay constant for removal of activity on leaf and plant surfaces by weathering, sec⁻¹;
- = 5.73 E-07 sec⁻¹ (14 day half-life);
- t_e = Period of pasture grass and crop exposure during the growing season, sec;
- t_f = The transport time from feed, to cow or goat, to milk, to receptor, sec;
- t_h = The transport time from pasture, to cow or goat, to milk to receptor, sec;
- t_b = Period of time that sediment is exposed to gaseous effluents, sec;
- B_{iv} = Concentration factor for uptake of radionuclide "i" from the soil by the edible parts of crops, pCi/Kg (wet weight) per pCi/Kg (dry soil)
- P = Effective surface density for soil, Kg (dry soil)/m²;
- f_p = Fraction of the year that the cow or goat is on pasture; (dimensionless).
- f_s = Fraction of the cow feed that is pasture grass while the cow is on pasture; (dimensionless).
- t_e = Period of pasture grass and crop exposure during the growing season, sec;
- I_i = Factor to account for fractional deposition of radionuclide "i."

For radionuclides other than iodine, the factor I_i is equal to one. For radioiodines, the value of I_i may vary. However, a value of 1.0 was used in calculating the R values in Tables 3.3-8 through 3.3-15. (Reference NUREG 0133)

Milk cattle and goats are considered to be fed from two potential sources, pasture grass and stored feeds. Following the development in Regulatory Guide 1.109, Revision 1, the value of f_s was considered unity in lieu of site-specific information. The value of f_p was 0.667 based upon an 8-month grazing period.

Table B-1 contains the appropriate parameter values and their source in Regulatory Guide 1.109, Revision

B.2.3 Grass Cow or Goat Milk Pathway (continued)

The concentration of tritium in milk is based on the airborne concentration rather than the deposition. Therefore, the R_i is based on X/Q :

$$R_{T_M} = K'' F_m Q F U_{ap} (DFL_i)_a 0.75 (0.5/H) \quad (B.2-4)$$

where:

R_{T_M} = Dose factor for the cow or goat milk pathway for tritium for the organ of interest, mrem/yr per $\mu\text{Ci}/\text{m}^3$;

K'' = A constant of unit conversion;
 = $10^3 \text{ gm}/\text{kg}$;

H = Absolute humidity of the atmosphere, gm/m^3 ; A value of $H = 8 \text{ grams}/\text{meter}^3$, was used in lieu of site-specific information.

0.75 = The fraction of total feed that is water;

0.5 = The ratio of the specific activity of the feed grass water to the atmospheric water.

and other parameters and values as previously defined.

B.2.4 Grass-Cow-Meat Pathway

The integrated concentration in meat follows in a similar manner to the development for the milk pathway; therefore:

$$R_{iB} = I_i K' Q_F U_{ap} F_f (DFL_i)_a e^{-\lambda_i t_s} (f_{ps} \left(\frac{r(1 - e^{-\lambda_{E_i} t_e})}{Y_p \lambda_{E_i}} \right) + \frac{B_{iv} (1 - e^{-\lambda_i t_b})}{P \lambda_i}) + (1 - \frac{f_{ps}}{P}) \left(\frac{r(1 - e^{-\lambda_{E_i} t_e})}{Y_s \lambda_{E_i}} + \frac{B_{iv} (1 - e^{-\lambda_i t_b})}{P \lambda_i} \right) e^{-\lambda_i t_h} \quad (B.2.5)$$

where:

- R_{iB} = Dose factor for the meat ingestion pathway for radionuclide "i" for any organ of interest, mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^{-2} ;
- F_f = The stable element transfer coefficients, pCi/Kg per pCi/day;
- U_{ap} = The receptor's meat consumption rate for age group "a," kg/yr;
- t_s = Transport time from slaughter to consumption, sec;
- t_h = Transport time from harvest to animal consumption, sec;
- t_e = Period of pasture grass and crop exposure during the growing season, sec;
- I_i = Factor to account for fractional deposition of radionuclide "i."

For radionuclides other than iodine, I_i is equal to one. For radioiodines, the value of I_i may vary. However, a value of 1.0 was used in calculating the R values in Tables 3.3-5 through 3.3-7.

All other terms remain the same as defined in Equation B.2-3. Table B-2 contains the values which were used in calculating R_i for the meat pathway.

The concentration of tritium in meat is based on its airborne concentration rather than the deposition. Therefore, the R_i is based on X/Q.

$$R_{TB} = K' K'' F_f Q_F U_{ap} (DFL_i)_a 0.75 (0.5/H) \quad (B.2-6)$$

where:

- R_{TB} = Dose factor for the meat ingestion pathway for tritium for any organ of interest, mrem/yr per $\mu\text{Ci}/\text{m}^3$.

All other terms are defined in Equations B.2-4 and B.2-5.

B.2.5 Vegetation Pathway

The integrated concentration in vegetation consumed by man follows the expression developed in the derivation of the milk factor. Man is considered to consume two types of vegetation (fresh and stored) that differ only in the time period between harvest and consumption; therefore:

$$R_{iv} = I_i K' (DFL_i)_a \left(U_{af}^L e^{-\lambda_i t_L} \left(\frac{r(1 - e^{-\lambda_{E_i} t_e})}{Y_v \lambda_{E_i}} + \frac{B_{iv} (1 - e^{-\lambda_i t_b})}{P \lambda_i} \right) + U_{ag}^S e^{-\lambda_i t_h} \left(\frac{r(1 - e^{-\lambda_{E_i} t_e})}{Y_v \lambda_{E_i}} + \frac{B_{iv} (1 - e^{-\lambda_i t_b})}{P \lambda_i} \right) \right) \quad (B.2-7)$$

where:

- R_{iv} = Dose factor for vegetable pathway for radionuclide "i" for the organ of interest, mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^2 ;
- K' = A constant of unit conversion;
 = $10^6 \text{pCi}/\mu\text{Ci}$;
- U_a^L = The consumption rate of fresh leafy vegetation by the receptor in age group "a," kg/yr;
- U_a^S = The consumption rate of stored vegetation by the receptor in age group "a," kg/yr;
- f_L = The fraction of the annual intake of fresh leafy vegetation grown locally;
 = 1.0
- f_g = The fraction of annual intake of stored vegetation grown locally;
 = 0.76
- t_L = The average time between harvest of leafy vegetation and its consumption, sec;
- t_h = The average time between harvest of stored vegetation and its consumption, sec;
- Y_v = The vegetation a real density, kg/m^2 ;
- t_e = Period of leafy vegetable exposure during growing season, sec;
- I_i = Factor to account for fractional deposition of radionuclide "i."

All other factors as previously defined.

B.2.5 Vegetation Pathway (continued)

For radionuclides other than iodine, the factor I_i is equal to one. For radioiodines, the value of I_i may vary. However, a value of 1.0 was used in Tables 3.3-2 through 3.3-4.

Table B-3 presents the appropriate parameter values and their source in Regulatory Guide 1.109, Revision 1.

In lieu of site-specific data default values for f_L and f_g , 1.0 and 0.76, respectively, were used in the calculations on R_i . These values were obtained from Table E-15 of Regulatory Guide 1.109, Revision 1.

The concentration of tritium in vegetation is based on the airborne concentration rather than the deposition. Therefore, the R_i is based on X/Q :

$$R_{T_V} = K'K'' \left[U_{aL}^{L} + U_{aG}^{S} \right] (DF_{I_i})_a \left[0.75 (0.5 / H) \right] \quad (B.2.8)$$

where:

R_{T_V} = Dose factor for the vegetable pathway for tritium for any organ of interest, mrem/yr per $\mu\text{Ci}/\text{m}^3$.

All other terms remain the same as those in Equations B.2-4 and B.2-7.

TABLE B-1
 Parameters For Cow and Goat Milk Pathways

Parameter	Value	Reference (Reg. Guide 1.109, Rev. 1)
Q_F (kg/day)	50 (cow) 6 (goat)	Table E-3 Table E-3
Y_p (kg/M ²)	0.7	Table E-15
t_f (seconds)	1.73 E+05 (2 days)	Table E-15
r	1.0 (radioiodines) 0.2 (particulates)	Table E-15 Table E-15
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	Table E-11 to E-14
F_m (pCi/liter per pCi/day)	Each stable element	Table E-1 (cow) Table E-2 (goat)
T_b (seconds)	4.75 E+08 (15 yr)	Table E-15
Y_s (kr/m ²)	2.0	Table E-15
t_h (seconds)	7.78 E+06 (90 days)	Table E-15
U_{ap} (liters/yr)	330 infant 330 child 400 teen 310 adult	Table E-5 Table E-5 Table E-5 Table E-5
t_e (seconds)	2.59 E+06 (pasture) 5.18 E+06 (stored feed)	Table E-15
B_{iv} (pCi/kg [wet weight] per pCi/kg [dry soil])	Each stable element	Table E-1
P (kg dry soil/m ²)	240	Table E-15

TABLE B-2

Parameters For The Meat Pathway

Parameter	Value	Reference (Reg. Guide 1.109, Rev. 1)
r	1.0 (radioiodines) 0.2 (particulates)	Table E-15 Table E-15
F_f (pCi/ke per (pCi/Day)	Each stable element	Table E-1
U_{ap} (kg/yr)	0 infant 41 child 65 teen 110 adult	Table E-5 Table E-5 Table E-5 Table E-5
$(DFL_a)_{I_a}$ (mrem/pCi)	Each radionuclide	Tables E-11 to E-14
Y_p (kg/m ²)	0.7	Table E-15
Y_s (kr/m ²)	2.0	Table E-15
T_b (seconds)	4.73 E+08 (15 yr)	Table E-15
T_s (seconds)	1.73 E+06 (20 days)	Table E-15
t_h (seconds)	7.78 E+06 (90 days)	Table E-15
t_e (seconds)	2.59 E+06 (pasture) 5.18 E+06 (stored feed)	Table E-15
Q_F (kg/day)	50	Table E-3
B_{IV} (pCi/kg [wet weight] per pCi/kg [dry soil])	Each stable element	Table E-1
P (kg dry soil/m ²)	240	Table E-15

TABLE B-3

Parameters for The Vegetable Pathway

Parameter	Value	Reference (Reg. Guide 1.109, Rev. 1)
r (dimensionless)	1.0 (radioiodines) 0.2 (particulates)	Table E-1 Table E-1
$(DFL)_{I_a}$ (mrem/pCi)	Each radionuclide	Tables E-11 to E-14
Q_F (kg/day)	50 (cow) 6 (goat)	Table E-3 Table E-3
U_a^L (kg/yr) - Infant - Child - Teen - Adult	0 26 42 64	Table E-5 Table E-5 Table E-5 Table E-5
U_a^S (kr/hr) - Infant - Child - Teen - Adult	0 520 630 520	Table E-5 Table E-5 Table E-5 Table E-5
T_L (seconds)	8.6 E+04 (1 day)	Table E-15
t_h (seconds)	5.18 E+06 (60 day)	Table E-15
Y_v (kg/m ²)	2.0	Table E-15
t_e (seconds)	5.18 E+06 (60 day)	Table E-15
t_b (seconds)	4.73 E+08 (15 yr)	Table E-15
P (kg dry soil/m ²)	240	Table E-15
B_{IV} (pCi/kg [wet weight] per pCi/kg [dry soil])	Each stable element	Table E-1

C.0 APPENDIX C

RADIOACTIVE LIQUID AND GASEOUS EFFLUENT
 MONITORING INSTRUMENTATION NUMBERS

	<u>Monitor Identification</u>
<u>I. Liquid Effluent Monitoring Instruments</u>	
A. Treated Laundry and Hot Shower Tank.....	REM-1WL-3540
B. Waste Monitor Tank	REM-21WL-3541
C. Waste Evaporator Condensate Tank.....	REM-21WL-3541
D. Secondary Waste Sample Tank	REM-21WS-3542
E. NSW Returns to Circulating Water System from Waste Processing Building	REM-1SW-3500A
from Reactor Auxiliary Building	REM-1SW-3500B
F. Outdoor Tank Area Drain Transfer Pump Monitor.....	REM-1MD-3530
G. Turbine Building Floor Drains Effluent.....	REM-1MD-3528
<u>II. Gaseous Effluent Monitoring Instruments</u>	
A. Plant Vent Stack 1	* RM-21AV-3509-1SA
B. Turbine Building Vent Stack 3A.....	* RM-1TV-3536-1
C. Waste Processing Building Vent Stack 5	REM-1WV-3546
.....	* RM-1WV-3546-1
D. Waste Processing Building Vent Stack 5A	* RM-1WV-3547-1

* Wide-Range Gas Monitor (WRGM)

D.0 APPENDIX D

PROGRAMMATIC CONTROLS

The surveillance and operational requirements pertaining to the ODCM Operational Requirements are detailed in Sections:

- D.1 - Instrumentation
- D.2 - Radioactive Effluents
- D.3 - Radiological Environmental Monitoring

D.1 INSTRUMENTATION

3/4.3.3 MONITORING INSTRUMENTATION

3/4.3.3.10 Radioactive Liquid Effluent Monitoring Instrumentation

OPERATIONAL REQUIREMENT

3.3.3.10 The radioactive liquid effluent monitoring instrumentation channels shown in Table 3.3-12 shall be OPERABLE with their Alarm/Trip Setpoints set to ensure that the limits of Operational Requirement 3.11.1.1 are not exceeded. The Alarm/Trip Setpoints of these channels shall be determined and adjusted in accordance with the methodology and parameters in the OFFSITE DOSE CALCULATION MANUAL (ODCM).

APPLICABILITY: At all times.

ACTION:

- a. With a radioactive liquid effluent monitoring instrumentation channel Alarm/Trip Setpoint less conservative than required by the above Operational Requirement, immediately (1) suspend the release of radioactive liquid effluents monitored by the affected channel or (2) declare the channel inoperable and take ACTION as directed by b. below.
- b. With less than the minimum number of radioactive liquid effluent monitoring instrumentation channels OPERABLE, take the ACTION shown in Table 3.3-12. Exert best effort to restore to the minimum number of radioactive liquid effluent channels within 30 days and, if unsuccessful, explain in the next Annual Radioactive Effluent Release Report pursuant to ODCM, Appendix F, Section F.2 why this inoperability was not corrected in a timely manner.

SURVEILLANCE REQUIREMENTS

4.3.3.10 Each radioactive liquid effluent monitoring instrumentation channel shall be demonstrated OPERABLE by performance of the CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION, and DIGITAL CHANNEL OPERATIONAL TEST at the frequencies shown in Table 4.3-8.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

TABLE 3.3-12

RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

INSTRUMENT		MINIMUM CHANNELS OPERABLE	ACTION
1.	Radioactivity Monitors Providing Alarm and Automatic Termination of Release		
a.	Liquid Radwaste Effluent Lines		
1)	Treated Laundry and Hot Shower Tanks Discharge Monitor	1	35
2)	Waste Monitor Tanks and Waste Evaporator Condensate Tanks Discharge Monitor	1	35
3)	Secondary Waste Sample Tank Discharge Monitor	1	35, 36*
b.	Turbine Building Floor Drains Effluent Line	1	36
2.	Radioactivity Monitor Providing Alarm and Automatic Stop Signal to Discharge Pump		
a.	Outdoor Tank Area Drain Transfer Pump Monitor	1	37
3.	Radioactivity Monitors Providing Alarm But Not Providing Automatic Termination of Release		
a.	Normal Service Water System Return From Waste Processing Building to the Circulating Water System	1	39
b.	Normal Service Water System Return From the Reactor Auxiliary Building to the Circulating Water System	1	39
4.	Flow Rate Measurement Devices		
a.	Liquid Radwaste Effluent Lines		
1)	Treated Laundry and Hot Shower Tanks Discharge	1	38
2)	Waste Monitor Tanks and Waste Evaporator Condensate Tanks Discharge	1	38
3)	Secondary Waste Sample Tank	1	38
b.	Cooling Tower Blowdown	1	38

* When the Secondary Waste System is in the continuous release mode and releases are occurring, Action 36 shall be taken when the monitor is inoperable. In the batch release mode, Action 35 is applicable.

TABLE 3.3-12 (Continued)

ACTION STATEMENTS

- ACTION 35 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue provided that prior to initiating a release:
- a. At least two independent samples are analyzed in accordance with Operational Requirement 4.11.1.1.1, and
 - b. At least two technically qualified members of the facility staff independently verify the release rate calculations and discharge line valving.
- Otherwise, suspend release of radioactive effluents via this pathway.
- ACTION 36 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue provided grab samples are analyzed for radioactivity at a lower limit of detection of no more than $1E-07$ $\mu\text{Ci/ml}$:
- a. At least once per 12 hours when the specific activity of the secondary coolant is greater than 0.01 $\mu\text{Ci/gram DOSE EQUIVALENT I-131}$ or,
 - b. At least once per 24 hours when the specific activity of the secondary coolant is less than or equal to 0.01 $\mu\text{Ci/gram DOSE EQUIVALENT I-131}$.
- ACTION 37 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue provided that, at least once per 12 hours, grab samples are collected and analyzed for radioactivity at a lower limit of detection of no more than $1E-07$ $\mu\text{Ci/ml}$.
- ACTION 38 - With the number of channels OPERABLE 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 during actual releases. Pump performance curves generated in place may be used to estimate flow.
- ACTION 39 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue provided the weekly Cooling Tower Blowdown weir surveillance is performed as required by Operational Requirement 4.11.1.1.1. Otherwise, follow the ACTION specified in ACTION 37 above.

TABLE 4.3-8

RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION
SURVEILLANCE REQUIREMENTS*

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	DIGITAL CHANNEL OPERATIONAL TEST
1. Radioactivity Monitors Providing Alarm and Automatic Termination of Release				
a. Liquid Radwaste Effluent Lines				
1) Treated Laundry and Hot Shower Tanks Discharge Monitor	D	P	R(3)	Q(1)
2) Waste Monitor Tanks and Waste Evaporator Condensate Tanks Discharge Monitor	D	P	R(3)	Q(1)
3) Secondary Waste Sample Tank Discharge Monitor	D	P, M(5)	R(3)	Q(1)
b. Turbine Building Floor Drains Effluent Line	D	M	R(3)	Q(1)
2. Radioactivity Monitor Providing Alarm and Automatic Stop Signal to Discharge Pump				
a. Outdoor Tank Area Drain Transfer Pump Monitor	D	M	R(3)	Q(1)
3. Radioactivity Monitors Providing Alarm But Not Providing Automatic Termination of Release				
a. Normal Service Water System Return From Waste Processing Building to the Circulating Water System	D	M	R(3)	Q(2)
b. Normal Service Water System Return From the Reactor Auxiliary Building to the Circulating Water System	D	M	R(3)	Q(2)
4. Flow Rate Measurement Devices				
a. Liquid Radwaste Effluent Lines				
1) Treated Laundry and Hot Shower Tanks Discharge	D(4)	N.A.	R	N.A.
2) Waste Monitor Tanks and Waste Evaporator Condensate Tanks Discharge	D(4)	N.A.	R	N.A.
3) Secondary Waste Sample Tank Pump Monitor	D(4)	N.A.	R	N.A.
b. Cooling Tower Blowdown	D(4)	N.A.	R	N.A.

* See Table G-1 for explanation of frequency notation

TABLE 4.3-8 (Continued)

TABLE NOTATIONS

- (1) The DIGITAL CHANNEL OPERATIONAL TEST shall also demonstrate automatic isolation of this pathway (or, for the Outdoor Tank Area Drains Monitor, automatic stop signal to the discharge pump) and control room alarm annunciation* occur if any of the following conditions exists (liquid activity channel only):
 - a. Instrument indicates measured levels above the Alarm/Trip Setpoint,
 - b. Circuit failure (monitor loss of communications (alarm only), detector loss of counts (Alarm only) and monitor loss of power),
 - c. Detector check source test failure (alarm only),
 - d. Detector channel out of service (alarm only),
 - e. Monitor loss of sample flow (alarm only). (Not applicable for Turbine Building Drain Rad Monitor)
- (2) The DIGITAL CHANNEL OPERATIONAL TEST shall also demonstrate that control room alarm annunciation* occurs if any of the following conditions exists (liquid activity channel only):
 - a. Instrument indicates measured levels above the Alarm Setpoint,
 - b. Circuit failure (monitor loss of communications, detector loss of counts, and monitor loss of power),
 - c. Detector check source test failure,
 - d. Detector channel out of service,
 - e. Monitor loss of sample flow.
- (3) The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Bureau of Standards (NBS) or using standards that have been obtained from suppliers that participate in measurement assurance activities with NBS. These standards shall permit calibrating the system over its intended range of energy and measurement range. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used.
- (4) CHANNEL CHECK shall consist of verifying indication of flow during periods of release. CHANNEL CHECK shall be made at least once per 24 hours on days on which continuous, periodic, or batch releases are made.
- (5) When the Secondary Waste System is being used in the batch release mode, the source check shall be prior to release. When the system is being used in the continuous release mode, the source check shall be monthly.

*Control Room Alarm Annunciation shall consist of a change in state of the tested channel on the RM-11 terminal (i.e., a change in color) or a highlighted message on the DICSP Workstation Channel.

3/4.3.3 MONITORING INSTRUMENTATION

3/4.3.3.11 Radioactive Gaseous Effluent Monitoring Instrumentation

OPERATIONAL REQUIREMENT

3.3.3.11 The radioactive gaseous effluent monitoring instrumentation channels shown in Table 3.3-13 shall be OPERABLE with their Alarm/Trip Setpoints set to ensure that the limits of Operational Requirements 3.11.2.1 are not exceeded. The Alarm/Trip Setpoints of these channels meeting Operational Requirement 3.11.2.1 shall be determined and adjusted in accordance with the methodology and parameters in the ODCM.

APPLICABILITY: As shown in Table 3.3-13

ACTION:

- a. With a radioactive gaseous effluent monitoring instrumentation channel Alarm/Trip Setpoint less conservative than required by the above Operational Requirement, immediately (1) suspend the release of radioactive gaseous effluents monitored by the affected channel or (2) declare the channel inoperable and take ACTION as directed by b. below.
- b. With the number of OPERABLE radioactive gaseous effluent monitoring instrumentation channels less than the Minimum Channels OPERABLE, take the ACTION shown in Table 3.3-13. Exert best efforts to return the instrument to OPERABLE status within 30 days. If unsuccessful, explain in the next Annual Radioactive Effluent Release Report pursuant to ODCM, Appendix F, Section F.2 why this inoperability was not corrected in a timely manner.

SURVEILLANCE REQUIREMENTS

4.3.3.11 Each radioactive gaseous effluent monitoring instrumentation channel shall be demonstrated OPERABLE by performance of the CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION and a DIGITAL CHANNEL OPERATIONAL TEST or an ANALOG CHANNEL OPERATIONAL TEST at the frequencies shown in Table 4.3-9.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

TABLE 3.3-13
RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

INSTRUMENT	MIN. CHANNELS OPERABLE	APPLICABILITY	ACTION
1. GASEOUS WASTE PROCESSING SYSTEM - HYDROGEN AND OXYGEN ANALYZERS			
Specification is not used in ODCM			
2. TURBINE BUILDING VENT STACK			
a. Noble Gas Activity Monitor	1	*	47
b. Iodine Sampler	1	*	49
c. Particulate Sampler	1	*	49
d. Flow Rate Monitor	1	*	46
e. Sampler Flow Rate Monitor	1	*	46
3. PLANT VENT STACK			
a. Noble Gas Activity Monitor	1	*	47
b. Iodine Sampler	1	*	49
c. Particulate Sampler	1	*	49
d. Flow Rate Monitor	1	*	46
e. Sampler Flow Rate Monitor	1	*	46
4. WASTE PROCESSING BUILDING VENT STACK 5			
a.1 Noble Gas Activity Monitor (PIG)	1	*	45, 51
a.2 Noble Gas Activity Monitor (WRGM)	1	MODES 1, 2, 3	52
b. Iodine Sampler	1	*	49
c. Particulate Sampler	1	*	49
d. Flow Rate Monitor	1	*	46
e. Sampler Flow Rate Monitor	1	*	46
5. WASTE PROCESSING BUILDING STACK 5A			
a. Noble Gas Activity Monitor	1	*	47
b. Iodine Sampler	1	*	49
c. Particulate Sampler	1	*	49
d. Flow Rate Monitor	1	*	46
e. Sampler Flow Rate Monitor	1	*	46

TABLE NOTATIONS

* At all times.

TABLE 3.3-13 (Continued)

ACTION STATEMENTS

- ACTION 45 - With the number channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, the contents of the waste gas decay tank(s) may be released to the environment provided that prior to initiating the release:
- a. At least two independent samples of the tank's contents are analyzed, and
 - b. At least two technically qualified members of the facility staff independently verify the release rate calculations and discharge valve lineup.
- Otherwise, suspend release of radioactive effluents via this pathway.
- ACTION 46 - With the number of channels OPERABLE 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 47 - With the number of channels OPERABLE 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 radioactivity within 24 hours.
- ACTION 48 - Not Used in the ODCM.
- ACTION 49 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via the affected pathway may continue provided samples are continuously collected with auxiliary sampling equipment as required in Table 4.11-2.
- ACTION 50 - Not used in the ODCM.
- ACTION 51 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement for both the PIG and WRGM, effluent releases via this pathway may continue provided grab samples are taken at least once per 12 hours and these samples are analyzed for radioactivity within 24 hours.
- ACTION 52 - With the number of OPERABLE accident monitoring instrumentation channels for the radiation monitor(s) less than the Minimum Channels OPERABLE requirements of Technical Specification Table 3.3-10, initiate the preplanned alternate method of monitoring the appropriate parameter(s) within 72 hours, and either restore the inoperable channel(s) to OPERABLE status within 14 days or prepare and submit a Special Report to the Commission, pursuant to Technical Specification 6.9.2, within the next 14 days that provides actions taken, cause of the inoperability, and the plans and schedule for restoring the channel(s) to OPERABLE status.

TABLE 4.3-9

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION
SURVEILLANCE REQUIREMENTS**

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	DIGITAL CHANNEL OPERATIONAL TEST	MODES FOR WHICH SURVEILLANCE IS REQUIRED
1. GASEOUS WASTE PROCESSING SYSTEM - HYDROGEN AND OXYGEN ANALYZERS					
Not Used in the ODCM.					
2. TURBINE BUILDING VENT STACK					
a. Noble Gas Activity	D	M	R(3)	Q(2)	*
b. Iodine Sampler	N.A.	N.A.	N.A.	N.A.	*
c. Particulate Sampler	N.A.	N.A.	N.A.	N.A.	*
d. Flow Rate Monitor	D	N.A.	R	Q	*
e. Sampler Flow Rate Monitor	D	N.A.	R	Q	*
3. PLANT VENT STACK					
a. Noble Gas Activity Monitor	D	M	R(3)	Q(2)	*
b. Iodine Sampler	N.A.	N.A.	N.A.	N.A.	*
c. Particulate Sampler	N.A.	N.A.	N.A.	N.A.	*
d. Flow Rate Monitor	D	N.A.	R	Q	*
e. Sampler Flow Rate Monitor	D	N.A.	R	Q	*
4. WASTE PROCESSING BUILDING VENT STACK 5					
a.1 Noble Gas Activity Monitor (PIG)	D	M	R(3)	Q(1)	*
a.2 Noble Gas Activity Monitor (WRGM)	D	M	R(3)	Q(2)	*
b. Iodine Sampler	N.A.	N.A.	N.A.	N.A.	*
c. Particulate Sampler	N.A.	N.A.	N.A.	N.A.	*
d. Flow Rate Monitor	D	N.A.	R	Q	*
e. Sampler Flow Rate Monitor	D	N.A.	R	Q	*
5. WASTE PROCESSING BUILDING VENT STACK 5A					
a. Noble Gas Activity Monitor	D	M	R(3)	Q(2)	*
b. Iodine Sampler	N.A.	N.A.	N.A.	N.A.	*
c. Particulate Sampler	N.A.	N.A.	N.A.	N.A.	*
d. Flow Rate Monitor	D	N.A.	R	Q	*
e. Sampler Flow Rate Monitor	D	N.A.	R	Q	*

* At all times.

** See Table G-1 for explanation of frequency notation

ABLE 4.3-9 (Continued)

TABLE NOTATIONS

- (1) The DIGITAL CHANNEL OPERATIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room annunciation* occur if any of the following conditions exists (gas activity and gas effluent channels only):
 - a. Instrument indicates measured levels above the Alarm/Trip Setpoint,
 - b. Circuit failure (monitor loss of communications - (alarm only), detector loss of counts (alarm only) and monitor loss of power),
 - c. Detector check source test failure (gas activity channel only), (alarm only),
 - d. Detector channel out of service (alarm only),
 - e. Monitor loss of sample flow (alarm only).
- (2) The DIGITAL CHANNEL OPERATIONAL TEST shall also demonstrate that control room alarm annunciation* occurs if any of the following conditions exists (gas activity and gas effluent channels only):
 - a. Instrument indicates measured levels above the Alarm Setpoint,
 - b. Circuit failure (monitor loss of communications (alarm only), detector loss of counts, and monitor loss of power),
 - c. Detector check source test failure (gas activity channel only),
 - d. Detector channel out of service,
 - e. Monitor loss of sample flow.
- (3) The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Bureau of Standards (NBS) or using standards that have been obtained from suppliers that participate in measurement assurance activities with NBS. These standards shall permit calibrating the system over its intended range of energy and measurement range. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used.
- (4) Not used in the ODCM.
- (5) Not used in the ODCM.

*Control Room Alarm Annunciation shall consist of a change in state of the tested channel on the RM-11 terminal (i.e., a change in color) or a highlighted message on the DICSP Workstation Channel.

D.2 RADIOACTIVE EFFLUENTS

3/4.11.1 LIQUID EFFLUENTS

3/4.11.1.1 Concentration

OPERATIONAL REQUIREMENT

3.11.1.1 The concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS (see Technical Specification Figure 5.1-3) shall be limited to 10 times the concentrations specified in 10 CFR Part 20.1001 - 20.2401, Appendix B, Table 2, Column 2 for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the concentration shall be limited to 2E-04 $\mu\text{Ci/ml}$ total activity.

APPLICABILITY: At all times.

ACTION:

- a. With the concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS exceeding the above limits, immediately restore the concentration to within the above limits.

SURVEILLANCE REQUIREMENTS

4.11.1.1.1 Radioactive liquid wastes shall be sampled and analyzed according to the sampling and analysis program of Table 4.11-1.

4.11.1.1.2 The results of the radioactivity analyses shall be used in accordance with the methodology and parameters in the ODCM to assure that the concentrations at the point of release are maintained within the limits of Operational Requirement 3.11.1.1.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

TABLE 4.11-1

RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM*

LIQUID RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPES OF ACTIVITY ANALYSIS	LOWER LIMIT OF DETECTION (LLD) ⁽¹⁾ (μCi/ml)
1. Batch Waste Release Tanks ⁽²⁾				
a. Waste Monitor Tanks	P Each Batch	P Each Batch	Principal Gamma Emitters ⁽³⁾	5E-07
			I-131	1E-06
b. Waste Evaporator Condensate Tanks	P One Batch/M	M	Dissolved and Entrained Gases (Gamma Emitters)	1E-05
c. Secondary Waste Sample Tank ⁽⁸⁾	P Each Batch	M Composite ⁽⁴⁾	H-3	1E-05
			Gross Alpha	1E-07
d. Treated Laundry and Hot Shower Tanks	P Each Batch	Q Composite ⁽⁴⁾	Sr-89, Sr-90	5E-08
			Fe-55	1E-06
2. Continuous Releases ⁽⁵⁾⁽⁷⁾				
a. Cooling Tower Weir	Continuous ⁽⁶⁾	W Composite ⁽⁶⁾⁽⁷⁾	Principal Gamma Emitters ⁽³⁾	5E-07
b. Secondary Waste Sample Tank ⁽⁸⁾	M ⁽⁷⁾ Grab Sample	M ⁽⁷⁾	Dissolved and Entrained Gases (Gamma Emitters)	1E-05
			I-131	1E-06
	Continuous ⁽⁶⁾	M Composite ⁽⁶⁾⁽⁷⁾	H-3	1E-05
			Gross Alpha	1E-07
	Continuous ⁽⁶⁾	Q Composite ⁽⁶⁾⁽⁷⁾	Sr-89, Sr-90	5E-08
Fe-55			1E-06	

* See Table G-1 for explanation of frequency notation

TABLE 4.11-1 (Continued)

TABLE NOTATIONS

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

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

$$LLD = \frac{4.66 \cdot S_b}{E \cdot V \cdot (2.22E + 06) \cdot Y \cdot e^{-\lambda \Delta t}}$$

Where:

- LLD = the "a priori" lower limit of detection (μ Ci per unit mass or volume),
- S_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),
- E = the counting efficiency (counts per disintegration),
- V = the sample size (units of mass or volume),
- 2.22E+06 = the number of disintegrations per minute per μ Ci,
- Y = the fractional radiochemical yield, when applicable,
- λ = the radioactive decay constant for the particular radionuclide (sec^{-1}), and
- Δt = the elapsed time between the midpoint of sample collection and the time of counting (sec).

Typical values of E, V, Y, and Δt should be used in the calculation.

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

- (2) A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated, and then thoroughly mixed by a method described in the ODCM to assure representative sampling.

TABLE 4.11-1 (Continued)

TABLE NOTATIONS (Continued)

- (3) The principal gamma emitters for which the LLD Operational Requirement applies include the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, and Ce-141. Ce-144 shall also be measured but with a LLD of 5E-06. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radioactive Effluent Release Report pursuant to ODCM, Appendix F, Section F.2 in the format outlined in Regulatory Guide 1.21, Appendix B, Revision 1, June 1974.
- (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 that is representative of the liquids released.
- (5) A continuous release is the discharge of liquid wastes of a nondiscrete volume, e.g., from a volume of a system that has an input flow during the continuous release.
- (6) To be representative of the quantities and concentrations of radioactive materials in liquid effluents, samples shall be collected continuously in proportion to the rate of flow of the effluent stream. Prior to analyses, all samples taken for the composite shall be thoroughly mixed in order for the composite sample to be representative of the effluent release.
- (7) These points monitor potential release pathways only and not actual release pathways. The potential contamination points are in the Normal Service Water (NSW) and Secondary Waste (SW) Systems. Action under this Operational Requirement is as follows:
 - a) If the applicable (NSW or SW) monitors in Table 3.3-12 are OPERABLE and not in alarm, then no analysis under this Operational Requirement is required but weekly composites will be collected.
 - b) If the applicable monitor is out of service, then the weekly analysis for principal gamma emitters will be performed.
 - c) If the applicable monitor is in alarm or if the principal gamma emitter analysis indicates the presence of radioactivity as defined in the ODCM, then all other analyses of this Operational Requirement shall be performed at the indicated frequency as long as the initiating conditions exist.
- (8) The Secondary Waste System releases can be either batch or continuous. The type of sample required is determined by the mode of operation being used.

3/4.11.1 LIQUID EFFLUENTS

3/4.11.1.2 Dose

OPERATIONAL REQUIREMENT

- 3.11.1.2 The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released to UNRESTRICTED AREAS (see Technical Specification Figure 5.1-3) shall be limited:
- a. During any calendar quarter to less than or equal to 1.5 mrem to the whole body and to less than or equal to 5 mrem to any organ, and
 - b. During any calendar year to less than or equal to 3 mrem to the whole body and to less than or equal to 10 mrem to any organ.

APPLICABILITY: At all times.

ACTION:

- a. 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, pursuant to Technical Specification 6.9.2, a Special Report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits.

SURVEILLANCE REQUIREMENTS

- 4.11.1.2 Cumulative dose contributions from liquid effluents for the current calendar quarter and the current calendar year shall be determined in accordance with the methodology and parameters in the ODCM at least once per 31 days.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

3/4.11.1 LIQUID EFFLUENTS

3/4.11.1.3 Liquid Radwaste Treatment System

OPERATIONAL REQUIREMENT

3.11.1.3 The Liquid Radwaste Treatment System shall be OPERABLE and appropriate portions of the system shall be used to reduce releases of radioactivity when the projected doses, due to the liquid effluent, to UNRESTRICTED AREAS (see Technical Specification Figure 5.1-3) would exceed 0.06 mrem to the whole body or 0.2 mrem to any organ in a 31-day period.

APPLICABILITY: At all times.

ACTION:

- a. With radioactive liquid waste being discharged without treatment and in excess of the above limits and any portion of the Liquid Radwaste Treatment System not in operation, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that 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,
 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

4.11.1.3.1 Doses due to liquid releases to UNRESTRICTED AREAS shall be projected at least once per 31 days in accordance with the methodology and parameters in the ODCM when Liquid Radwaste Treatment Systems are not being fully utilized.

4.11.1.3.2 The installed Liquid Radwaste Treatment System shall be considered OPERABLE by meeting Operational Requirements 3.11.1.1 and 3.11.1.2.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

3/4.11.2 GASEOUS EFFLUENTS

3/4.11.2.1 Dose Rate

OPERATIONAL REQUIREMENT

- 3.11.2.1 The dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY (see Technical Specification Figure 5.1-1) shall be limited to the following:
- a. For noble gases: Less than or equal to 500 mrems/yr to the whole body and less than or equal to 3000 mrems/yr to the skin, and
 - b. For Iodine-131, for Iodine-133, for tritium, and for all radionuclides in particulate form with half-lives greater than 8 days: Less than or equal to 1500 mrems/yr to any organ.

APPLICABILITY: At all times.

ACTION:

- a. With the dose rate(s) exceeding the above limits, immediately restore the release rate to within the above limit(s).

SURVEILLANCE REQUIREMENTS

- 4.11.2.1.1 The dose rate due to noble gases in gaseous effluents shall be determined to be within the above limits in accordance with the methodology and parameters in the ODCM.
- 4.11.2.1.2 The 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 above limits in accordance with the methodology and parameters in the ODCM by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 4.11-2.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

TABLE 4.11-2
RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM*

GASEOUS RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS	LOWER LIMIT OF DETECTION (LLD) ⁽¹⁾ (μCi/ml)
1. Waste Gas Storage Tank	P Each Tank Grab Sample	P Each Tank	Principal Gamma Emitters ^(2a)	1E-04
2. Containment Purge or Vent ⁽¹⁰⁾	P Each PURGE ⁽³⁾	P Each PURGE ⁽³⁾	Principal Gamma Emitters ^(2a)	1E-04
	Grab Sample	M	H-3 (oxide)	1E-06
3. a. Plant Vent Stack	M ^{(3),(4),(5)} Grab Sample	M	Principal Gamma Emitters ^(2a)	1E-04
			H-3 (oxide)	1E-06
b. Turbine Bldg Vent Stack, Waste Proc. Bldg. Vent Stacks 5 & 5A	M Grab Sample	M	Principal Gamma Emitters ^(2a)	1E-04
4. All Release Types as listed in 1., 2., and 3. above ^{(6), (9), (10)}	Continuous ⁽⁶⁾	W ⁽⁷⁾ Charcoal Sample	I-131 ^(2b)	1E-12
			I-133 ^(2b)	1E-10
	Continuous ⁽⁶⁾	W ^(7,12) Particulate Sample	Principal Gamma Emitters ^(2c)	1E-11
	Continuous ⁽⁶⁾	M Composite Particulate Sample	Gross Alpha	1E-11
5. Equipment Hatch during Refueling	Continuous	D Charcoal Sample	I-131 ^(2b)	1E-11
			I-133 ^(2b)	1E-09
	Continuous	D ⁽¹¹⁾ Particulate Sample	Principal Gamma Emitters	1E-10

* See Table G-1 for explanation of frequency notation

TABLE 4.11-2 (Continued)

TABLE NOTATIONS

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

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

$$LLD = \frac{4.66 \cdot S_b}{E \cdot V \cdot (2.22E + 06) \cdot Y \cdot e^{-\lambda \Delta t}}$$

Where:

- LLD = the "a priori" lower limit of detection (μ Ci per unit mass or volume),
- S_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),
- E = the counting efficiency (counts per disintegration),
- V = the sample size (units of mass or volume),
- 2.22E+06 = the number of disintegrations per minute per μ Ci,
- Y = the fractional radiochemical yield, when applicable,
- λ = the radioactive decay constant for the particular radionuclide (sec^{-1}), and
- Δt = the elapsed time between the midpoint of sample collection and the time of counting (sec).

Typical values of E, V, Y, and Δt should be used in the calculation.

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

TABLE 4.11-2 (Continued)

TABLE NOTATIONS (Continued)

- (2a) The principal gamma emitters for which the LLD Operational Requirement applies include the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 in noble gas releases. This list does not mean that only these nuclides are to be considered. Other noble gas gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radioactive Effluent Release Report pursuant to ODCM, Appendix F, Section F.2 in the format outlined in Regulatory Guide 1.21, Appendix B, Revision 1, June 1974.
- (2b) The principal gamma emitters for which the LLD Operational Requirement applies include I-131 and I-133 in iodine (charcoal cartridge) samples. This list does not mean that only these nuclides are to be considered. Other iodine gamma peaks that are identifiable, together with I-131 and I-133 nuclides, shall also be analyzed and reported in the Annual Radioactive Effluent Release Report pursuant to ODCM, Appendix F, Section F.2 in the format outlined in Regulatory Guide 1.21, Appendix B, Revision 1, June 1974.
- (2c) The principal gamma emitters for which the LLD Operational Requirement applies include the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, I-131, Cs-134, Cs-137, Ce-141, and Ce-144 in particulate releases. This list does not mean that only these nuclides are to be considered. Other particulate gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radioactive Effluent Release Report pursuant to ODCM, Appendix F, Section F.2 in the format outlined in Regulatory Guide 1.21, Appendix B, Revision 1, June 1974.
- (3) Sampling and analysis shall also be performed following shutdown, startup, or a THERMAL POWER change exceeding 15% of RATED THERMAL POWER within a 1-hour period.
- (4) Tritium grab samples shall be taken at least once per 24 hours when the refueling canal is flooded.
- (5) Tritium grab samples shall be taken at least once per 7 days from the ventilation exhaust from the spent fuel pool area, whenever spent fuel is in the spent fuel pool.
- (6) 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 Operational Requirements 3.11.2.1, 3.11.2.2, and 3.11.2.3.
- (7) Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing, or after removal from sampler. Sampling 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 does not apply if: (1) analysis shows that the DOSE EQUIVALENT I-131 concentration in the reactor coolant has not increased more than a factor of 3; and (2) the noble gas monitor shows that effluent activity has not increased more than a factor of 3.
- (8) Continuous sampling of Waste Gas Decay Tank (WGDT) releases can be met using the continuous samplers on Wide Range Gas Monitor RM-*1WV-3546-1 on Waste Processing Building Vent Stack 5.
- (9) Continuous sampling of containment atmosphere for (1) Venting, (2) Normal Purge, and (3) Pre-entry purge operations, required by Operational Requirement 4.11.2.1.2, can be met using the continuous samplers on Wide Range Gas Monitor RM-01AV-3509-1SA on Plant Vent Stack 1

TABLE 4.11-2 (Continued)

TABLE NOTATIONS (Continued)

- (10) The requirement to sample the containment atmosphere prior to release for normal and pre-entry containment purge operations (that is, to "permit" the release per the ODCM) is required on initial system startup, and prior to system restart following any system shutdown due to radiological changes in the containment (e.g. valid high alarms on leak detection or containment area monitors). System shutdown occurring on changes in containment pressure, equipment malfunctions, operational convenience, sampling, and so forth, do not require new samples or release permits.
- (11) The composite of all filters collected when releases were being made through the equipment hatch are to be analyzed for gross alpha, strontium-89, and strontium 90 at the end of the outage.
- (12) If isokinetic skid for Plant Vent Stack 1 is INOPERABLE particulate sampling for effluent accountability is to be installed on 286' of the fuel handling building. ANSI 13.1, 1969 defines the conditions for obtaining a representative particulate sample.

3/4.11.2 GASEOUS EFFLUENTS

3/4.11.2.2 Dose - Noble Gases

OPERATIONAL REQUIREMENT

- 3.11.2.2 The air dose due to noble gases released in gaseous effluents to areas at and beyond the SITE BOUNDARY (see Technical Specification Figure 5.1-3) shall be limited to the following:
- a. During any calendar quarter: Less than or equal to 5 mrad for gamma radiation and less than or equal to 10 mrad for beta radiation, and
 - b. During any calendar year: Less than or equal to 10 mrad for gamma radiation and less than or equal to 20 mrad for beta radiation.

APPLICABILITY: At all times.

ACTION:

- a. 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, pursuant to Technical Specification 6.9.2, a Special Report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits.

SURVEILLANCE REQUIREMENTS

- 4.11.2.2 Cumulative dose contributions for the current calendar quarter and current calendar year for noble gases shall be determined in accordance with the methodology and parameters in the ODCM at least once per 31 days.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

3/4.11.2 GASEOUS EFFLUENTS

3/4.11.2.3 Dose - Iodine-131, Iodine-133, Tritium, and Radioactive Material in Particulate Form

OPERATIONAL REQUIREMENT

3.11.2.3 The dose to a MEMBER OF THE PUBLIC from Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released to areas at and beyond the SITE BOUNDARY (see Technical Specification Figure 5.1-3) shall be limited to the following:

- a. During any calendar quarter: Less than or equal to 7.5 mrem to any organ, and
- b. During any calendar year: Less than or equal to 15 mrem to any organ.

APPLICABILITY: At all times.

ACTION:

- a. With the calculated dose, from the release of Iodine-131, Iodine-133, tritium, and radionuclides in particulate form with half-lives greater than 8 days, in gaseous effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits.

SURVEILLANCE REQUIREMENTS

4.11.2.3 Cumulative dose contributions for the current calendar quarter and current calendar year for Iodine-131, Iodine-133, tritium, and radionuclides in particulate form with half-lives greater than 8 days shall be determined in accordance with the methodology and parameters in the ODCM at least once per 31 days.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

3/4.11.2 GASEOUS EFFLUENTS

3/4.11.2.4 Gaseous Radwaste Treatment System

OPERATIONAL REQUIREMENT

- 3.11.2.4 The VENTILATION EXHAUST TREATMENT SYSTEM and the GASEOUS RADWASTE TREATMENT SYSTEM shall be OPERABLE and appropriate portions of these systems shall be used to reduce releases of radioactivity when the projected doses in 31 days due to gaseous effluent releases to areas at and beyond the SITE BOUNDARY (see Technical Specification Figure 5.1-3) would exceed:
- a. 0.2 mrad to air from gamma radiation, or
 - b. 0.4 mrad to air from beta radiation, or
 - c. 0.3 mrem to any organ of a MEMBER OF THE PUBLIC.

APPLICABILITY: At all times.

ACTION:

- a. With radioactive gaseous waste being discharged without treatment and in excess of the above limits, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that includes the following information:
 - 1. Identification of any inoperable equipment or subsystems, and the reason for the inoperability,
 - 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

4.11.2.4.1 Doses due to gaseous releases to areas at and beyond the SITE BOUNDARY shall be projected at least once per 31 days in accordance with the methodology and parameters in the ODCM when the GASEOUS RADWASTE TREATMENT SYSTEM is not being fully utilized.

4.11.2.4.2 The installed VENTILATION EXHAUST TREATMENT SYSTEM and GASEOUS RADWASTE TREATMENT SYSTEM shall be considered OPERABLE by meeting Operational Requirements 3.11.2.1 and 3.11.2.2 or 3.11.2.3.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

3/4.11.4 TOTAL DOSE

OPERATIONAL REQUIREMENT

3.11.4 The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to less than or equal to 25 mrems to the whole body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrems.

APPLICABILITY: At all times.

ACTION:

- a. With the calculated doses from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of Operational Requirement 3.11.1.2a., 3.11.1.2b., 3.11.2.2a., 3.11.2.2b., 3.11.2.3a., or 3.11.2.3b., calculations shall be made including direct radiation contributions from the units and from outside storage tanks to determine whether the above limits of Operational Requirement 3.11.4 have been exceeded. If such is the case, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that defines the corrective action to be taken to reduce subsequent releases to prevent recurrence of exceeding the above limits and includes the schedule for achieving conformance with the above limits. This Special Report, as defined in 10 CFR 20.405(c), shall include an analysis that estimates the radiation exposure (dose) to a MEMBER OF THE PUBLIC from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s) covered by this report. It shall also describe levels of radiation and concentrations of radioactive material involved, and the cause of the exposure levels or concentrations. If the estimated dose(s) exceeds the above limits, and if the release condition resulting in violation of 40 CFR Part 190 has not already been corrected, the Special Report shall include a request for a variance in accordance with the provisions of 40 CFR Part 190. Submittal of the report is considered a timely request, and a variance is granted until staff action on the request is complete.

SURVEILLANCE REQUIREMENTS

4.11.4.1 Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with Operational Requirements 4.11.1.2, 4.11.2.2, and 4.11.2.3, and in accordance with the methodology and parameters in the ODCM.

4.11.4.2 Cumulative dose contributions from direct radiation from the units and from radwaste storage tanks shall be determined in accordance with the methodology and parameters in the ODCM. This requirement is applicable only under conditions set forth in ACTION a. of Operational Requirement 3.11.4.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

D.3 RADIOLOGICAL ENVIRONMENTAL MONITORING

3/4.12.1 MONITORING PROGRAM

OPERATIONAL REQUIREMENT

3.12.1 The Radiological Environment Monitoring Program shall be conducted as specified in Table 3.12-1.

APPLICABILITY: At all times.

ACTION:

- a. With the Radiological Environmental Monitoring Program not being conducted as specified in Table 3.12-1, prepare and submit to the Commission, in the Annual Radiological Environmental Operating Report required by ODCM, Appendix F, Section F.1, 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 3.12-2 when averaged over any calendar quarter, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, 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 Operational Requirements 3.11.1.2, 3.11.2.2, or 3.11.2.3. When more than one of the radionuclides in Table 3.12-2 are detected in the sampling medium, this report shall be submitted if:

$$\frac{\text{concentration}(1)}{\text{reporting level}(1)} + \frac{\text{concentration}(2)}{\text{reporting level}(2)} + \dots \geq 1.0$$

When radionuclides other than those in Table 3.12-2 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 from all radionuclides is equal to or greater than the calendar year limits of Operational Requirement 3.11.1.2, 3.11.2.2, or 3.11.2.3. 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 Operating Report required by ODCM, Appendix F, Section F.1.

*The methodology and parameters used to estimate the potential annual dose to a MEMBER OF THE PUBLIC shall be indicated in this report.

3/4.12.1 MONITORING PROGRAM

OPERATIONAL REQUIREMENT

ACTION (Continued):

- c. With milk or fresh leafy vegetation samples unavailable from one or more of the sample locations required by Table 3.12-1, identify specific locations for obtaining replacement samples and add them within 30 days to the Radiological Environmental Monitoring Program given in the ODCM. The specific locations from which samples were unavailable may then be deleted from the monitoring program. Pursuant to ODCM, Appendix F, Section F.2, submit in the next Annual Radioactive Effluent Release Report documentation for a change in the ODCM including a revised figure(s) and table for the ODCM reflecting the new location(s) with supporting information identifying the cause of the unavailability of samples and justifying the selection of the new location(s) for obtaining samples.
- d. If any sample result for onsite groundwater, that is or may be used as a source of drinking water, exceeds the reporting criteria of ODCM Table 3.12-2, then submit a special 30 day written report to the NRC. Additionally, a copy of this report shall be forwarded to designated state/local offices listed below in Action e.
- e. If any offsite groundwater, offsite surface water, onsite groundwater monitoring well, or onsite surface water that is hydrologically connected to groundwater exceed the reporting criteria of ODCM Table 3.12-2, then make informal notification to the designated state/local offices listed below by the end of the next business day. Special Ground Water Protection Reports listed in this section are not required for subsequent sample results that are from the same plume and have already been reported in accordance with this section. The Designated State offices for notification are as follows: 1) North Carolina Department of Environmental and Natural Resources, Radiation Protection Section and 2) North Carolina Department of Environmental and Natural Resources, Division of Water Quality.

SURVEILLANCE REQUIREMENTS

- 4.12.1 The radiological environmental monitoring samples shall be collected pursuant to Table 3.12-1 from the specific locations given in the table and figure(s) in the ODCM, and shall be analyzed pursuant to the requirements of Table 3.12-1 and the detection capabilities required by Table 4.12-1.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

TABLE 3.12-1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

<u>EXPOSURE PATHWAY AND/OR SAMPLE</u>	<u>NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS⁽¹⁾</u>	<u>SAMPLING AND COLLECTION FREQUENCY</u>	<u>TYPE AND FREQUENCY OF ANALYSIS</u>
1. Direct Radiation ⁽²⁾	<p>Forty routine monitoring stations either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, placed as follows:</p> <p>An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY;</p> <p>An outer ring of stations, one in each meteorological sector in the 6 to 8 km range from the site; and</p> <p>The balance of the stations to be placed in special interest areas such as population centers, nearby residences, schools, and in one or two areas to serve as control stations.</p>	Quarterly.	Gamma dose quarterly.

TABLE 3.12-1 (Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
2. Airborne Radioiodine and Particulates	<p>Samples from five locations:</p> <p>Three samples from close to the three SITE BOUNDARY locations, in different sectors, of the highest calculated annual average ground-level D/Q;</p> <p>One sample from the vicinity of a community having the highest calculated annual average ground-level D/Q; and</p> <p>One sample from a control location, as for example 15 to 30 km distant and in the least prevalent wind direction.</p>	<p>Continuous sampler operation with sample collection weekly, or more frequently if required by dust loading.</p>	<p><u>Radioiodine Cannister:</u> I-131 analysis weekly.</p> <p><u>Particulate Sampler:</u> Gross beta radioactivity analysis following filter change;⁽³⁾ and gamma isotopic analysis⁽⁴⁾ of composite (by location) quarterly.</p>
3. Waterborne a. Surface ⁽⁵⁾	<p>One sample upstream.</p> <p>One sample downstream.</p>	<p>Composite sample over 1-month period.⁽⁶⁾</p>	<p>Gamma isotopic analysis⁽⁴⁾ monthly. Composite for tritium analysis quarterly.</p>
b. Ground	<p>Samples from one or two sources only if likely to be affected⁽⁷⁾.</p>	<p>Quarterly.</p>	<p>Gamma isotopic⁽⁴⁾ and tritium analysis quarterly.</p>

TABLE 3.12-1 (Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
<p>3. Waterborne (Continued)</p> <p>c. Drinking</p>	<p>One sample in the vicinity of the nearest downstream municipal water supply intake from the Cape Fear River.</p> <p>One sample from a control location.</p>	<p>Composite sample over 2-week period⁽⁶⁾ when I-131 analysis is performed; monthly composite otherwise.</p>	<p>I-131 analysis on each composite when the dose calculated for the consumption of the water is greater than 1 mrem per year.⁽⁸⁾</p> <p>Composite for gross beta and gamma isotopic analyses⁽⁴⁾ monthly.</p> <p>Composite for tritium analysis quarterly.</p>
<p>d. Sediment from Shoreline</p>	<p>One sample in the vicinity of the cooling tower blowdown discharge in an area with existing or potential recreational value.</p>	<p>Semiannually.</p>	<p>Gamma isotopic analysis⁽⁴⁾ semiannually.</p>
<p>4. Ingestion</p> <p>a. Milk</p>	<p>Samples from milking animals in three locations within 5 km distance having the highest dose potential. If there are none, then one sample from milking animals in each of three areas between 5 to 8 km distant where doses are calculated to be greater than 1 mrem per yr.⁽⁸⁾</p> <p>One sample from milking animals at a control location 15 to 30 km distant and in the least prevalent wind direction.</p>	<p>Semimonthly when animals are on pasture; monthly at other times. When no milk animals are available at indicator locations, milk sampling of the control location can be reduced to once per month to maintain historical data.</p>	<p>Gamma isotopic⁽⁴⁾ and I-131 analysis semimonthly when animals are on pasture; monthly at other times.</p>

TABLE 3.12-1 (Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
4. Ingestion (Continued) b. Fish and Invertebrates	One sample of Sunfish, Catfish, and Large-Mouth Bass species in vicinity of plant discharge area. One sample of same species in areas not influenced by plant discharge.	Sample in season, or semiannually if they are not seasonal.	Gamma isotopic analysis ⁽⁴⁾ on edible portions.
c. Food Products	One sample of each principle class of food products from any area that is irrigated by water which liquid plant wastes have been discharged	At time of harvest ⁽⁹⁾	Gamma isotopic analysis ⁽⁴⁾ on edible portions.
	Samples of three different kinds of broad leaf vegetation grown nearest each of two different locations of highest predicted annual average ground level D/Q if milk sampling is not performed. One sample of each of the similar broad leaf vegetation grown 15 to 30 km distant in the least prevalent wind direction if milk sampling is not performed.	Monthly during growing season.	Gamma isotopic ⁽⁴⁾ and I-131 analysis.

TABLE 3.12-1 (Continued)

TABLE NOTATIONS

- (1) Specific parameters of distance and direction sector from the centerline of one reactor, and additional description where pertinent, shall be provided for each and every sample location in Table 3.12-1 in a table and figure(s) in the ODCM. Refer to NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978, and to Radiological Assessment Branch Technical Position, Revision 1, November 1979. Deviations are permitted from the required sampling schedule if specimens are unobtainable due to circumstances such as hazardous conditions, seasonal unavailability, and malfunction of automatic sampling equipment. If specimens are unobtainable due to sampling equipment malfunction, effort 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 Specification 6.9.1.3. 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. Pursuant to ODCM, Appendix F, Section F.2, submit in the next Annual Radioactive Effluent Release Report documentation for a change in the ODCM including a revised figure(s) and table for the ODCM reflecting the new location(s) with supporting information identifying the cause of the unavailability of samples for that pathway and justifying the selection of the new location(s) for obtaining samples.
- (2) One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dosimeters. For the purposes of this table, a thermoluminescent dosimeter (TLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation. (The 40 stations are not an absolute number. The number of direct radiation monitoring stations may be reduced according to geographical limitations; e.g., at an ocean site, some sectors will be over water so that the number of dosimeters may be reduced accordingly. The frequency of analysis or readout for TLD systems will depend upon the characteristics of the specific system used and should be selected to obtain optimum dose information within minimal fading.)
- (3) Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for 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) The "upstream sample" shall be taken at a distance beyond significant influence of the discharge. The "downstream" sample shall be taken in an area beyond but near the mixing zone. "Upstream" samples in an estuary must be taken far enough upstream to be beyond the plant influence. Salt water shall be sampled only when the receiving water is utilized for recreational activities.
- (6) A composite sample is one in which the quantity (aliquot) of liquid sampled is proportional to the quantity of flowing liquid and in which the method of sampling employed results in a specimen that is representative of the liquid flow. In this program composite sample aliquots shall be collected at time intervals that are very short (e.g., hourly) relative to the compositing period (e.g., monthly) in order to assure obtaining a representative sample.
- (7) Groundwater samples shall be taken when this source is tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination. None of the previously identified locations have been used for drinking water since pre-operational days of Harris Nuclear Project nor have these wells ever been used for irrigation purposes. These wells were abandoned for drinking water purposes prior to plant operations. Since that time, these wells have been used to monitor the hydraulic gradient or gradient properties for the Harris Site and for the operational Radiological Environmental Monitoring program.

TABLE 3.12-1 (Continued)

TABLE NOTATIONS (Continued)

- (8) The dose shall be calculated for the maximum organ and age group, using the methodology and parameters in the ODCM.
- (9) If harvest occurs more than once per year, sampling shall be performed during each discrete harvest. If harvest occurs continuously, sampling shall be monthly.

TABLE 3.12-2

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	20,000*				
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-Nb-95	400				
I-131	2**	0.9		3	100
Cs-134	30	10	1,000	60	1,000
Cs-137	50	20	2,000	70	2,000
Ba-La-140	200			300	

*For drinking water samples. This is 40 CFR Part 141 value. If no drinking water pathway exists, a value of 30,000 pCi/l may be used.

**If no drinking water pathway exists, a value of 20 pCi/l may be used.

TABLE 4.12-1

DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS⁽¹⁾

LOWER LIMIT OF DETECTION (LLD)⁽²⁾

ANALYSIS	WATER (pCi/l)	AIRBORNE PARTICULATE OR GASES (pCi/m ³)	FISH (pCi/kg, wet)	MILK (pCi/l)	FOOD PRODUCTS (pCi/kg, wet)	SEDIMENT (pCi/kg, dry)
Gross Beta	4	0.01				
H-3	2000*					
Mn-54	15		130			
Fe-59	30		260			
Co-58, 60	15		130			
Zn-65	30		260			
Zr-Nb-95	15					
I-131	1**	0.07		1	60	
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-La-140	15***			15***		

*If no drinking water pathway exists, a value of 3000 pCi/l may be used.

**If no drinking water pathway exists, a value of 15 pCi/l may be used.

***The specific LLD applies to the daughter nuclide of an equilibrium mixture of the parent and daughter nuclides. Per the Branch Technical Position, value of 60 pCi/L may be used for Ba-140 and 15 pCi/L may be used for La-140.

TABLE 4.12-1 (Continued)

TABLE NOTATIONS

- (1) This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report pursuant to ODCM, Appendix F, Section F.1.
- (2) The LLD is defined, for purposes of these Operational Requirements, as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

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

$$LLD = \frac{4.66 \cdot S_b}{E \cdot V \cdot (2.22E + 06) \cdot Y \cdot e^{-\lambda \Delta t}}$$

Where:

- LLD = the "a priori" lower limit of detection (μ Ci per unit mass or volume),
- S_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),
- E = the counting efficiency (counts per disintegration),
- V = the sample size (units of mass or volume),
- 2.22E+06 = the number of disintegrations per minute per μ Ci,
- Y = the fractional radiochemical yield, when applicable,
- λ = the radioactive decay constant for the particular radionuclide (sec^{-1}), and
- Δt = the elapsed time between the midpoint of sample collection and the time of counting (sec).

Typical values of E, V, Y, and Δt should be used in the calculation.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement. Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report pursuant to ODCM, Appendix F, Section F.1.

3/4.12.2 LAND USE CENSUS

OPERATIONAL REQUIREMENT

3.12.2 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 m² (500 ft²) 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 Operational Requirement 4.11.2.3, pursuant to ODCM, Appendix F, Section F.2, identify the new location(s) in the next Annual Radioactive Effluent Release 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% greater than at a location from which samples are currently being obtained in accordance with Operational Requirement 3.12.1, add the new location(s) within 30 days to the Radiological Environmental Monitoring Program given in the ODCM. 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. Pursuant to ODCM, Appendix F, Section F.2, submit in the next Annual Radioactive Effluent Release Report documentation for a change in the ODCM including a revised figure(s) and table(s) for the ODCM reflecting the new location(s) with information supporting the change in sampling locations.

SURVEILLANCE REQUIREMENTS

4.12.2 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 Operating Report pursuant to ODCM, Appendix F, Section F.1.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

*Broad leaf vegetation sampling of at least three different kinds of vegetation may be performed at the SITE BOUNDARY in each of two different direction sectors with the highest predicted D/Qs in lieu of the garden census. Operational Requirements for broad leaf vegetation sampling in Table 3.12-1, Part 4.c., shall be followed, including analysis of control samples.

3/4.12.3 INTERLABORATORY COMPARISON PROGRAM

OPERATIONAL REQUIREMENT

3.12.3 Analyses shall be performed on all radioactive materials, supplied as part of an Interlaboratory Comparison Program, that correspond to samples required by Table 3.12-1.

APPLICABILITY: At all times.

ACTION:

- a. With analyses not being performed as required above, report the corrective actions taken to prevent a recurrence to the Commission in the Annual Radiological Environmental Operating Report pursuant to ODCM, Appendix F, Section F.1.

SURVEILLANCE REQUIREMENTS

4.12.3 The Interlaboratory Comparison Program shall be described in the ODCM. A summary of the results obtained as part of the above required Interlaboratory Comparison Program shall be included in the Annual Radiological Environmental Operating Report pursuant to ODCM, Appendix F, Section F.1.

Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

E.0 APPENDIX E

PROGRAMMATIC CONTROL BASES

The Bases for the ODCM Operational Requirements are detailed in Sections:

- E.1 - Instrumentation
- E.2 - Radioactive Effluents
- E.3 - Radiological Environmental Monitoring

E.1 INSTRUMENTATION BASES

3/4.3.3 MONITORING INSTRUMENTATION

3/4.3.3.10 Radioactive Liquid Effluent Monitoring 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 Set Points for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of 10 CFR Part 20. The OPERABILITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

3/4.3.3.11 Radioactive Gaseous Effluent Monitoring 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 Set Points for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of 10 CFR Part 20. The OPERABILITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50. The sensitivity of any noble gas activity monitors used to show compliance with the gaseous effluent release requirements of Operational Requirement 3.11.2.2 shall be such that concentrations as low as $1\text{E-}06 \mu\text{Ci/ml}$ are measurable.

E.2 RADIOACTIVE EFFLUENTS BASES

3/4.11.1 LIQUID EFFLUENTS

3/4.11.1.1 Concentration

This Operational Requirement is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to UNRESTRICTED AREAS will be less than the concentration levels specified in 10 CFR Part 20, Appendix B, Table 2, Column 2. This limitation provides additional assurance that the levels of radioactive materials in bodies of water in UNRESTRICTED AREAS will result in exposures within: (1) the Section II.A design objectives of Appendix I, 10 CFR Part 50, to a MEMBER OF THE PUBLIC, and (2) the limits of 10 CFR Part 20.106(e) to the population. The concentration limit for dissolved or entrained noble gases is based upon the assumption that Xe-135 is the controlling radioisotope and its MPC in air (submersion) was converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection (ICRP) Publication 2.

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

3/4.11.1.2 Dose

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

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

3/4.11.1.3 Liquid Radwaste Treatment System

The OPERABILITY of the Liquid Radwaste Treatment System ensures that this system will be available for use whenever liquid effluents require treatment prior to release to the environment. 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 Operational Requirement implements the requirements of 10 CFR 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50 and the design objective given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the Liquid Radwaste Treatment System were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50 for liquid effluents.

E.2 RADIOACTIVE EFFLUENTS BASES (continue)

3/4.11.2 GASEOUS EFFLUENTS

3/4.11.2.1 Dose Rate

This Operational Requirement is provided to ensure that the dose at any time at and beyond the SITE BOUNDARY from gaseous effluents from all units on the site will be within the annual dose limits of 10 CFR Part 20 to UNRESTRICTED AREAS. The annual dose limits are the doses associated with the concentrations of 10 CFR Part 20, Appendix B, Table II, Column I. These limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a MEMBER OF THE PUBLIC in an UNRESTRICTED AREA, either within or outside the SITE BOUNDARY, to annual average concentrations exceeding the limits specified in Appendix B, Table II of 10 CFR Part 20 [10 CFR Part 20.106(b)]. For MEMBERS OF THE PUBLIC who may at times be within the SITE BOUNDARY, the occupancy of that MEMBER OF THE PUBLIC will usually be sufficiently low to compensate for any increase in the atmospheric diffusion factor above that for the SITE BOUNDARY. Examples of calculations for such MEMBERS OF THE PUBLIC, with the appropriate occupancy factors, shall be given in the ODCM. The specified release rate limits restrict, at all times, the corresponding gamma and beta dose rates above background to a MEMBER OF THE PUBLIC at or beyond the SITE BOUNDARY to less than or equal to 500 mrem/year to the whole body or to less than or equal to 3000 mrem/year to the skin. These release rate limits also restrict, at all times, the corresponding thyroid dose rate above background to a child via the inhalation pathway to less than or equal to 1500 mrem/year.

The required detection capabilities for radioactive material in gaseous waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD, and other detection limits, can be found in HASL Procedures Manual, HASL-300, 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).

3/4.11.2.2 Dose - Noble Gases

This Operational Requirement is provided to implement the requirements of Section II.B, III.A, and IV.A of Appendix I, 10 CFR Part 50. The Operational Requirement implements the guides set forth in Section I.B of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable." The Surveillance Requirements implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The dose calculation methodology and parameters 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, "Calculation of Annual Dose to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision I, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors," Revision 1, July 1977. The ODCM equations provided for determining the air doses at and beyond the SITE BOUNDARY are based upon the historical average atmospheric conditions.

E.2 RADIOACTIVE EFFLUENTS BASES (continue)

3/4.11.2 GASEOUS EFFLUENTS

3/4.11.2.3 Dose - Iodine-131, Iodine-133, Tritium, and Radioactive Material in Particulate Form

This Operational Requirement is provided to implement the requirements of Sections II.C, III.A, and IV.A of Appendix I, 10 CFR Part 50. The Operational Requirements are the guides set forth in Section II.C of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonable achievable." The ODCM calculational methods specified in the Surveillance Requirements implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The ODCM calculational methodology and parameters for calculating the doses due to the actual release rates of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors," Revision 1, July 1977. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate Operational Requirements for Iodine-131, Iodine-133, tritium, and radionuclides in particulate form with half-lives greater than 8 days are dependent upon the existing radionuclide pathways to man in the areas at and beyond the SITE BOUNDARY. The pathways that were examined in the development of the calculations were: (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 of the ground with subsequent exposure of man.

3/4.11.2.4 Gaseous Radwaste Treatment System

The OPERABILITY of the WASTE GAS HOLDUP SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM ensure that the systems will be available for use whenever gaseous effluents require treatment prior to release to the environment. 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 Operational Requirement implements the requirements of 10 CFR 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50 and the design objectives given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the systems were specified as a suitable fraction of the dose design objectives set forth in Sections II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

3/4.11.3 SOLID RADIOACTIVE WASTES

This specification implements the requirements of 10 CFR 50.36a, 10 CFR 61, and General Design Criterion 60 of Appendix A to 10 CFR Part 50. The process parameters included in establishing the PROCESS CONTROL PROGRAM may include, but are not limited to, waste type, waste pH, waste/liquid/SOLIDIFICATION agent/catalyst ratios, waste oil content, waste principal chemical constituents, and mixing and curing times.

E.2 RADIOACTIVE EFFLUENTS BASES (continued)

3/4.11.4 TOTAL DOSE

This Operational Requirement is provided to meet the dose limitations of 40 CFR Part 190 that have been incorporated into 10 CFR Part 20 by 46 FR 18525. The Operational Requirement requires the preparation and submittal of a Special Report whenever the calculated doses due to releases of radioactivity and to radiation from uranium fuel cycle sources exceed 25 mrems to the whole body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrems. For sites containing up to four reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR Part 190 if the individual reactors remain within twice the dose design objectives of Appendix I, and if direct radiation doses from the units and from outside storage tanks are kept small. The Special Report will describe a course of action that should result in the limitation of the annual dose to a MEMBER OF THE PUBLIC to within the 40 CFR Part 190 limits. For the purposes of the Special Report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible, with the exception that 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 is estimated to exceed the requirements of 40 CFR Part 190, the Special Report with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in accordance with the provisions of 40 CFR 190.11 and 10 CFR 20.2203, is considered to be a timely request and fulfills the requirements of 40 CFR Part 190 until NRC staff action is completed. The variance only relates to the limits of 40 CFR Part 190, and does not apply in any way to the other requirements for dose limitation of 10 CFR Part 20, as addressed in Operational Requirements 3.11.1.1 and 3.11.2.1. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation that is part of the nuclear fuel cycle.

E.3 RADIOLOGICAL ENVIRONMENTAL MONITORING BASES

3/4.12.1 MONITORING PROGRAM

The Radiological Environmental Monitoring Program required by this Operational Requirement provides representative measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposure of MEMBERS OF THE PUBLIC resulting from the plant operation. This monitoring program implements Section IV.B.2 of Appendix I to 10 CFR Part 50 and thereby supplements the Radiological Effluent Monitoring Program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the modeling of the environmental exposure pathways. Guidance for this monitoring program is provided by the Radiological Assessment Branch Technical Position on Environmental Monitoring, Revision 1, November 1979. The initially specified monitoring program will be effective for at least the first 3 years of commercial operation. Following this period, program changes may be initiated based on operational experience.

The required detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLDs). The LLDs required by Table 4.12-1 are 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, 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).

3/4.12.2 LAND USE CENSUS

This Operational Requirement is provided to ensure that changes in the use of areas at and beyond the SITE BOUNDARY are identified and that modifications to the Radiological Environmental Monitoring Program are made, if required, by the results of this census. The best information from the door-to-door survey, from aerial survey, or from consulting with local agricultural authorities shall be used. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the census to gardens of greater than 50 m² 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/m².

3/4.12.3 INTERLABORATORY COMPARISON PROGRAM

The requirement for participation in an approved Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive materials in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring in order to demonstrate that the results are valid for the purposes of Section IV.B.2 of Appendix I to 10 CFR Part 50.

F.0 APPENDIX F

ADMINISTRATIVE CONTROLS

The Reporting Requirements pertaining to the ODCM Operational Requirements are detailed in Sections:

- F.1 - Annual Radiological Environmental Operating Report
- F.2 - Annual Radioactive Effluent Release Report
- F.3 - Major changes to the Radwaste Treatment System (liquid and gaseous)

F.1 Annual Radiological Environmental Operating Report
(Formerly part of Specification 6.9.1.3)

Routine Annual Radiological Environmental Operating Reports, covering the operation of the unit during the previous calendar year, shall be submitted prior to May 1 of each year. The initial report shall be submitted prior to May 1 of the year following initial criticality.

The Annual Radiological Environmental Operating Reports shall include summaries, interpretations, and an analysis of trends of the results of the radiological environmental surveillance activities for the report period, including a comparison with preoperational studies, with operational controls, as appropriate, and with previous environmental surveillance reports, and an assessment of the observed impacts of the plant operation on the environment. The reports shall also include the results of the Land Use Census required by Operational Requirement 3.12.2.

The Annual Radiological Environmental Operating Reports shall include the results of analysis of all radiological environmental samples and of all environmental radiation measurements taken during the period pursuant to the locations specified in the table and figures in the OFFSITE DOSE CALCULATION MANUAL, as well as summarized and tabulated results of these analyses and measurements in the format of the table in the Radiological Assessment Branch Technical Position, Revision 1, November 1979. In the event that some individual results are not available for inclusion with the report, the report shall be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted as soon as possible in a supplementary report. The reports shall also include the following: a summary description of the Radiological Environmental Monitoring Program; at least two legible maps* covering all sampling locations keyed to a table giving distances and directions from the centerline of the reactor; the results of licensee participation in the Interlaboratory Comparison Program and the corrective action taken if the specified program is not being performed as required by Operational Requirement 3.12.3; reasons for not conducting the Radiological Environmental Monitoring Program as required by Operational Requirement 3.12.1, and discussion of all deviations from the sampling schedule of Table 3.12-1; discussion of environmental sample measurements that exceed the reporting levels of Table 3.12-2 but are not the result of plant effluents, pursuant to ACTION b. of Operational Requirement 3.12.1; and discussion of all analyses in which the LLD required by Table 4.12-1 was not achievable.

* One map shall cover stations near the EXCLUSION AREA BOUNDARY; a second shall include the more distant station.

F.2 Annual Radioactive Effluent Release Report
(Formerly part of Specification 6.9.1.4)

Routine Annual Radioactive Effluent Release Report covering the operation of the unit during the previous 12 months of operation shall be submitted by May 1 of each year. The period of the first report shall begin with the date of initial criticality.

The Annual Radioactive Effluent Release Report shall include a summary of the quantities of radioactive liquid and gaseous effluents released from the unit as outlined in 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, with data summarized on a quarterly basis following the format of Appendix B thereof.

The Annual Radioactive Effluent Release Report shall include an annual summary of hourly meteorological data collected over the previous year. This annual summary may be either in the form of an hour-by-hour listing on magnetic tape of wind speed, wind direction, atmospheric stability, and precipitation (if measured), or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability." This report shall include an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the unit or station during the previous calendar year. For the assessment of radiation doses, approximate and conservative methods are acceptable. The assessment of radiation doses shall be performed in accordance with the methodology and parameters in the Offsite Dose Calculation Manual (ODCM).

The Annual Radioactive Effluent Release Report shall also include an assessment of radiation doses to the likely most exposed MEMBER OF THE PUBLIC from reactor releases and other nearby uranium fuel cycle sources, including doses from primary effluent pathways and direct radiation, for the previous calendar year to show conformance with 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operation."

The Annual Radioactive Effluent Release Report shall also include the dose contribution from return/re-use of previously radioactive effluents (tritium from the lake) at the end of each year. If the dose from the particular pathway is greater than 10 percent of the total dose from all pathways from plant releases (liquid, gaseous, iodines particulates > 8 day half life's & tritium from gaseous releases) the dose from the return of previously discharged effluents is to be reported. The total body, each organ, and each age group if applicable the dose should be calculated at the end of year unless it is known to be less than 10 percent of all doses.

The Annual Radioactive Effluent Release Report shall include a list and description of unplanned releases, from the site to UNRESTRICTED AREAS, of radioactive materials in gaseous and liquid effluents made during the reporting period.

The Annual Radioactive Effluent Release Report shall include any changes made during the reporting period to the ODCM, pursuant to Technical Specification 6.14, as well as any major change to Liquid and Gaseous Radwaste Treatment Systems pursuant to ODCM, Appendix F, Section F.3. It shall also include a listing of new locations for dose calculations and/or environmental monitoring identified by the Land Use Census pursuant to Operational Requirement 3.12.2.

The Annual Radioactive Effluent Release Report shall also include the following: an explanation as to why the inoperability of liquid or gaseous effluent monitoring instrumentation was not corrected within the time specified in Operational Requirement 3.3.3.10 or 3.3.3.11, respectively; and a description of the events leading to liquid holdup tanks or gas storage tanks exceeding the limits of Technical Specifications or PLP-114.

The Annual Radioactive Effluent Release Report shall include any dose calculations that were performed as a result of a spill or leak from the site that occurred during the reporting period. The Annual Radioactive Effluent Release Report shall include a summary of any on-site spills and leaks that occurred during the reporting period that are communicated IAW the NEI Voluntary Groundwater Initiative.

** In lieu of submission with the Annual Radioactive Effluent Release Report, the licensee has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.

F.3 Major Changes to Liquid and Gaseous Radwaste Treatment Systems*
(Formerly part of Specification 6.15)

Licensee-initiated major changes to the Radwaste Treatment Systems (liquid and gaseous):

- a. Shall be reported to the Commission in the Annual Radioactive Effluent Release Report for the period in which the evaluation was reviewed by the PNSC (ORC). The discussion of each change shall contain:
 1. A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR 50.59.
 2. Sufficient detailed information to totally support the reason for the change without benefit of additional or supplemental information.
 3. A detailed description of the equipment, components, and processes involved and the interfaces with other plant systems.
 4. An evaluation of the change, which shows the predicted releases of radioactive materials in liquid and gaseous effluents that differ from those previously predicted in the License application and amendments thereto.
 5. An evaluation of the change, which shows the expected maximum exposures, to a MEMBER OF THE PUBLIC in the UNRESTRICTED AREA and to the general population, that differ from those previously estimated in the License application and amendments thereto.
 6. A comparison of the predicted releases of radioactive materials in liquid and gaseous effluents to the actual releases for the period prior to when the change is to be made.
 7. An estimate of the exposure to plant operating personnel as a result of the change.
 8. Documentation of the fact that the change was reviewed and found acceptable by the PNSC (ORC).
- b. Shall become effective upon review and acceptance by the PNSC (ORC).

* Licensees may choose to submit the information called for in the Operational Requirement as part of the annual FSAR update

G.0 | APPENDIX G

DEFINITIONS

The defined terms of this section appear in capitalized type and are applicable throughout the ODCM Operational Requirements.

ACTION

ACTION shall be that part of an ODCM Operational Requirement which prescribes remedial measures required under designated conditions.

ANALOG CHANNEL OPERATIONAL TEST

An ANALOG CHANNEL OPERATIONAL TEST shall be the injection of a simulated signal into the channel as close to the sensor as practicable to verify OPERABILITY of alarm, interlock and/or trip functions. The ANALOG CHANNEL OPERATIONAL TEST shall include adjustments, as necessary, of the alarm, interlock and/or Trip Setpoints such that the Setpoints are within the required range and accuracy.

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 sensors and alarm, interlock and/or trip functions and may be performed by any series of sequential, overlapping, or total channel steps such that the entire channel is calibrated.

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 instrument channels measuring the same parameter.

DIGITAL CHANNEL OPERATIONAL TEST

A DIGITAL CHANNEL OPERATIONAL TEST shall consist of exercising the digital computer hardware using data base manipulation to verify OPERABILITY of alarm and/or trip functions.

DOSE EQUIVALENT I-131

DOSE EQUIVALENT I-131 shall be that concentration of I-131 ($\mu\text{Ci}/\text{gram}$) which 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, "Limits for Intakes of Radionuclides by Workers."

EXCLUSION AREA BOUNDARY

The EXCLUSION AREA BOUNDARY shall be that line beyond which the land is not controlled by the licensee to limit access.

FREQUENCY NOTATION

The FREQUENCY NOTATION specified for the performance of Operational Requirements shall correspond to the intervals defined in Table G-1.

GASEOUS RADWASTE TREATMENT SYSTEM

A GASEOUS RADWASTE TREATMENT SYSTEM is any system designed and installed to reduce radioactive gaseous effluents by collecting primary coolant system off-gases from the primary system and providing for delay or holdup for the purpose of reducing the total radioactivity prior to release to the environment.

DEFINITIONS (continued)

LIQUID WASTE PROCESSING SYSTEM

A LIQUID WASTE PROCESSING SYSTEM provides for the collection, storing, processing, and controlled release of radioactive and potentially radioactive liquids. The system is considered fully utilized when the Modular Fluidized Transfer Demineralization System (MFTDS) is used for the purpose of reducing the total radioactivity prior to release to the environment. Some of the original processing equipment and evaporators have been removed from service but descriptions are still maintained to allow for future reactivation.

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 plant.

OFFSITE DOSE CALCULATION MANUAL

The OFFSITE DOSE CALCULATION MANUAL (ODCM) shall contain the methodology and parameters used in the calculation of offsite doses due to radioactive gaseous and liquid effluents, in the calculation of gaseous and liquid effluent monitoring Alarm/Trip Setpoints, and in the conduct of the Environmental Radiological Monitoring Program.

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).

OPERATIONAL MODE - MODE

An OPERATIONAL MODE (i.e., MODE) shall correspond to any one inclusive combination of core reactivity condition, power level, and average reactor coolant temperature specified in Table G-2.

PROCESS CONTROL PROGRAM

The PROCESS CONTROL PROGRAM (PCP) shall contain the current formulas, sampling, analyses, tests, and determinations to be made to ensure that processing and packaging of solid radioactive wastes based on demonstrated processing of actual or simulated wet solid wastes will be accomplished in such a way as to assure compliance with 10 CFR Parts 20, 61, and 71 and Federal and State regulations, burial ground requirements, and other requirements governing the disposal of radioactive waste.

PURGE - PURGING

PURGE or PURGING shall be any controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or gas is required to purify the confinement.

DEFINITIONS (continued)

RELEASE

A RELEASE shall be the discharge of radioactive effluent from the facility in gaseous, particulate or liquid media. Releases can be further categorized for evaluation purposes:

ABNORMAL/UNPLANNED DISCHARGE – Unplanned or uncontrolled emission of licensed radioactive effluent to the unrestricted area. Release may be batch or continuous discharges. Examples: unintentional discharge of a waste gas decay tank, failure of radiation monitor to terminate a release.

ABNORMAL/UNPLANNED RELEASE – Unplanned or uncontrolled release of licensed radioactive material from the plant within the site boundary.

CONTROLLED RELEASE/DISCHARGE – A pre-planned release which can be controlled through component manipulation to assure the discharge was properly accounted, within ODCM limits, and had a pre-planned method of termination or altering the flow rate.

ELEVATED RELEASE – A gaseous effluent release made from a height that is more than twice the height of adjacent solid structures

GROUND-LEVEL RELEASE – A gaseous release made from a height that is at, or less than, the height of adjacent solid structures.

MONITORED RELEASE – A RELEASE which is monitored through installed or portable samplers.

NON-ROUTINE, PLANNED RELEASE/DISCHARGE – An effluent release from a release point that is not defined in the ODCM but that has been planned, monitored, and discharged in accordance with 10 CFR 20.2001.

UNCONTROLLED RELEASE/DISCHARGE – An effluent release that does not meet the definition of a controlled release

SITE BOUNDARY

For these Operational Requirements, the SITE BOUNDARY shall be identical to the EXCLUSION AREA BOUNDARY defined above.

SOLIDIFICATION

SOLIDIFICATION shall be the conversion of wet wastes into a form that meets shipping and burial ground requirements.

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.

UNRESTRICTED AREA

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

DEFINITIONS (continued)

VENTILATION EXHAUST TREATMENT SYSTEM

A VENTILATION EXHAUST TREATMENT SYSTEM shall be any system designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in effluents by passing ventilation or vent exhaust gases through charcoal adsorbers and/or HEPA filters for the purpose of removing iodines or particulates from the gaseous exhaust stream prior to the release to the environment. Such a system is not considered to have any effect on noble gas effluents. Engineered Safety Features Atmospheric Cleanup Systems are not considered to be VENTILATION EXHAUST TREATMENT SYSTEM components.

VENTING

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

TABLE G-1
 FREQUENCY NOTATION

NOTATION	FREQUENCY*
S	At least once per 12 hours.
D	At least once per 24 hours.
W	At least once per 7 days.
M	At least once per 31 days.
Q	At least once per 92 days.
SA	At least once per 184 days.
R	At least once per 18 months.
S/U	Prior to each reactor startup.
N.A.	Not applicable.
P	Completed prior to each release.

* Each Surveillance Requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25% of the specified surveillance interval.

TABLE G-2
 OPERATIONAL MODES

Mode	Reactivity Condition	Keff	% RATED THERMAL POWER*	AVERAGE COOLANT TEMPERATURE
1	Power Operations	≥ 0.99	$> 5\%$	$\geq 350^{\circ}\text{F}$
2	Startup	≥ 0.99	$\leq 5\%$	$\geq 350^{\circ}\text{F}$
3	Hot Standby	< 0.99	0	$\geq 350^{\circ}\text{F}$
4	Hot Shutdown	< 0.99	0	$350^{\circ}\text{F} > T_{\text{avg}} > 200^{\circ}\text{F}$
5	Cold Shutdown	< 0.99	0	$\leq 200^{\circ}\text{F}$
6	Refueling **	< 0.95	0	$\leq 140^{\circ}\text{F}$

* Excluding decay heat.

** Fuel in the reactor vessel with the vessel head closure bolts less than fully tensioned or with the head removed.

Attachment 10
Summary of Changes to the Process Control Program

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 10

Summary of Changes to the Process Control Program

This attachment includes a summary of changes to the PCP.

Attachment 10
Summary of Changes to the Process Control Program

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

I. Description of Change

The following changes were applied to Revision 14 of PLP-300, Process Control Program:

- 5.2.4- Cleaned up formatting on Table of Vendor Procedures and updated FO-AD-002, to revision 39.
- Added AD-LS-ALL-0019 and AP-004 to procedure references.
- Added Energy Solutions Letter of Transmittal regarding Rev. 39 to FO-AD-002.
- Updated procedure formatting to align with Rev 9 of AD-DC-ALL-0202, Writer's Manual for Procedures and Work Instructions.
- Added explicit approval of changes by Plant General Manager (Non Delegated) as required by Technical Specification 6.13.b.
- Throughout: Changed Plant Nuclear Safety Committee (PNSC) to On Site Review Committee (ORC)



Information Use

HARRIS UNIT 1
PLANT PROGRAM

PLP-300

PROCESS CONTROL PROGRAM

REVISION 14

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REVISION SUMMARY
PRR 2239045 DESCRIPTION
<p>The following changes were implemented in this revision to support implementation of the Process Control Program:</p> <p>5.2.4 Added Table of Vendor Procedures (including Table caption) in the PCP and updated FO-AD-002, to Revision 39 (Reference 7.3.15)</p> <p>Added AD-LS-ALL-0019 and AP-004 to Procedure References.</p> <p>7.3.15: Added Energy Solutions Letter of Transmittal regarding Rev. 39 to FO-AD-002.</p> <p>Updated procedure formatting to align with Rev 9 of AD-DC-ALL-0202, Writer's Manual for Procedures and Work Instructions.</p> <p>5.2 & 5.4: Added explicit approval of changes by Plant General Manager (Non Delegated) as required by Technical Specification 6.13.b. (PRR 2235934)</p> <p>Throughout: Changed Plant Nuclear Safety Committee (PNSC) to On-Site Review Committee (ORC) (PRR 2129831)</p>

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1.0 PURPOSE

1. The purpose of the Process Control Program (PCP) is to establish the management responsibilities and controls used at Harris Nuclear Power Plant (HNP) to provide reasonable assurance of complete dewatering and solidification of various radioactive waste.

2.0 SCOPE

1. This procedure demonstrates compliance with 10CFR20, 10CFR61, Plant Technical Specifications, Federal and State regulation, burial site requirements and other requirements governing the disposal of radioactive waste.

3.0 DEFINITIONS

1. **Batch** - For the purpose of the HNP PCP, a batch is a specific quantity of a particular waste stream which can be isolated from further inputs. This may be the volume in a tank or in a liner.
2. **Dewatering** - The process of removing water from a bed of solid waste. Dewatering processes can also be used to prepare solid waste for shipment without solidification using cement or other chemical agents. Dewatered waste must meet NRC and burial site conditions on the utmost drainable liquid content.
3. **High Integrity Containers (HICs)** - Containers certified by the burial state to meet the stability requirements for wastes requiring stability for disposal.
4. **Liner** - A container into which radioactive waste is placed for shipment to the burial site.
5. **Qualified Process Control Program** - A PCP which the testing to meet 10CFR61 requirements is underway or test results have been transmitted to the NRC, or agreement state, for approval.
6. **Scaling Factor** - The ratio of a hard to measure isotope to an isotope that is easily measured through techniques such as gamma-spectral analysis.
7. **Solidification** - The process of converting wet wastes, pretreatment chemicals, cement and the appropriate additives together to produce a free standing solidified form that meets shipping and burial ground requirements.

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3.0 DEFINITIONS (continued)

8. **Solidification Formulation** - The quantities of waste, pretreatment chemicals, cement and additives required to affect solidification. Also referred to as the recipe.
9. **Stable Waste** - Wastes that, by virtue of their radionuclide content, have been dewatered in high integrity containers or solidified using a solidification formulation that results in a solidified product that meets the performance requirements of 10CFR61.56, Waste Characteristics.
10. **Unstable Waste** - Wastes that, by virtue of their radionuclide content, have been dewatered in steel liners or solidified to meet the lowest requirements of 10CFR61.56(a).
11. **Waste Classification** - The determination of a waste class as outlined in 10CFR61 by radionuclide isotopic analysis or correlation with other measured nuclides.
12. **Waste Streams** - Radioactive wastes are divided into separate waste streams categories based on scaling factors and characteristics of the waste.

4.0 RESPONSIBILITIES

4.1 General Manager - Harris Plant

1. Ensures that radioactive waste is processed and shipped per the appropriate state and federal regulations.

4.2 Manager - RP

1. Assures spent resin, radwaste filters, radwaste sludge, and radwaste evaporator concentrates and other radioactive wastes are processed and packaged per Attachment 1, Solid Radwaste Programmatic Controls, HPP-830, the PCP, and plant procedures.
2. Ensures that radioactive wastes are stored and shipped per plant procedures; and the state, burial site, and federal regulations.
3. Ensures radioactive wastes are sampled and classified per 10CFR61.

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4.3 PCP Coordinator (continued)

4.3 PCP Coordinator

1. Advises plant management on the appropriate technical standards, regulations, and requirements related to solidification and dewatering of radioactive waste.
2. Ensures the vendor's PCP and solidification/dewatering procedures are reviewed and approved as required.
3. Retains vendor supplied documentation for NRC inspection and review.
4. Advises plant management on the appropriate technical standards, regulations, and requirements related to storage and shipment of radioactive waste.

5.0 INSTRUCTIONS

5.1 Background Information

1. The installed plant solidification system at HNP failed to meet the requirements of 10CFR61 and has been abandoned. Vendor processes and equipment are used for solidification / dewatering of radioactive waste. Attachment 1, Solid Radwaste Programmatic Controls, requires the Solid Radwaste System to be used per a vendor PCP to meet shipping and transportation requirements and disposal site criteria. It is the objective of the HNP PCP to provide reasonable assurance of meeting, the applicable shipping, transportation, and disposal site requirements by:
 - Requiring solidification, dewatering, packaging, waste classification, and transportation to be done per the HNP PCP and approved plant procedures.
 - Defining the various solid radwaste waste streams at HNP.
 - Providing management programmatic controls for vendor solidification and dewatering of these waste streams.
 - Implementing the burial site disposal criteria.
 - Implementing a sampling and waste classification system per 10CFR61.55 and 10CFR20.2006 Appendix F to 20.1001-20.2402.

- Providing a quality control program required by 10CFR20.2006 Appendix F to 20.1001-20.2402.

5.2 Review, Approval, And Changes

1. The HNP PCP shall be reviewed by the On-Site Review Committee (ORC), approved by the Plant General Manager (Non-Delegated) and approved by the NRC before implementation. Revision 0 of the HNP PCP was submitted to the NRC in September 1985 and approved in the Shearon Harris Safety Evaluation Report, (NUREG-1038) Supplement #3.
2. Changes to the Process Control Program shall become effective after:
 - a. Review and acceptance by the Onsite Review Committee (ORC) which was formerly known as the Plant Nuclear Safety Committee. Section 7.3 Miscellaneous Document 8, **[TS 6.13.b]**
 - b. Approval by the Plant General Manager (Non-Delegated). Section 7.3 Miscellaneous Document 8, **[TS 6.13.b]**
3. Vendor PCP procedures shall be included in the HNP PCP and are subject to the same review by the ORC as changes to this Program. These procedures are contained in the following Table 1, Vendor Procedures:

Table 1, Vendor Procedures

Vendor Procedure	Vendor Revision Number	Vendor Procedure Title
CS-OP-PR-008	4	Setup And Operation Of Energy Solutions Self-Engaging Dewatering System Fillhead
CS-OP-PR-010	4	Bead Resin/Activated Carbon Dewatering Procedure For Energy Solutions 14-215 Or Smaller Liners, Utilizing Energy Solutions Self-Engaging Dewatering System (S.E.D.S)
FO-AD-002	39	Operating Guidelines For Use Of Polyethylene High Integrity Containers

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5.3 General Requirements

1. All radioactive waste shall be processed, packaged, classified, and shipped to the burial site per the requirements of the HNP PCP.
2. Class A Unstable waste products need only demonstrate that the product is a free standing monolith with **NO** more than 0.5 percent of the waste volume as free liquid. Qualified Individuals shall ensure that Class A Stable, Class B and Class C wastes meet stability requirements of 10CFR61 or be packaged in a High Integrity Container approved by the burial site.
3. Solidification or dewatering shall be done by qualified individuals who have completed a solidification or dewatering training and qualification program.
4. If solidification does not meet disposal site and shipping/transportation requirements, the PCP Coordinator/designee shall immediately suspend shipment of inadequately processed waste and correct the PCP, the implementing procedures, or the Solid Waste Processing System to prevent recurrence.
5. If solidification is not performed per the HNP PCP, the PCP Coordinator/designee shall ensure the processed waste in each container is tested to ensure it meets burial site and shipping requirements and take appropriate actions to prevent recurrence.
6. With the installed Solid Waste Processing equipment incapable of meeting requirements of Attachment 1, Solid Radwaste Programmatic Controls, or declared inoperable, the PCP Coordinator/designee shall ensure the equipment is returned to operable status or provide for contract capability to process waste as necessary to satisfy applicable transportation and disposal requirements.

5.4 Implementation

1. The HNP PCP shall be implemented by use of approved plant procedures. These procedures shall provide step-by-step direction for the operation of solidification/dewatering systems and for transportation/disposal of waste at a licensed burial facility. All plant procedures which implement the PCP shall be reviewed and approved per Technical Specification 6.13 as follows:

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5.4 Implementation (continued)

- a. Review and acceptance by the Onsite Review Committee (ORC) which was formerly known as the Plant Nuclear Safety Committee. Section 7.3 Miscellaneous Document 8 **[TS 6.13.b]**
- b. Approval by the Plant General Manager (Non-Delegated). Section 7.3 Miscellaneous Document 8 **[TS 6.13.b]**

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5.5 Waste Streams

1. Radioactive wastes are divided into separate waste stream categories based on scaling factors and characteristics of the waste or batch. Waste streams at HNP include, but are not limited to:
 - Dry Active Waste (DAW)
 - Radwaste Filters
 - Radwaste Resin/Charcoal
 - CVCS Resin/BTRS Resin/Spent Fuel Pool Resin
 - Sludge
 - Evaporator Concentrates
 - Spent Fuel Pool Charcoal
 - Spent Fuel Pool Filters
 - Decontamination Waste
 - Oil

5.6 Vendor Solidification/Dewatering Requirements

1. Before performing solidification/dewatering services at HNP, the vendor shall provide documentation on the following for Duke Energy review, evaluation, and retention:
 - a. A qualified PCP or a program approved by the NRC, or agreement state. For each low-level radioactive waste formulation, the PCP (reference HPP-830 for current vendor PCP) for addressing the boundary conditions for processing the waste to provide reasonable assurance that the final waste form will meet 10CFR61 stability requirements.
 - b. Topical Report for Solidification/Dewatering including review and acceptance letter from the NRC, or agreement state.
 - c. Copy of the 10CFR61 Testing Program to meet stability requirements including submittal letter or NRC approval letter. This is not required if the vendor only performs dewatering service or solidification of waste not requiring stability.

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5.6 Vendor Solidification/Dewatering Requirements (continued)

- d. Sketch or drawing of the solidification/dewatering process system.
 - e. Detailed procedures for operation of the solidification/dewatering equipment, inspection, and use of containers.
 - f. Documentation that the operator has been qualified per the vendor's solidification/dewatering training and qualification program.
 - g. Identification of solidification agent(s) and formulation used by the process.
 - h. Copies of the Technical Specification(s) and Safety Data Sheets for all chemicals that will be used by the vendor.
 - i. Certificate of Compliance for any High Integrity Containers and a list of incompatible waste.
2. The vendor is accountable to the PCP Coordinator/designee for the solidification /dewatering of liquid waste. The RP unit is responsible for shipping of solidified and dewatered wastes.
 3. Solidification/dewatering shall be done by qualified individuals who have completed a solidification/dewatering training and qualification program. Certification shall be provided by the vendor for vendor operators and shall be on file prior to any solidification/dewatering work performed by the individual.
 4. Solidification/dewatering shall be done per approved procedures described in HPP-830.
 5. As required by Attachment 1, Solid Radwaste Programmatic Controls, a test solidification of at least every tenth batch of each type of wet radioactive waste shall be performed. Test solidification of every batch may be performed if desired.
 6. If any test specimen fails to verify solidification, the solidification of the batch under test shall not be performed until such time as additional test specimens can be obtained, alternative solidification parameters can be determined, and a subsequent test verifies solidification. Solidification of the batch may then be resumed using the alternative solidification parameters.

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5.6 Vendor Solidification/Dewatering Requirements (continued)

7. **IF** the initial test specimen from a batch of waste fails to verify solidification, **THEN** representative test samples shall be collected from each consecutive batch of the same type of wet waste until at least three consecutive initial test specimens demonstrate solidification.
8. For high activity waste, where handling samples could result in personnel radiation exposures which are inconsistent with ALARA principles, representative non-radioactive samples may be test solidified. These samples shall be as close to the actual waste and chemical properties as possible. For resins, the resin beads shall be depleted prior to test solidification.
9. The quality of the solidified/dewatered product shall meet or exceed regulatory requirements and the disposal site criteria prior to release from the HNP site. Copies of the site disposal criteria shall be maintained by the PCP Coordinator/designee. The site disposal criteria requirements are implemented as requirements by reference from this PCP.

5.7 High Integrity Containers

1. With the approval from the land disposal facility, wastes may be disposed of in approved high integrity containers (HICs). Certificate of Compliance from the disposal facility shall be on file prior to use of any high integrity containers.
2. The utmost allowable free liquid in a high integrity container shall be less than one percent of the waste volume.
3. Corrosion and chemical tests to be performed to confirm the suitability of the proposed container. List of prohibited contents shall be available. If it is suspected that the waste may contain any of the prohibited chemicals, chemical tests shall be run to verify the absence of the chemical. At the least, the waste pH shall be determined to be within the acceptable range for the HIC.
4. Written procedure or documentation for use, inspection, and storage of a HIC shall be provided by the manufacturer/supplier.
5. The length of on-site storage of HICs may vary depending on the type of container. Procedures for use and storage of HICs need to contain specific storage times. Photosensitive containers shall be kept out of direct sunlight and away from any other sources of ultraviolet radiation.

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6. HICs shall be inspected prior to use.

5.8 Reporting Of Mishaps

1. Any knowledge of misuse or failure of waste forms and containers shall be reported to the NRC's Director of the Division of Low Level Waste Management and Decommissioning as well as the designated State disposal site regulatory authority within 30 days of the knowledge of the incident. An Condition Report shall be completed and sent to Regulatory Compliance Unit. For any such waste form mishap occurrence, the affected waste form shall not be shipped off-site until approval is obtained from the disposal site regulatory authority. Such mishaps include, but are not necessarily limited to:
 - a. The failure of high integrity containers used to ensure structural stability. Such failure may be evidenced by changed container dimensions, cracking, or injury from mishandling.
 - b. The misuse of high integrity containers, as evidenced by a quantity of free liquid greater than or equal to one percent of the waste volume, or an excessive void space within the container.
 - c. The production of solidified Class A Stable, Class B, or Class C waste form that has any of the following characteristics:
 - (1) Greater than 0.5 percent volume of free liquid.
 - (2) Concentrations of radionuclides greater than the concentrations demonstrated to be stable in the waste form in qualification testing accepted by the regulatory agency.
 - (3) Greater or lesser amounts of solidification media than were used in qualification testing accepted by the regulatory agency.
 - (4) Contains chemical ingredients not present or accounted for in qualification testing accepted by the regulatory agency.
 - (5) Shows instability evidenced by crumbling, cracking, spalling, voids, softening, disintegration, non homogeneity, or change in dimensions.

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5.8 Reporting Of Mishaps (continued)

- (6) Evidences processing phenomena that exceed the limiting processing conditions identified in applicable topical reports or PCPs, such as foaming, excessive temperature, premature or slow hardening, production of volatile material.

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5.9 10CFR61 Implementation

Solidified radioactive waste packaged for disposal at a licensed burial facility shall meet the requirements of 10CFR61.

5.9.1 Waste Classification 10CFR61.55

1. Waste is determined to be generally unacceptable for near-surface disposal if it contains any of the radionuclides listed in Table 1 and 2 of 10CFR61.55 in concentrations exceeding the limits established for the radionuclides. Compliance with these limits shall be determined prior to shipment.
2. Waste transported for disposal must be classified as Class A, Class B, or Class C for the purpose of segregation at the disposal site. The waste class is based on the concentration of certain radionuclides in the waste form as given in 10CFR61.55.
3. Waste shall be classified based on isotopic analysis and the use of scaling factors for hard to measure isotopes. Initially, generic scaling factors will be used for waste classification. Each waste stream shall then be sampled after the first three months of commercial operation or prior to the first shipment if generated after the first three months of commercial operation.
4. Confirmatory sampling for Class A waste shall be performed on a biennial basis. Class B and Class C wastes shall be sampled for confirmation of scaling factors at least on an annual basis. These frequencies may be extended based on fuel performance factors influencing the affected waste stream. Samples shall not be required if the waste stream is not generated during the sampling frequency. These infrequently generated waste stream shall be sampled and the scaling factors updated prior to shipment. In addition, a waste stream shall be sampled if it is determined that a factor of 10 shift in any scaling factor has occurred in that waste stream.
5. If the plant is in an outage period at the same time the sampling period is due, the sampling period may be delayed until after the outage period. The preference is that resampling not be completed until after two months at full power operation to allow the reactor water chemistry and waste stream characteristics to stabilize.

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5.9.1 Waste Classification 10CFR61.55 (continued)

6. A computerized waste classification and shipping program is normally used to determine waste classification from isotopic analysis and the scaling factors. Manual methods may be used if the computer system is not available. Waste Classification is controlled by AD-RP-ALL-5000, Preparation and Shipment of Radioactive Material and Radioactive Waste.

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5.9.2 Radioactive Waste Characteristics 10CFR61.56

1. The eight lowest waste characteristics identified in 10CFR61.56(a) and listed below shall apply to any waste solidified or dewatered at HNP.
 - a. Waste must not be packaged for disposal in cardboard or fiberboard boxes.
 - b. Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the liquid.
 - c. Solid waste containing liquid shall contain as little free standing and noncorrosive liquid as is reasonably achievable, but in **NO** case shall the liquid exceed 1% of the volume.
 - d. Waste must not be readily capable of detonation, explosive decomposition, reaction at normal pressures and temperatures, or of explosive reaction with water.
 - e. Waste must not contain, or be capable of generating:
 - (1) Quantities of toxic gases
 - (2) Vapors
 - (3) Fumes harmful to persons transporting, handling, or disposing of the waste.
 - f. Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.
 - g. Waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20°C. Total Activity must not exceed 100 curies per container.
 - h. Waste containing hazardous, biological, pathogenic, or infectious material must be treated to reduce the potential hazard from the non-radiological materials within the allowable limits.
2. Waste stability requirements are assured by the requirement in Section 5.3 for the vendor to provide a copy of the 10CFR61 Testing Program for Waste Stability.

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5.9.3 Labeling 10CFR61.57

1. Each package of waste shall be clearly labeled to identify the appropriate waste classification per Section 5.6 Step 1.

5.10 10CFR20.2006 Implementation

Radioactive waste transferred for disposal by Harris Nuclear Plant shall meet the requirements of 10CFR20.2006 and Appendix F to 20.1001-20.2402.

5.10.1 Shipment Manifest

The requirements of 10CFR20.2006 and Appendix F to 20.1001-20.2402 for shipment manifest and record keeping shall be included in AD-RP-ALL-5000, Preparation and Shipment of Radioactive Material and Radioactive Waste.

5.10.2 Quality Control Program

1. The quality control program consists of required use of plant procedures which implement the PCP and audits by personnel independent of the activities.
2. The PCP and implementing procedures for processing and packaging radioactive wastes are audited once per 24 months by Nuclear Oversight (NOS) per DUKE-QAPD-001, Duke Energy Corporation Topical Report Quality Assurance Program Description Operating Fleet. These audits shall be reviewed by the Superintendent - RP.

6.0 RECORDS

1. No QA records are generated by this procedure.

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7.0 REFERENCES

7.1 Commitments

None

7.2 Procedures

1. [AP-004](#), HNP Procedures Administration and Control Program
2. [AD-LS-ALL-0019](#), On Site Review Committee
3. [AD-RP-ALL-5000](#), Preparation and Shipment of Radioactive Material and Radioactive Waste
4. [HPP-830](#), Process Control Program Implementation

7.3 Miscellaneous Documents

1. 10CFR20.2006, Transfer for Disposal and Manifests
2. 10CFR61, Licensing Requirements for Land Disposal of Radioactive Waste
3. CS-OP-PR-008, PCP Energy Solutions Setup & Operation of SEDS Fillhead
4. CS-OP-PR-010, PCP Energy Solutions SEDS Dewatering Bead Resin or Activated Carbon
5. DUKE-QAPD-001, Duke Energy Corporation Topical Report Quality Assurance Program Description Operating Fleet
6. EPRI BTP Implementation Guide 2016 (EPRI Report 3002008189)
7. FO-AD-002, PCP Energy Solutions Operating Guidelines For Use of Polyethylene High Integrity Containers
8. HNP Technical Specification 6.13, Process Control Program
9. Issuance of Final Branch Technical Position on Concentration Averaging and Encapsulation, Revision in Part to Waste Classification Technical Position - February 2015
10. NUREG-0133, Preparation of Radiological Effluent Technical Specification for Nuclear Power Plants
11. NUREG-0472, Radiological Effluent Technical Specification for PWR, July 1979

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7.3 Miscellaneous Documents (continued)

12. NUREG-1038, Supplement #3, Safety Evaluation Report
13. Technical Position on Waste Form - January 1991
14. USNRC Generic Letter 89-01, Implementation of Programmatic Controls for Radiological 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
15. Energy Solutions Letter of Transmittal (CC#0568, 10/23/18), FO-AD-002, Rev. 39, OPERATING GUIDELINES FOR USE OF POLYETHYLENE HIGH INTEGRITY CONTAINERS.

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3/4.11.3 SOLID RADIOACTIVE WASTES (historical information removed from Technical Specifications)

OPERATIONAL REQUIREMENT

3.11.3 Radioactive wastes shall be solidified **OR** dewatered per the PROCESS CONTROL PROGRAM to meet shipping and transportation requirements during transit, **AND** disposal site requirements when received at the disposal site.

APPLICABILITY: At all times.

ACTION:

- a. With SOLIDIFICATION **OR** dewatering **NOT** meeting disposal site **AND** shipping **AND** transportation requirements, suspend shipment of the inadequately processed wastes **AND** correct the PROCESS CONTROL PROGRAM, the procedures, **OR** the Solid Waste System as necessary to prevent recurrence.
- b. With SOLIDIFICATION **OR** dewatering **NOT** performed per the PROCESS CONTROL PROGRAM, test the improperly processed waste in each container to ensure that it meets burial ground **AND** shipping requirements **AND** take appropriate administrative action to prevent recurrence.

SURVEILLANCE REQUIREMENTS

4.11.3 SOLIDIFICATION of at least one representative test specimen from at least every tenth batch of each type of wet radioactive wastes (for example, filter sludges, spent resins, evaporator bottoms, boric acid solutions, and sodium sulfate solutions) shall be verified per the PROCESS CONTROL PROGRAM:

- a. **IF** any test specimen fails to verify SOLIDIFICATION, the SOLIDIFICATION of the batch under test shall be suspended until such time as additional test specimens can be obtained, alternative SOLIDIFICATION parameters can be determined per the PROCESS CONTROL PROGRAM, **AND** a subsequent test verifies SOLIDIFICATION. SOLIDIFICATION of the batch may **THEN** be resumed using the alternative SOLIDIFICATION parameters determined by the PROCESS CONTROL PROGRAM;

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- b. **IF** the initial test specimen from a batch of waste fails to verify SOLIDIFICATION, the PROCESS CONTROL PROGRAM shall provide for the collection **AND** testing of representative test specimens from each consecutive batch of the same type of wet waste until at least three consecutive initial test specimens demonstrate SOLIDIFICATION. The PROCESS CONTROL PROGRAM shall be modified as required, as provided in Technical Specification 6.13, to assure SOLIDIFICATION of subsequent batches of waste; **AND**

- c. With the installed equipment incapable of meeting Effluent Specification 3.11.3 **OR** declared inoperable, restore the equipment to OPERABLE status **OR** provide for contract capability to process wastes as necessary to satisfy all applicable transportation **AND** disposal requirements.

3/4.11.3 SOLID RADIOACTIVE WASTES

BASES

This specification implements the requirements of 10CFR50.36a, 10CFR61, **AND** General Design Criterion 60 of Appendix A to 10CFR50. The process parameters included in establishing the PROCESS CONTROL PROGRAM may include, but are **NOT** limited to, waste type, waste pH, waste/liquid/SOLIDIFICATION agent/catalyst ratios, waste oil content, waste principal chemical constituents, **AND** mixing and curing times.

ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT

6.9.1.4 Routine Annual Radioactive Effluent Release Reports covering the operation of the unit during the previous year of operation shall be submitted by May 1 of each year. The period of the first report shall begin with the date of initial criticality.

The Annual Radioactive Effluent Release Reports shall include a summary of the quantities of radioactive liquid **AND** gaseous effluents **AND** solid waste released from the unit as outlined in 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, with data summarized on a quarterly basis following the format of Appendix B thereof. For solid wastes, the format for Table 3 in Appendix B shall be supplemented with three additional categories: class of solid wastes (as defined by 10CFR61), type of container (for example, Type A, Type B) and SOLIDIFICATION agent or absorbent (for example, cement).

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<< Solid Radwaste Programmatic Controls >>

6.15 MAJOR CHANGES TO SOLID RADWASTE TREATMENT SYSTEMS* (Operational Requirement)

Licensee-initiated major changes to the Solid Radwaste Treatment Systems:

- a. Shall be reported to the Commission in the Annual Radioactive Effluent Release Report for the period in which the evaluation was reviewed per Technical Specification 6.9. The discussion of each change shall contain:
 1. A summary of the evaluation that led to the determination that the change could be made per 10CFR50.59;
 2. Sufficient detailed information to totally support the reason for the change without benefit of additional **OR** supplemental information;
 3. A detailed description of the equipment, components, **AND** processes involved **AND** the interfaces with other plant systems;
 4. An evaluation of the change, which shows the predicted quantity of solid waste that differ from those previously predicted in the License application **AND** amendments thereto;
 5. A comparison of the predicted releases of radioactive materials, in solid waste, to the actual releases for the period prior to **WHEN** the change is to be made;
 6. An estimate of the exposure to plant operating personnel as a result of the change; **AND**
 7. Documentation of the fact that the change was reviewed **AND** found acceptable per Technical Specification 6.13.

- b. Shall become effective upon review **AND** acceptance per Technical Specification 6.13.

*Licensees may choose to submit the information called for in this Operational Requirement as part of the annual FSAR update.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 11

Summary of Major Modifications to the Radioactive Waste Treatment Systems

This attachment includes a description of major modifications to the radioactive waste treatment systems that are anticipated to affect effluent releases.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

There were no major modifications to Shearon Harris Nuclear Power Plant liquid or solid waste treatment systems in 2019.

Attachment 12
Errata to a Previous Year's ARERR

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

ATTACHMENT 12

Errata to a Previous Year's ARERR

This attachment includes any amended pages from a previous year's ARERR.

Attachment 12
Errata to a Previous Year's ARERR

Shearon Harris Nuclear Power Plant Unit 1
Period 1/1/2019 - 12/31/2019

There were no changes to a previous year's Annual Radiological Effluent Release Report.

Enclosure 4
RA-20-0078

ENCLOSURE 4: [MNS Annual Radioactive Effluent Release Report](#)



McGuire Nuclear Station Units 1 and 2

Annual Radioactive Effluent Release Report

January 1, 2019 through December 31, 2019

Dockets 50-369 and 50-370



Introduction

The Annual Radioactive Effluent Release Report is pursuant to McGuire Nuclear Station Technical Specification 5.6.3 and Selected Licensee Commitment 16.11.17. The below listed attachments to this report provide the required information. In addition, the ODCM is included pursuant to McGuire Nuclear Station Technical Specification 5.5.1.

- Attachment 1 Summary of Gaseous and Liquid Effluents
- Attachment 2 Supplemental Information
- Attachment 3 Solid Radioactive Waste Disposal
- Attachment 4 Meteorological Data
- Attachment 5 Unplanned Offsite Releases
- Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public
- Attachment 7 Information to Support the NEI Ground Water Protection Initiative
- Attachment 8 Inoperable Equipment
- Attachment 9 Summary of Changes to the Offsite Dose Calculation Manual
- Attachment 10 Summary of Changes to the Process Control Program
- Attachment 11 Summary of Major Modifications to the Radioactive Waste Treatment Systems
- Attachment 12 Errata to a Previous Year's ARERR

Attachment 1
Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 1

Summary of Gaseous and Liquid Effluents

This attachment includes a summary of the quantities of radioactive liquid and gaseous effluents as outlined in Regulatory Guide 1.21, Appendix B.

Attachment 1

Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
1. Total Release	Ci	5.064E-01	3.412E-01	4.764E-01	5.49E-01	1.873E+00
2. Avg. Release Rate	μCi/sec	6.512E-02	4.339E-02	5.993E-02	6.906E-02	5.939E-02
B. Iodine-131						
1. Total Release	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2. Avg. Release Rate	μCi/sec	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C. Particulates Half-Life ≥ 8 days						
1. Total Release	Ci	1.733E-04	3.499E-04	0.000E+00	0.000E+00	5.232E-04
2. Avg. Release Rate	μCi/sec	2.229E-05	4.450E-05	0.000E+00	0.000E+00	1.659E-05
D. Tritium						
1. Total Release	Ci	1.679E+01	2.292E+01	2.048E+01	1.828E+01	7.848E+01
2. Avg. Release Rate	μCi/sec	2.159E+00	2.916E+00	2.576E+00	2.300E+00	2.489E+00
E. Carbon-14						
1. Total Release	Ci	5.220E+00	4.676E+00	5.504E+00	5.610E+00	2.101E+01
2. Avg. Release Rate	μCi/sec	6.712E-01	5.947E-01	6.924E-01	7.057E-01	6.662E-01
F. Gross Alpha						
1. Total Release	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2. Avg. Release Rate	μCi/sec	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Attachment 1 Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Elevated Releases - Continuous Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life ≥ 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* McGuire Nuclear Station Units 1 and 2 do not have elevated releases.

Attachment 1 Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Elevated Releases - Batch Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life ≥ 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* McGuire Nuclear Station Units 1 and 2 do not have elevated releases.

Attachment 1 Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground Releases - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
None	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
B. Iodines						
None	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C. Particulates Half-Life ≥ 8 days						
CO-60	Ci	1.716E-04	3.499E-04	0.000E+00	0.000E+00	5.215E-04
CS-137	Ci	1.700E-06	0.000E+00	0.000E+00	0.000E+00	1.700E-06
Total for Period	Ci	1.733E-04	3.499E-04	0.000E+00	0.000E+00	5.232E-04
D. Tritium						
H-3	Ci	1.670E+01	2.096E+01	2.043E+01	1.824E+01	7.633E+01
E. Carbon-14 *						
C-14	Ci	1.566E+00	1.403E+00	1.651E+00	1.683E+00	6.303E+00
F. Gross Alpha						
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* 30% of total C-14 released is assumed to be in continuous mode. See Attachment 2, Supplemental Information, of this report.

Attachment 1 Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground Releases - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
AR-41	Ci	4.914E-01	3.177E-01	4.606E-01	5.285E-01	1.798E+00
XE-131M	Ci	0.000E+00	0.000E+00	9.451E-05	0.000E+00	9.451E-05
XE-133	Ci	1.433E-02	2.119E-02	1.571E-02	2.045E-02	7.168E-02
XE-135	Ci	6.567E-04	2.320E-03	0.000E+00	0.000E+00	2.976E-03
Total for Period	Ci	5.064E-01	3.412E-01	4.764E-01	5.490E-01	1.873E+00
B. Iodines						
None	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
C. Particulates Half-Life ≥ 8 days						
	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
D. Tritium						
H-3	Ci	8.716E-02	1.967E+00	4.699E-02	4.275E-02	2.144E+00
E. Carbon-14*						
C-14	Ci	3.654E+00	3.273E+00	3.852E+00	3.927E+00	1.471E+01
F. Gross Alpha						
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
G. Other						
	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* 70% of total C-14 released is assumed to be in batch mode. See Attachment 2, Supplemental Information, of this report.

Attachment 1 Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Mixed-Mode Releases - Continuous Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life ≥ 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* McGuire Nuclear Station Units 1 and 2 do not have mixed-mode releases.

Attachment 1 Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Mixed-Mode Releases - Batch Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life ≥ 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* McGuire Nuclear Station Units 1 and 2 do not have mixed-mode releases.

Attachment 1 Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products *						
1. Total Release	Ci	2.960E-02	4.005E-03	3.224E-03	3.805E-03	4.063E-2
2. Avg. Diluted Conc.	µCi/ml	4.661E-13	6.060E-14	5.374E-14	5.126E-14	1.541E-13
3. Batch Releases	µCi/ml	3.648E-11	4.381E-12	3.164E-12	4.027E-12	1.101E-11
B. Tritium						
1. Total Release	Ci	2.537E+02	2.941E+02	3.616E+02	1.754E+02	1.085E+03
2. Avg. Diluted Conc.	µCi/ml	5.003E-09	1.124E-08	1.050E-08	3.587E-09	7.397E-09
3. Batch Releases	µCi/ml	3.126E-07	3.210E-07	3.546E-07	1.855E-07	2.937E-07
C. Dissolved & Entrained Gases						
1. Total Release	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2. Avg. Diluted Conc.	µCi/ml	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3. Batch Releases	µCi/ml	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
D. Gross Alpha						
1. Total Release	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2. Avg. Diluted Conc.	µCi/ml	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3. Batch Releases	µCi/ml	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E. Volume of Liquid Waste						
1. Continuous Releases	liters	7.640E+07	7.567E+07	5.736E+07	5.279E+07	2.622E+08
2. Batch Releases	liters	9.885E+05	1.062E+06	9.911E+05	6.806E+05	3.722E+06
F. Volume of Dilution Water						
1. Continuous Releases	liters	1.348E+11	1.032E+11	4.359E+10	5.206E+10	3.337E+11
2. Batch Releases	liters	8.112E+11	9.140E+11	1.019E+12	9.447E+11	3.689E+12

* Excludes tritium, dissolved and entrained noble gases, and gross alpha.

Attachment 1
Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Liquid Effluents - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
None	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
B. Tritium						
H-3	Ci	1.383E-01	7.121E-01	1.988E-01	6.468E-02	1.114E+00
C. Dissolved & Entrained Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
D. Gross Alpha						
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Attachment 1 Summary of Gaseous and Liquid Effluents

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
BE-7	Ci	0.000E+00	1.212E-05	0.000E+00	0.000E+00	1.212E-05
CR-51	Ci	0.000E+00	1.164E-05	0.000E+00	0.000E+00	1.164E-05
MN-54	Ci	1.435E-03	1.041E-04	8.621E-06	4.316E-05	1.591E-03
FE-55	Ci	3.736E-03	7.094E-04	1.231E-04	1.455E-04	4.715E-03
CO-57	Ci	7.301E-06	0.000E+00	5.471E-07	0.000E+00	7.848E-06
CO-58	Ci	9.836E-04	1.594E-04	9.775E-05	1.662E-04	1.407E-03
CO-60	Ci	2.094E-02	2.109E-03	1.092E-03	1.017E-03	2.516E-02
NI-63	Ci	1.282E-03	2.000E-04	9.806E-04	1.588E-03	4.050E-03
ZN-65	Ci	1.878E-05	0.000E+00	0.000E+00	0.000E+00	1.878E-05
BR-82	Ci	0.000E+00	2.102E-06	0.000E+00	0.000E+00	2.102E-06
SR-85	Ci	3.557E-06	0.000E+00	0.000E+00	0.000E+00	3.557E-06
NB-95	Ci	2.442E-04	6.577E-06	3.074E-06	0.000E+00	2.538E-04
ZR-95	Ci	2.471E-05	0.000E+00	0.000E+00	0.000E+00	2.471E-05
AG-108M	Ci	0.000E+00	0.000E+00	1.563E-06	0.000E+00	1.563E-06
SN-113	Ci	3.855E-06	0.000E+00	0.000E+00	0.000E+00	3.855E-06
SB-125	Ci	5.913E-04	2.202E-04	3.185E-04	3.748E-04	1.505E-03
TE-123M	Ci	0.000E+00	1.284E-06	0.000E+00	0.000E+00	1.284E-06
CS-137	Ci	3.303E-04	4.687E-04	5.981E-04	4.702E-04	1.867E-03
Total for Period	Ci	2.960E-02	4.005E-03	3.224E-03	3.805E-03	4.063E-02
B. Tritium						
H-3	Ci	2.536E+02	2.934E+02	3.614E+02	1.753E+02	1.084E+03
C. Dissolved & Entrained Gases						
None	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
D. Gross Alpha						
Total for Period	Ci	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

**Attachment 2
Supplemental Information**

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 2

Supplemental Information

This attachment includes supplemental information to the gaseous and liquid effluents report.

Attachment 2 Supplemental Information

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

I. Regulatory Limits - Per Unit

A. Noble Gases - Air Dose

1. Calendar Quarter Gamma Dose	= 5	mRAD
2. Calendar Quarter Beta Dose	= 10	mRAD
3. Calendar Year Gamma Dose	= 10	mRAD
4. Calendar Year Beta Dose	= 20	mRAD

B. Liquid Effluents - Dose

1. Calendar Quarter Total Body Dose	= 1.5	mREM
2. Calendar Quarter Organ Dose	= 5	mREM
3. Calendar Year Total Body Dose	= 3	mREM
4. Calendar Year Organ Dose	= 10	mREM

C. Gaseous Effluents - Iodine-131 & 133, Tritium, and Particulates with Half-lives > 8 days

1. Calendar Quarter Organ Dose	= 7.5	mREM
2. Calendar Year Organ Dose	= 15	mREM

II. Maximum Permissible Effluent Concentrations

A. Gaseous Effluents

1. Information found in Offsite Dose Calculation Manual

B. Liquid Effluents

1. Information found in 10 CFR Part 20, Appendix B, Table 2, Column 2

III. Average Energy

(not applicable)

IV. Measurements and Approximations of Total Radioactivity

Analyses of specific radionuclides in selected or composited samples as described in the Selected Licensee Commitments are used to determine the radionuclide composition of the effluent. A summary description of the method used for estimating overall errors associated with radioactivity measurements is provided as part of this attachment.

V. Batch Releases

A. Liquid Effluents

1. Total Number of Batch Releases	=	205
2. Total Time (min) for Batch Releases	=	1.238E+04
3. Maximum Time (min) for a Batch Release	=	2.590E+02
4. Average Time (min) for Batch Releases	=	6.040E+01
5. Minimum Time (min) for a Batch Release	=	8.000E+00
6. Average Dilution Water Flow During Release (lpm)	=	6.456E+04

B. Gaseous Effluents

1. Total Number of Batch Releases	=	30
2. Total Time (min) for Batch Releases	=	9.996E+05
3. Maximum Time (min) for a Batch Release	=	4.463E+04
4. Average Time (min) for Batch Releases	=	3.332E+04
5. Minimum Time (min) for a Batch Release	=	1.560E+02

VI. Abnormal Releases

See Attachment 5, Unplanned Offsite Releases.

Attachment 2 Supplemental Information

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Carbon-14

Carbon-14 (C-14), with a half-life of 5730 years, is a naturally occurring isotope of carbon produced by cosmic ray interactions in the atmosphere. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. C-14 is also produced in commercial nuclear reactors, but the amounts produced are much less than those produced naturally or from weapons testing.

In Regulatory Guide 1.21, Revision 2, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste", the NRC recommends U.S. nuclear power plants evaluate whether C-14 is a "principal radionuclide", and if so, report the amount of C-14 released. Improvements over the years in effluent management practices and fuel performance have resulted in a decrease in gaseous radionuclide (non-C-14) concentrations, and a change in the distribution of gaseous radionuclides released to the environment. As a result, many sites show C-14 has become a "principal radionuclide" for the gaseous effluent pathway, as defined in Regulatory Guide 1.21, Rev. 2. McGuire Nuclear Station 2019 ARERR contains estimates of C-14 radioactivity released in 2019, and estimates of public dose resulting from the C-14 effluent.

Because the dose contribution of C-14 from liquid radioactive waste is much less than that contributed by gaseous radioactive waste, evaluation of C-14 in liquid radioactive waste is not required (Ref. Reg. Guide 1.21, Rev. 2). The quantity of gaseous C-14 released to the environment can be estimated by use of a C-14 source term scaling factor based on power generation (Ref. Reg. Guide 1.21, Rev. 2). Many documents provide information related to the magnitude of C-14 in typical effluents from commercial nuclear power plants. Those documents suggest that nominal annual releases of C-14 in gaseous effluents are approximately 5 to 7.3 curies from PWRs (Ref. Reg. Guide 1.21, Rev. 2). A more recent study recommends a higher C-14 gaseous source term scaling factor of approximately 9.0 to 9.8 Ci/GWe-yr for a PWR (Westinghouse) (Ref. EPRI 1021106). For the McGuire Nuclear Station 2019 ARERR a source term scaling factor of 9.4 Ci/GWe-yr is assumed. Using a source term scaling factor of 9.4 Ci/GWe-yr and actual electric generation (MWe-hrs) from McGuire Nuclear Station in 2019 results in a site total C-14 gaseous release estimate to the environment of 2.101×10^1 Curies. 70% of the C-14 gaseous effluent is assumed to be from batch releases and 30% of C-14 gaseous effluent is assumed to be from continuous releases through the unit vents (ref. IAEA Technical Reports Series no. 421, "Management of Waste Containing Tritium and Carbon-14", 2004; EPRI 1021106).

C-14 releases in PWRs occur primarily as a mix of organic carbon and carbon dioxide released from the waste gas system. Since the PWR operates with a reducing chemistry, most, if not all, of the C-14 species initially produced are organic (e.g., methane). As a general rule, C-14 in the primary coolant is essentially all organic with a large fraction as a gaseous species. Any time the RCS liquid or gas is exposed to an oxidizing environment (e.g. during shutdown or refueling), a slow transformation from an organic to an inorganic chemical form can occur. Various studies documenting measured C-14 releases from PWRs suggest a range of 70% to 95% organic with an average of 80% organic with the remainder being CO₂ (Ref. EPRI TR-105715). For the McGuire Nuclear Station 2019 ARERR a value of 80% organic C-14 is assumed.

Public dose estimates from airborne C-14 are performed using dose models in NUREG-0133 and Regulatory Guide 1.109. The dose models and assumptions used are documented in the McGuire ODCM. The estimated C-14 dose impact on the maximum organ dose from airborne effluents released from McGuire Nuclear Station in 2019 is well below the 10CFR50, Appendix I, ALARA design objective (i.e., 15 mrem/yr per unit).

Attachment 2
Supplemental Information

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Overall Estimate of Error for Effluent Radioactivity Release Reported

The estimated percentage of overall error for both Liquid and Gaseous effluent release data at McGuire Nuclear Station has been determined to be $\pm 30.3\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

1. Flow Rate Determining Devices = $\pm 20\%$
2. Counting Statistical Error = $\pm 20\%$
3. Calibration Error = $\pm 10\%$
4. Calibration Source Error = $\pm 2.5\%$
5. Sample Preparation Error = $\pm 3\%$

Attachment 2 Supplemental Information

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Summary of Changes in Land Use Census Affecting Effluent Dose Calculations

The 2019 Land Use Census was performed June 5-6, 2019, and the results were certified and made available for use on July 3rd, 2019. The following are changes to residences, gardens, and milk animals from the previous year.

Residences

The residence in the ESE sector (0.71 miles) was replaced with a residence at 0.69 miles.
The residence in the SSW sector (2.56 miles) was replaced with a residence at 1.64 miles.

Gardens

A garden was not found in the N sector during the 2018 MNS LUC, but an irrigated garden was found in the N sector at 3.03 miles during the 2019 MNS LUC.
The non-irrigated garden in the ESE sector (1.93 miles) was replaced with a non-irrigated garden at 1.10 miles.
The non-irrigated garden in the SE sector (1.20 miles) was no longer available and was replaced with another non-irrigated garden at 1.20 miles.
The non-irrigated garden in the SSW sector (2.94 miles) was no longer available and was replaced with another non-irrigated garden at 3.02 miles.

Milk Animals

No changes to nearest milk animal in each sector.

Environmental Monitoring Locations

No changes to environmental monitoring locations in each sector.

Attachment 3
Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 3

Solid Radioactive Waste Disposal

This attachment includes a summary of the solid waste shipped off-site for burial and/or disposal, including:

- Container volume
- Total Curie content
- Principal Radionuclides
- Source/Type of waste
- Solidification agent or absorbent
- Type of shipping container
- Number of shipments
- Other relevant information as necessary

Attachment 3 Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Type of Waste Shipped	Number of Shipments	Number of Containers	Waste Class	Container Type	Burial Volume (m ³)	Total Activity (Curies)
1. <u>Waste from Liquid Systems</u>						
a. Dewatered Powdex Resin (brokered)	None					
b. Dewatered Powdex Resin	None					
c. Dewatered Bead Resin (brokered)	None					
d. Dewatered Bead Resin	None					
e. Dewatered Radwaste System Resin	1	1	A/U	DBP	5.52	1.74
f. Dewatered Primary Bead Resins (brokered)	5	5	B	B	16.99	533
g. Dewatered Mechanical Filter Media	None					
h. Dewatered Mechanical Filter Media (brokered)	None					
i. Solidified Waste	None					
2. <u>Dry Solid Waste</u>						
a. Dry Active Waste (compacted)	None					
b. Dry Active Waste (non-compacted)	None					
c. Dry Active Waste (brokered / compacted)	None					
d. Dry Active Waste (brokered / non-compacted)	11	20	A/U	DBP	570.84	1.768
e. Sealed Sources / Smoke Detectors	None					
f. Sealed Sources	None					
g. Irradiated Components	None					
3. <u>Total Waste</u>	17	26			593.35	536.5

Attachment 3 Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Type of Waste Shipped	Radionuclide	% Abundance
1. <u>Waste from Liquid Systems</u>		
a. Dewatered Powdex Resin (brokered)	No shipments in 2019	
b. Dewatered Powdex Resin	No shipments in 2019	
c. Dewatered Bead Resin (brokered)	No shipments in 2019	
d. Dewatered Bead Resin	No shipments in 2019	
e. Dewatered Radwaste System Resin (brokered) RSR 2019 - 005	<u>Nuclide</u>	<u>%Abundance</u>
	Co-60	8.64
	Cs-137	3.88
	Cs-134	0.03
	Fe-55	4.46
	Ni-63	77.85
	C-14	2.94
	Sb-125	2.09
	Sr-90	0.02
	Tc-99	0.08

Attachment 3 Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

f. Dewatered Primary Bead Resins
(brokered)

RSR 2019 - 0003

<u>Nuclide</u>	<u>%Abundance</u>
H-3	0.01
Mn-54	1.11
Co-57	0.01
Co-58	0.34
Co-60	15.11
Cs-137	0.37
Fe-55	9.81
Ni-63	71.00
C-14	1.18
Be-7	0.19
Ce-144	0.01
Sb-125	0.16
Sr-90	0.02
Zn-65	0.23
Ni-59	0.44

RSR 2019 - 0013

<u>Nuclide</u>	<u>%Abundance</u>
H-3	0.04
Mn-54	2.61
Co-57	0.05
Co-58	0.36
Co-60	22.78
Cs-137	0.33
Fe-55	19.31
Ni-63	51.10
C-14	0.06
Ce-144	0.02
Sb-125	0.36
Sr-90	0.02
Zn-65	0.56
Ni-59	0.39

RSR 2019 - 0014

<u>Nuclide</u>	<u>%Abundance</u>
H-3	0.06
Mn-54	1.95
Co-57	0.04
Co-58	0.28
Co-60	22.90
Cs-137	0.48
Fe-55	19.44
Ni-63	53.41
C-14	0.06
Ce-144	0.03
Sb-125	0.41
Sr-90	0.03
Zn-65	0.52
Ni-59	0.39

Attachment 3 Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

RSR 2019 - 0015	<u>Nuclide</u>	<u>%Abundance</u>
	H-3	0.09
	Mn-54	1.14
	Co-57	0.02
	Co-58	0.14
	Co-60	23.15
	Cs-137	0.71
	Fe-55	19.62
	Ni-63	53.96
	C-14	0.06
	Ce-144	0.04
	Sb-125	0.33
	Sr-90	0.04
	Zn-65	0.31
	Ni-59	0.40

RSR 2019 - 0016	<u>Nuclide</u>	<u>%Abundance</u>
	H-3	0.18
	Mn-54	0.52
	Co-58	0.05
	Co-60	23.19
	Cs-137	1.43
	Fe-55	19.60
	Ni-63	53.98
	C-14	0.06
	Ce-144	0.08
	Sb-125	0.28
	Sr-90	0.08
	Zn-65	0.15
	Ni-59	0.40

- | | | |
|----|----------------------------------------------|----------------------|
| g. | Dewatered Mechanical Filter Media | No Shipments in 2019 |
| h. | Dewatered Mechanical Filter Media (brokered) | No Shipments in 2019 |
| i. | Solidified Waste | No shipments in 2019 |

2. Dry Solid Waste

- | | | |
|----|-----------------------------------------|----------------------------------------|
| a. | Dry Active Waste (compacted) | Compaction no longer performed on site |
| b. | Dry Active Waste (non-compacted) | No shipments in 2019 |
| c. | Dry Active Waste (brokered / compacted) | No shipments in 2019 |

Attachment 3 Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

- d. Dry Active Waste
(brokered / non-compacted)

RSR 2019 - 0002	<u>Nuclide</u>	<u>%Abundance</u>
	Cr-51	12.42
	Mn54	3.93
	Co-57	0.08
	Co-58	16.56
	Co-60	30.36
	Cs-137	0.05
	Fe-55	14.12
	Fe-59	0.61
	Ni-63	1.43
	C-14	0.07
	Nb-95	12.24
	Hf-181	0.02
	Ce-144	0.15
	Sb-124	0.12
	Sb-125	0.56
	Zr-95	6.26
	Sr-90	0.01
	Sn-113	0.31
	Zn-65	0.69

RSR 2019 - 0004	<u>Nuclide</u>	<u>%Abundance</u>
	Cr-51	40.00
	Mn-54	2.15
	Co-57	0.05
	Co-58	15.94
	Co-60	14.53
	Cs-137	0.02
	Fe-55	6.91
	Fe-59	0.93
	Ni-63	0.66
	C-14	0.03
	Nb-95	11.10
	Hf-181	0.03
	Ce-144	0.08
	Sb-124	0.13
	Sb-125	0.27
	Zr-95	6.53
	Sr-90	0.01
	Sn-113	0.22
	Zn-65	0.40

Attachment 3 Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

RSR 2019 - 0006	<u>Nuclide</u>	<u>%Abundance</u>
	Cr-51	47.85
	Mn-54	2.06
	Co-57	0.05
	Co-58	10.68
	Co-60	18.96
	Cs-137	0.02
	Fe-55	7.66
	Fe-59	0.81
	Ni-63	1.91
	H-3	0.13
	C-14	0.12
	Nb-95	4.80
	Ce-144	0.08
	Sb-124	0.33
	Sb-125	0.94
	Zr-95	2.93
	Sr-90	0.01
	Sn-113	0.10
	Zn-65	0.56

RSR 2019 - 0007	<u>Nuclide</u>	<u>%Abundance</u>
	Cr-51	47.49
	Mn-54	2.09
	Co-57	0.05
	Co-58	10.75
	Co-60	19.06
	Cs-137	0.02
	Fe-55	7.73
	Fe-59	0.81
	Ni-63	1.93
	H-3	0.13
	C-14	0.13
	Nb-95	4.84
	Ce-144	0.08
	Sb-124	0.33
	Sb-125	0.95
	Zr-95	2.96
	Sr-90	0.01
	Sn-113	0.10
	Zn-65	0.56

RSR 2019 - 0008	<u>Nuclide</u>	<u>%Abundance</u>
	Cr-51	47.54
	Mn-54	2.08
	Co-57	0.05
	Co-58	10.75
	Co-60	19.05
	Cs-137	0.02
	Fe-55	7.71
	Fe-59	0.81
	Ni-63	1.92
	H-3	0.13
	C-14	0.13
	Nb-95	4.84
	Ce-144	0.08
	Sb-124	0.33
	Sb-125	0.95
	Zr-95	2.95
	Sr-90	0.01
	Sn-113	0.10
	Zn-65	0.56

Attachment 3
Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

RSR 2019 - 0011	<u>Nuclide</u>	<u>%Abundance</u>
	Cr-51	44.36
	Mn-54	2.23
	Co-57	0.05
	Co-58	10.99
	Co-60	20.68
	Cs-137	0.03
	Fe-55	8.34
	Fe-59	0.80
	Ni-63	2.09
	H-3	0.14
	C-14	0.14
	Nb-95	4.99
	Ce-144	0.09
	Sb-124	0.33
	Sb-125	1.03
	Zr-95	3.00
	Sr-90	0.01
	Sn-113	0.11
	Zn-65	0.60

RSR 2019 - 0018	<u>Nuclide</u>	<u>%Abundance</u>
	Cr-51	13.62
	Mn-54	3.75
	Co-57	0.09
	Co-58	10.38
	Co-60	40.09
	Cs-137	0.05
	Fe-55	15.76
	Fe-59	0.49
	Ni-63	4.05
	H-3	0.28
	C-14	0.27
	Nb-95	5.07
	Ce-144	0.15
	Sb-124	0.28
	Sb-125	1.94
	Zr-95	2.62
	Sr-90	0.02
	Sn-113	0.13
	Zn-65	0.96

Attachment 3
Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

RSR 2019 - 0019

Nuclide

%Abundance

Co-60	0.53
Cs-137	0.24
Fe-55	0.23
Ni-63	0.03
C-14	13.69
H-3	84.82
Ce-144	0.41
Sr-90	0.06

Attachment 3 Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

RSR 2019 - 0019	<u>Nuclide</u>	<u>%Abundance</u>
	Cr-51	20.19
	Mn-54	3.42
	Co-57	0.08
	Co-58	11.05
	Co-60	35.18
	Cs-137	0.05
	Fe-55	13.95
	Fe-59	0.59
	Ni-63	3.64
	H-3	0.24
	C-14	0.24
	Nb-95	5.34
	Ce-144	0.13
	Sb-124	0.30
	Sb-125	1.71
	Zr-95	2.86
	Sr-90	0.01
	Sn-113	0.13
	Zn-65	0.89
RSR 2019 - 0021	<u>Nuclide</u>	<u>%Abundance</u>
	Cr-51	0.44
	Mn-54	3.59
	Co-57	0.07
	Co-58	1.91
	Co-60	60.05
	Cs-137	0.11
	Fe-55	25.08
	Fe-59	0.04
	Ni-63	4.47
	H-3	0.24
	C-14	0.24
	Nb-95	0.93
	Ce-144	0.12
	Sb-124	0.04
	Sb-125	1.52
	Zr-95	0.44
	Sr-90	0.03
	Sn-113	0.06
	Zn-65	0.61
RSR 2019 - 0022	<u>Nuclide</u>	<u>%Abundance</u>
	Cr-51	28.61
	Mn-54	3.00
	Co-57	0.07
	Co-58	11.43
	Co-60	29.60
	Cs-137	0.04
	Fe-55	11.84
	Fe-59	0.69
	Ni-63	3.03
	H-3	0.20
	C-14	0.20
	Nb-95	5.44
	Ce-144	0.12
	Sb-124	0.33
	Sb-125	1.45
	Zr-95	3.02
	Sr-90	0.01
	Sn-113	0.13
	Zn-65	0.79

Attachment 3
Solid Radioactive Waste Disposal

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

- | | |
|-------------------------------------|----------------------|
| e. Sealed Sources / Smoke Detectors | No shipments in 2019 |
| f. Sealed Sources | No shipments in 2019 |
| g. Irradiated Components | No shipments in 2019 |

**Attachment 4
Meteorological Data**

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 4

Meteorological Data

This attachment includes a summary of meteorological joint frequency distributions of wind speed, wind direction, and atmospheric stability (hours of occurrence).

Attachment 4 Meteorological Data

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
A	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
	1.01-1.25	5	3	0	0	0	0	0	0	0	1	0	0	0	1	0	
	1.26-1.50	15	6	1	0	0	0	0	1	0	0	1	2	0	1	10	
	1.51-2.00	58	31	11	3	2	1	1	1	0	3	4	10	7	7	22	
	2.01-3.00	62	32	13	5	4	5	0	3	2	9	5	12	11	6	16	
	3.01-4.00	8	8	6	3	1	0	0	2	2	1	1	4	0	0	3	
	4.01-5.00	3	2	9	1	0	0	1	0	1	2	4	2	1	1	0	
	5.01-6.00	3	3	0	0	0	0	0	0	0	0	2	3	1	0	0	
	6.01-8.00	7	2	0	0	0	0	0	0	0	0	1	2	0	0	0	
	8.01-10.00	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
10.01-max	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
B	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
	1.01-1.25	2	0	0	0	1	0	0	0	0	0	0	0	0	0	1	
	1.26-1.50	6	3	1	1	0	0	0	1	0	1	0	0	0	0	3	
	1.51-2.00	17	17	9	2	0	1	0	1	1	0	2	4	2	1	9	
	2.01-3.00	13	17	13	6	6	2	3	0	7	8	6	9	7	2	9	
	3.01-4.00	2	12	10	3	2	3	0	1	1	9	5	4	4	4	1	
	4.01-5.00	2	6	5	1	0	2	0	0	1	2	5	7	3	1	0	
	5.01-6.00	1	2	1	1	0	0	0	0	0	0	3	4	0	0	0	
	6.01-8.00	3	2	0	0	0	0	0	0	0	0	4	2	1	1	2	
	8.01-10.00	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Attachment 4 Meteorological Data

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence																
		Sector																
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
C	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	1.01-1.25	3	0	0	0	0	0	0	0	1	0	0	0	1	0	1	2	
	1.26-1.50	4	5	2	2	0	0	0	0	0	0	0	3	0	1	2	1	
	1.51-2.00	9	10	11	5	2	1	3	0	4	0	5	4	1	2	3	4	
	2.01-3.00	16	22	13	12	7	4	0	2	4	7	16	12	6	6	2	8	
	3.01-4.00	5	13	28	12	2	3	0	0	2	8	8	8	8	6	5	3	
	4.01-5.00	11	10	12	2	0	0	0	0	1	5	7	5	3	6	8	5	
	5.01-6.00	5	6	1	0	0	0	0	0	0	0	8	2	3	1	3	3	
	6.01-8.00	5	6	0	0	0	0	0	0	0	0	0	1	2	2	3	4	
	8.01-10.00	0	1	0	0	0	0	0	0	0	0	0	0	0	3	2	2	
	10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
D	0.46-0.75	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
	0.76-1.00	4	1	3	1	0	0	0	2	2	2	0	1	2	5	4		
	1.01-1.25	5	3	5	1	2	5	1	3	9	1	5	10	9	4	5	7	
	1.26-1.50	13	18	13	6	7	4	5	10	11	6	7	9	10	6	5	10	
	1.51-2.00	32	46	45	31	23	19	34	34	44	22	21	30	31	16	11	19	
	2.01-3.00	53	72	159	92	94	78	57	23	50	68	114	70	44	27	29	24	
	3.01-4.00	38	68	142	59	82	42	27	7	17	80	148	61	38	26	24	36	
	4.01-5.00	22	38	103	14	6	9	3	2	10	43	156	39	12	25	26	26	
	5.01-6.00	19	18	38	0	1	2	1	1	9	26	89	32	7	23	18	21	
	6.01-8.00	15	35	23	0	0	0	0	0	0	8	23	10	4	11	33	32	
	8.01-10.00	0	1	0	0	0	0	0	0	0	0	0	0	0	1	3	6	1
	10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0

Attachment 4 Meteorological Data

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
E	0.46-0.75	0	1	0	1	0	2	1	1	0	0	3	1	2	0	1	0
	0.76-1.00	2	1	2	4	2	0	6	7	2	6	7	4	7	7	2	4
	1.01-1.25	4	0	9	4	7	8	6	19	12	9	17	7	12	6	2	1
	1.26-1.50	7	7	8	10	6	9	14	33	18	14	6	28	17	7	3	6
	1.51-2.00	16	14	27	23	20	16	30	51	67	29	43	51	18	16	13	17
	2.01-3.00	24	33	94	54	69	47	60	44	81	141	125	50	25	17	23	30
	3.01-4.00	13	17	54	16	38	13	28	7	18	60	129	18	21	16	23	16
	4.01-5.00	3	3	46	6	11	1	5	2	8	13	50	11	1	10	18	9
	5.01-6.00	2	2	5	0	1	0	1	0	2	3	14	2	1	1	12	1
	6.01-8.00	0	1	2	0	0	0	0	0	0	2	5	2	1	3	4	1
	8.01-10.00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	
F	0.46-0.75	0	3	1	1	0	1	1	2	1	6	6	5	4	1	0	2
	0.76-1.00	1	1	2	2	2	5	3	5	18	13	11	16	10	3	7	2
	1.01-1.25	4	2	2	1	2	2	4	8	10	16	11	23	8	7	2	0
	1.26-1.50	2	1	0	1	2	1	5	8	17	16	13	17	8	6	3	2
	1.51-2.00	1	2	1	1	0	2	3	14	43	36	28	22	11	1	4	1
	2.01-3.00	0	2	1	0	0	0	2	4	21	29	33	19	5	2	3	0
	3.01-4.00	0	0	0	0	0	0	0	0	1	0	1	0	4	3	1	0
	4.01-5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Attachment 4 Meteorological Data

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
G	0.46-0.75	1	0	1	1	1	1	0	1	1	16	20	11	5	4	4	2
	0.76-1.00	1	1	0	1	0	1	1	3	11	48	57	28	8	1	0	0
	1.01-1.25	0	0	0	0	0	0	0	1	6	19	21	10	4	1	0	0
	1.26-1.50	0	1	1	0	0	1	0	1	9	14	13	5	1	1	2	0
	1.51-2.00	0	0	0	0	0	0	0	5	14	12	12	4	3	0	0	0
	2.01-3.00	0	0	0	0	0	0	0	0	3	2	5	1	2	1	0	0
	3.01-4.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4.01-5.00	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

**Attachment 5
Unplanned Offsite Releases**

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 5

Unplanned Offsite Releases

This attachment includes a summary of the unplanned offsite releases of gaseous and liquid radioactive effluents.

Attachment 5
Unplanned Offsite Releases

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

McGuire Nuclear Station experienced no unplanned offsite releases in 2019.

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 6

Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

(includes fuel cycle dose calculation results)

This attachment includes an assessment of radiation doses to the maximum exposed member of the public due to radioactive liquid and gaseous effluents released from the site for each calendar quarter for the calendar year of the report as well as the total dose for the calendar year.

This attachment also includes an assessment of radiation doses to the maximum exposed member of the public from all uranium fuel cycle sources within 8 km of the site for the calendar year of this report to show conformance with 40 CFR Part 190.

Methods for calculating the dose contribution from liquid and gaseous effluents are given in the Offsite Dose Calculation Manual (ODCM).

Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

McGuire Nuclear Station Units 1 & 2 Period 1/1/2019 - 12/31/2019

Gaseous Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Noble Gases						
1. Maximum Gamma Air	mRAD	1.104E-02	7.159E-03	1.035E-02	1.188E-02	4.043E-02
(a) Limit	mRAD	1.000E+01	1.000E+01	1.000E+01	1.000E+01	2.000E+01
(b) % of Limit		1.104E-01	7.159E-02	1.035E-01	1.188E-01	2.022E-01
2. Maximum Beta Air	mRAD	3.930E-03	2.582E-03	3.686E-03	4.235E-03	1.443E-02
(a) Limit	mRAD	2.000E+01	2.000E+01	2.000E+01	2.000E+01	4.000E+01
(b) % of Limit		1.965E-02	1.291E-02	1.843E-02	2.118E-02	3.608E-02

Receptor Location **0.5 miles NNE**

B. Iodine, H-3, & Particulates						
1. Maximum Organ Dose	mREM	1.799E-01	1.663E-01	1.848E-01	1.884E-01	7.194E-01
(a) Limit	mREM	1.500E+01	1.500E+01	1.500E+01	1.500E+01	3.000E+01
(b) % of Limit		1.199E+00	1.109E+00	1.232E+00	1.256E+00	2.398E+00

Receptor Location **0.5 miles ENE**

Critical Age **CHILD**

Critical Organ **BONE**

Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

McGuire Nuclear Station Units 1 & 2 Period 1/1/2019 - 12/31/2019

Liquid Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Batch Mode						
1. Maximum Organ Dose	mREM	3.464E-02	3.584E-02	4.011E-02	2.189E-02	1.327E-01
(a) Limit	mREM	1.000E+01	1.000E+01	1.000E+01	1.000E+01	2.000E+01
(b) % of Limit		3.464E-01	3.584E-01	4.011E-01	2.189E-01	6.635E-01
(c) Critical Age		Child	Child	Child	Child	Child
(d) Critical Organ		Liver	Liver	Liver	Liver	Liver
2. Maximum Total Body Dose	mREM	3.325E-02	3.390E-02	3.785E-02	1.997E-02	1.251E-01
(a) Limit	mREM	3.000E+00	3.000E+00	3.000E+00	3.000E+00	6.000E+00
(b) % of Limit		1.108E+00	1.130E+00	1.262E+00	6.657E-01	2.085E+00
(c) Critical Age		Child	Child	Child	Child	Child
B. Continuous Mode						
1. Maximum Organ Dose	mREM	6.097E-05	7.142E-04	1.715E-04	1.013E-04	1.048E-03
(a) Limit	mREM	1.000E+01	1.000E+01	1.000E+01	1.000E+01	2.000E+01
(b) % of Limit		6.097E-04	7.142E-03	1.715E-03	1.013E-03	5.238E-03
(c) Critical Age		Child	Child	Child	Child	Child
(d) Critical Organ		Liver	Liver	Liver	Liver	Liver
2. Maximum Total Body Dose	mREM	6.097E-05	7.142E-04	1.715E-04	1.013E-04	1.048E-03
(a) Limit	mREM	3.000E+00	3.000E+00	3.000E+00	3.000E+00	6.000E+00
(b) % of Limit		2.032E-03	2.381E-02	5.717E-03	3.376E-03	1.746E-02
(c) Critical Age		Child	Child	Child	Child	Child

Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

McGuire Nuclear Station Units 1 & 2 Period 1/1/2019 - 12/31/2019

40 CFR Part 190 Uranium Fuel Cycle Dose Calculation Results

In accordance with the requirements of 40 CFR Part 190, the annual dose commitment to any member of the general public shall be calculated to assure that doses are limited to 25 millirems to the total body or any organ with the exception of the thyroid which is limited to 75 millirems. The fuel cycle dose assessment for McGuire Nuclear Station includes liquid and gaseous effluent dose contributions from McGuire Nuclear Station and direct and air-scatter dose from the onsite ISFSI. No other uranium fuel cycle facility contributes significantly to the maximum exposed individual. Included in the gaseous effluent dose calculations is an estimate of the dose contributed by Carbon-14 (Ref. Attachment 2, Supplemental Information, of this report for further information). The combined dose to a maximum exposed individual from effluent releases and direct and air-scatter dose from the ISFSI is below 40 CFR Part 190 limits as shown by the following summary.

Note: The 40 CFR Part 190 effluent dose analysis to the maximum exposed individual from liquid and gas releases includes the dose from noble gases (i.e., total body and skin).

40 CFR Part 190 Effluent Dose Summary

A. Maximum Organ Dose (other than TB)	7.362E-01
1. Location	0.5 miles ENE
2. Critical Age	Child
3. Critical Organ	Bone
4. Gas Contribution %	9.772E+01
5. Liquid Contribution %	2.282E+00
B. Maximum Total Body Dose	4.123E-01
1. Location	0.5 miles ENE
2. Critical Age	Child
3. Gas non-NG Contribution %	5.539E+01
4. Gas Contribution %	3.613E+00
5. Liquid Contribution %	4.099E+01

Direct and air-scatter radiation dose contributions from the onsite ISFSI have been determined from the 10 CFR 72.212 Evaluation Report, MAGNASTOR[®], Revision 06. Spent Fuels Group Engineering has evaluated and determined an additional 1.01 mrem to be added to account for the 6 MAGNASTOR[®] casks outside of the most recent 10 CFR 72.212 Evaluation Report. The maximum dose rate to the nearest real individual from the ISFSI is conservatively calculated to be less than 5 mrem/yr.

The attached excerpt from the 10 CFR 72.212 Evaluation Report, MAGNASTOR[®], Revision 06 is provided to document the method used to calculate the dose from ISFSI as less than 5 mrem/yr to the nearest real individual.

Total dose from liquid and gaseous effluents from McGuire Nuclear Station and direct and air-scatter dose from the onsite ISFSI is conservatively estimated to be less than 9 mrem/yr to the nearest real individual. This meets the 40 CFR Part 190 requirements of an annual dose commitment to any member of the general public of less than 25 mrem total body or any organ and 75 mrem to the thyroid.

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

10 CFR 72.212 Evaluation Report, MAGNASTOR®, Revision 07

6.0 10 CFR 72.212(b)(5)(iii) - Radioactive Materials in Effluents and Direct Radiation

6.1 Purpose

10 CFR 72.212(b)(5)(iii) requires the general licensee to perform written evaluations, before use and before applying the changes authorized by an amended CoC to a cask loaded under the initial CoC or an earlier amended CoC, that establish that the requirements of 10 CFR 72.104 have been met. A copy of this record shall be retained until spent fuel is no longer stored under the general license issued under 10 CFR 72.210. 10 CFR 72.104 provides the regulatory criteria for radioactive materials in effluents and direct radiation from an independent spent fuel storage installation (ISFSI) during normal operation and anticipated occurrences. Specifically, 10 CFR 72.104(a) limits the annual dose equivalent to any real individual who is located beyond the controlled area to 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other critical organ. This dose equivalent must include contributions from (1) planned discharges of radioactive materials (radon and its decay products excepted) to the general environment, (2) direct radiation from ISFSI operations, and (3) any other radiation from uranium fuel cycle operations within the region. In addition, 10 CFR 72.104(b) requires that operational restrictions be established to meet as low as is reasonably achievable (ALARA) objectives for radioactive materials in effluents and direct radiation levels associated with ISFSI operations. Also, 10 CFR 72.104(c) requires that operational limits be established for radioactive materials in effluents and direct radiation levels associated with ISFSI operations to meet the above-mentioned dose limits.

This section provides the written evaluation required by 10 CFR 72.212(b)(5)(iii), demonstrating Duke Energy's compliance with the requirements of 10 CFR 72.104 for the MNS ISFSI.

6.2 Evaluation

This evaluation addresses the radiological dose rate from a composite population of all MNS ISFSI cask types.

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

6.2.1 §72.104(a) – Dose Limits

Duke Energy Engineering Instruction MCEI-0400-241 determined that the distance from the nearest residence to the ISFSI is 0.65 miles (1046 meters). Hence, it is conservative to assume that the closest real individual is at least 700 meters from the ISFSI. Enercon determined the annual total dose (gamma plus neutron) at a distance of 700 meters from all currently loaded casks (10 TN-32A casks and 28 NAC-UMS® casks) to be approximately 1.62 mrem. The evaluation was based on actual cask average burn-up (as loaded) and considering cooling time on the storage pads as of September 1, 2010. The distance at which this dose is calculated (700 meters) is conservative compared to the distance to the closest real individual.

NAC International determined the annual total dose (gamma plus neutron) at a distance of 700 meters from a (future) 2x6 array of MAGNASTOR® casks to be approximately 1.01 mrem (2.02 mrem for two arrays). The evaluation was conservatively based on full cask loads of 37 fuel assemblies at the maximum allowable heat load of 35.5 kW. The distance at which this dose is calculated (700 meters) is conservative compared to the distance to the closest real individual.

The total calculated annual public dose from liquid and gaseous effluent pathways averaged over a ten-year period is less than 4 mrem. No other uranium fuel cycle facility contributes significantly to the dose received by the closest real individual.

Based on the above, the calculated annual dose (performed in December 2015 per Reference 10) revised the annual dose to the closest real individual due to the ISFSI, which is comprised of the currently existing ten TN-32A casks and 28 NAC-UMS® casks, and up to two 2x6 arrays of MAGNASTOR® casks (*see Note below*), is determined to be less than 4 mrem, and the estimated annual dose due to McGuire power generation is less than 4 mrem. Hence, the total annual dose to the closest real individual (less than 8 mrem) is within the 10 CFR 72.104(a) limit.

Note: As stated above, up to two 2x6 arrays of MAGNASTOR® casks are assumed in this evaluation. The first eight MAGNASTOR® casks are planned to be placed on a concrete pad currently containing four NAC-UMS® casks. This will conservatively count as one 2x6 array. Additional MAGNASTOR® casks will be placed on their own concrete pad (the second 2x6 array). Hence, this §72.104(a) evaluation bounds up to 20 MAGNASTOR® casks, arranged as described

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 7

Information to Support the NEI Ground Water Protection Initiative

This attachment includes a summary of voluntary reports made in accordance with the NEI Ground Water Protection Initiative and a summary of ground water well sample data.

Attachment 7 Information to Support the NEI Ground Water Protection Initiative

McGuire Nuclear Station Units 1 & 2 Period 1/1/2019 - 12/31/2019

Duke Energy implemented a Ground Water Protection program in 2007. This initiative was developed to ensure timely and effective management of situations involving inadvertent releases of licensed material to ground water. As part of this program, McGuire Nuclear Station monitored 95 wells, 4 surface water points, and 1 leachate pond in 2019.

Wells are typically sampled quarterly or semi-annually. Ground water samples are regularly analyzed for tritium and gamma emitters, with select wells being analyzed for difficult-to-detect radionuclides. No gamma or difficult-to-detect radionuclides, other than naturally occurring radionuclides, were identified in well samples during 2019. Results from sampling during 2019 confirmed existing knowledge of tritium concentrations in site ground water.

Results from sampling during 2019 are shown in the table below.

No events meeting the criteria for voluntary notification per NEI 07-07, Industry Ground Water Protection Initiative, occurred at McGuire Nuclear Station in 2019.

Key to below table.

NS	-	Not scheduled to be sampled, not sampled due to insufficient volume in well, or well inaccessible during outage.
pCi/l	-	picocuries per liter.
< MDA	-	less than minimum detectable activity, typically 250 pCi/l.
20,000 pCi/l	-	the Environmental Protection Agency drinking water standard for tritium. This standard applies only to water used for drinking.
1,000,000 pCi/l	-	the 10 CFR Part 20, Appendix B, Table 2, Column 2, Effluent Concentration Limit for tritium.

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

McGuire Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Well Name	Location / Description	Tritium Concentration (pCi/l)				# of Samples
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	
M-100R	MNS GWPI / M-100R / SE of WC	NS	<MDA	NS	<MDA	2
M-101	MNS GWPI / M-101 / SE of WC	NS	<MDA	NS	<MDA	2
M-102	MNS GWPI / M-102 / SW of WC	1.57E+03	1.13E+03	1.26E+03	1.24E+03	4
M-103	MNS GWPI / M-103 / S of WC	5.38E+02	3.84E+02	3.73E+02	4.62E+02	4
M-103R	MNS GWPI / M-103R / S of WC	NS	5.16E+02	NS	4.07E+02	2
M-104DR	MNS GWPI / M-104DR / W of WC	NS	6.95E+02	NS	6.29E+02	2
M-104R	MNS GWPI / M-104R / W of WC	3.09E+03	1.54E+03	1.09E+03	9.23E+02	4
M-105	MNS GWPI / M-105 / Landfarm	NS	2.68E+02	NS	3.19E+02	2
M-20	MNS GWPI / M-20 / S of Hwy. 73	NS	4.44E+02	NS	5.87E+02	2
M-20R	MNS GWPI / M-20R / S of Hwy. 73	NS	NS	NS	5.07E+02	1
M-21	MNS GWPI / M-21 / S of Hwy. 73	NS	<MDA	NS	<MDA	2
M-22	MNS GWPI / M-22 / S of Hwy. 73	NS	<MDA	NS	<MDA	2
M-22R	MNS GWPI / M-22R / S of Hwy. 73	NS	NS	NS	<MDA	1
M-23	MNS GWPI / M-23 / S of Ac. Rd.	NS	NS	NS	<MDA	1
M-31	MNS GWPI / M-31 / Access road	NS	NS	NS	<MDA	1
M-32	MNS GWPI / M-32 / Main entrance	NS	<MDA	NS	<MDA	2
M-33	MNS GWPI / M-33 / by softball field / HWY 73	NS	NS	NS	<MDA	1
M-34DR	MNS GWPI / M-34DR / Access road	NS	NS	NS	<MDA	1
M-34R	MNS GWPI / M-34R / Access road	NS	NS	NS	<MDA	1
M-42	MNS GWPI / M-42 / U-2 Rx. Bldg.	1.13E+04	1.25E+04	6.43E+03	3.53E+03	23
M-48DR	MNS GWPI / M-48DR / U-2 SFP	NS	<MDA	NS	<MDA	2
M-48R	MNS GWPI / M-48R / U-2 SFP	NS	5.52E+02	NS	4.65E+02	2
M-53	MNS GWPI / M-53 / N of plant	NS	7.43E+02	NS	6.44E+02	2
M-55	MNS GWPI / M-55 / NAB	NS	<MDA	NS	<MDA	2
M-59	MNS GWPI / M-59 / U-2 Doghouse	9.40E+02	9.08E+02	8.44E+02	8.82E+02	4
M-60	MNS GWPI / M-60 / MOC Parking	NS	NS	NS	<MDA	1
M-62	MNS GWPI / M-62 / S of RWF	2.40E+02	<MDA	<MDA	<MDA	4
M-64	MNS GWPI / M-64 / Rdwst. Bldg.	NS	2.92E+02	NS	3.61E+02	2
M-66	MNS GWPI / M-66 / S of SSF	7.90E+02	7.24E+02	7.07E+02	7.32E+02	4
M-66R	MNS GWPI / M-66R / S of SSF	NS	<MDA	NS	<MDA	2
M-68	MNS GWPI / M-68 / U-1 RMWST	5.45E+02	2.59E+02	3.50E+02	4.36E+02	4
M-70	MNS GWPI / M-70 / U-1 SFP	4.78E+02	2.63E+02	4.77E+02	4.98E+02	4
M-70DR	MNS GWPI / M-70DR / U-1 SFP	NS	<MDA	NS	<MDA	2
M-70R	MNS GWPI / M-70R / U-1 SFP	NS	<MDA	NS	2.94E+02	2
M-72	MNS GWPI / M-72 / Rdwst. Trench	5.99E+02	4.76E+02	4.74E+02	5.84E+02	4
M-76	MNS GWPI / M-76 / W of U-1 SFP	4.69E+02	3.49E+02	3.97E+02	4.31E+02	4
M-82	MNS GWPI / M-82 / River	NS	NS	NS	4.20E+02	1
M-84	MNS GWPI / M-84 / River	NS	NS	NS	9.91E+02	1
M-84R	MNS GWPI / M-84R / River	NS	NS	NS	1.32E+03	1
M-85	MNS GWPI / M-85 / River	NS	NS	NS	3.49E+02	1
M-87	MNS GWPI / M-87 / Landfarm	NS	NS	NS	2.51E+02	1
M-89	MNS GWPI / M-89 / Landfarm	NS	NS	NS	4.62E+02	1

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

McGuire Nuclear Station Units 1 & 2
 Period 1/1/2019 - 12/31/2019

Well Name	Location / Description	Tritium Concentration (pCi/l)				# of Samples
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	
M-90	MNS GWPI / M-90 / Landfarm	NS	NS	NS	2.94E+02	1
M-91	MNS GWPI / M-91 / E of WC	NS	3.61E+02	NS	2.17E+02	2
M-91R	MNS GWPI / M-91R / E of WC	NS	NS	NS	3.74E+02	1
M-92	MNS GWPI / M-92 / N of WC Ponds	NS	2.08E+02	NS	2.66E+02	2
M-92R	MNS GWPI / M-92R / N of WC Ponds	NS	NS	NS	<MDA	1
M-93	MNS GWPI / M-93 / N of IHUP	NS	3.83E+02	NS	4.45E+02	2
M-93R	MNS GWPI / M-93R / N of IHUP	NS	NS	NS	<MDA	1
M-94	MNS GWPI / M-94 / SE of IHUP	NS	<MDA	NS	<MDA	2
M-95	MNS GWPI / M-95 / Lower Parking	NS	<MDA	NS	<MDA	2
M-95R	MNS GWPI / M-95R / Lower Parking	NS	NS	NS	<MDA	1
M-96	MNS GWPI / M-96 / West Parking	NS	<MDA	NS	<MDA	2
M-96R	MNS GWPI / M-96R / West Parking	NS	NS	NS	<MDA	1
M-97	MNS GWPI / M-97 / East Parking	NS	<MDA	NS	<MDA	2
M-98	MNS GWPI / M-98 / S of Amin. Bldg.	NS	<MDA	NS	<MDA	2
M-98R	MNS GWPI / M-98R / S of Amin. Bldg.	NS	NS	NS	<MDA	1
MNS LEACHP	MNS Landfill 2 / Leachate Pond	NS	4.40E+02	NS	NS	1
MNS MW-10A	MNS Landfill 2 / MW-10A	NS	<MDA	NS	<MDA	2
MNS MW-4R	MNS Landfarm 2 / MW-4R	NS	NS	NS	<MDA	1
MNS MW-5A	MNS Landfill 2 / MW-5A	NS	<MDA	NS	<MDA	2
MNS MW-5R	MNS Landfill 2 / MW-5R	NS	<MDA	NS	<MDA	2
MNS MW-6	MNS Landfill 2 / MW-6	NS	<MDA	NS	<MDA	2
MNS MW-6A	MNS Landfill 2 / MW-6A	NS	<MDA	NS	<MDA	2
MNS MW-7A	MNS Landfill 2 / MW-7A	NS	<MDA	NS	<MDA	2
MNS MW-7R	MNS Landfill 2 / MW-7R	NS	<MDA	NS	<MDA	2
MNS MW-8	MNS Landfill 2 / MW-8	NS	<MDA	NS	<MDA	2
MNS MW-8A	MNS Landfill 2 / MW-8A	NS	<MDA	NS	<MDA	2
MNS MW-9	MNS Landfill 2 / MW-9	NS	<MDA	NS	<MDA	2
MNS MW-9A	MNS Landfill 2 / MW-9A	NS	<MDA	NS	<MDA	2
MNS SW-1	MNS Landfill 2 / SW-1	NS	<MDA	NS	<MDA	2
MNS SW-2	MNS Landfill 2 / SW-2	NS	<MDA	NS	<MDA	2
MNS-MW-1	MNS Landfarm 2 / MW-1	NS	NS	NS	<MDA	1
MNS-MW-1A	MNS Landfarm 2 / MW-1A	NS	NS	NS	<MDA	1
MNS-MW-2	MNS Landfarm 2 / MW-2	NS	NS	NS	<MDA	1
MNS-MW-2A	MNS Landfarm 2 / MW-2A	NS	NS	NS	<MDA	1
MNS-MW-3	MNS Landfarm 2 / MW-3	NS	NS	NS	<MDA	1
MNS-MW-3A	MNS Landfarm 2 / MW-3A	NS	NS	NS	<MDA	1
MNS-MW-4A	MNS Landfarm 2 / MW-4A	NS	NS	NS	<MDA	1
MS-1	MNS GWPI / MS-1 / Surface Water	NS	<MDA	NS	<MDA	2
MS-2	MNS GWPI / MS-2 / Surface Water	NS	<MDA	NS	2.62E+02	2
MS-3	MNS GWPI / MS-3 / Surface Water	NS	4.48E+02	NS	3.64E+02	2

**Attachment 8
Inoperable Equipment**

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 8

Inoperable Equipment

This attachment includes an explanation of inoperable instruments related to effluent monitoring in excess of allowed time defined by licensing bases and an explanation of unprotected permanent or temporary outside liquid storage tanks exceeding 10 Curies total activity (excluding tritium and dissolved or entrained noble gases).

Attachment 8
Inoperable Equipment

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

McGuire Nuclear Station did not experience inoperable equipment relevant to effluent monitoring in excess of SLC limits during 2019.

McGuire Nuclear Station does not have unprotected permanent or temporary outside liquid storage tanks, therefore now exceeded 10 Curies total activity (excluding tritium and dissolved or entrained noble gases) during 2019.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 9

Summary of Changes to the Offsite Dose Calculation Manual

This attachment includes a summary of changes to the ODCM and Radiological Effluent Controls.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

The McGuire ODCM was not revised in 2019. The most recent revision is 60 and was provided with the 2018 ARERR.

Radiological Effluent Controls (SLC 16.11)

The McGuire Nuclear Station Radiological Effluent Controls are contained in SLC 16.11 and are included in this section. SLC 16.11 was not revised in 2019.

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.1 Liquid Effluents – Concentration

COMMITMENT The concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS (see Figure 16.11.1-1) shall be limited:

- a. For radionuclides other than dissolved or entrained noble gases, 10 times the effluent concentrations specified in 10 CFR Part 20, Appendix B, Table 2, Column 2, and
- b. For dissolved or entrained noble gases, the concentration shall be limited to 2×10^{-4} microCurie/ml total activity.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS not within limits.	A.1 Restore the concentration to within limits.	Immediately

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11.1.1 -----NOTE----- The results of the radioactivity analyses shall be used in accordance with the methodology and parameters in the ODCM to assure that the concentrations at the point of release are maintained within the limits. ----- Sample and analyze radioactive liquid wastes according to Table 16.11.1-1.	According to Table 16.11.1-1

TABLE 16.11.1-1
(Page 1 of 3)

RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM

LIQUID RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS	LOWER LIMIT OF DETECTION (LLD) microCi/ml ⁽¹⁾
1. Batch Waste Release Tanks (WMT and RMT) ⁽⁴⁾	P Each Batch	P Each Batch	Principal Gamma Emitters ⁽⁶⁾	5×10^{-7}
			I-131	1×10^{-6}
	P One Batch/M	M	Dissolved and Entrained Gases (Gamma emitters) ⁽⁷⁾	1×10^{-5}
	P Each Batch	M Composite ⁽²⁾	H-3	1×10^{-5}
			Gross Alpha	1×10^{-7}
P Each Batch	Q Composite ⁽²⁾	Sr-89, Sr-90	5×10^{-8}	
2. Continuous Releases (VUCDT discharge, CWWTS outlet and Turbine Building Sump to RC) ⁽⁵⁾	Continuous ⁽³⁾	W Composite ⁽³⁾	Principal Gamma Emitters ⁽⁶⁾	5×10^{-7}
			I-131	1×10^{-6}
	M Grab Sample	M	Dissolved and Entrained Gases (Gamma emitters) ⁽⁷⁾	1×10^{-5}
	Continuous ⁽³⁾	M Composite ⁽³⁾	H-3	1×10^{-5}
			Gross Alpha	1×10^{-7}
Continuous ⁽³⁾	Q Composite ⁽³⁾	Sr-89, Sr-90	5×10^{-8}	

TABLE 16.11.1-1
(Page 2 of 3)

NOTES:

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

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{(2.71/T) + 4.65S_b}{E \cdot V \cdot 2.22 \times 10^6 \cdot Y \cdot \exp(-\lambda\Delta t)}$$

Where:

LLD is the "a priori" lower limit of detection as defined above (as microCurie per unit mass or volume),

S_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute),

E is the counting efficiency (as counts per disintegration),

V is the sample size (in units of mass or volume),

2.22×10^6 is the number of disintegrations per minute per microCurie,

Y is the fractional radiochemical yield (when applicable),

λ is the radioactive decay constant for the particular radionuclide,

Δt is the elapsed time between midpoint of sample collection and time of counting (for plant effluents, not environmental samples), and

T is the background and sample counting time in minutes.

Typical values of E, V, Y and Δt shall be used in the calculation.

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

- (2) 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.

TABLE 16.11.1-1
(Page 3 of 3)

- (3) To be representative of the quantities and concentrations of radioactive materials in liquid effluents, samples shall be collected continuously or intermittently in proportion to the rate of flow of the effluent stream. Prior to analyses, all samples taken for the composite shall be thoroughly mixed in order for the composite sample to be representative of the effluent release.
- (4) A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated and thoroughly mixed to assure representative sampling.
- (5) A continuous release is the discharge of liquid wastes of a nondiscrete volume; e.g., from a volume of system that has an input flow during the continuous release.
- (6) The principal gamma emitters for which the LLD specification applies exclusively are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, and Ce-141. The LLD for Ce-144 is 5×10^{-6} microCi/ml. This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall be identified and reported in the Annual Radioactive Effluent Release Report.
- (7) The principal gas gamma emitters for which the LLD specification applies are Xe-133 and Xe-135. These are the reference nuclides in Regulatory Guide 1.21.

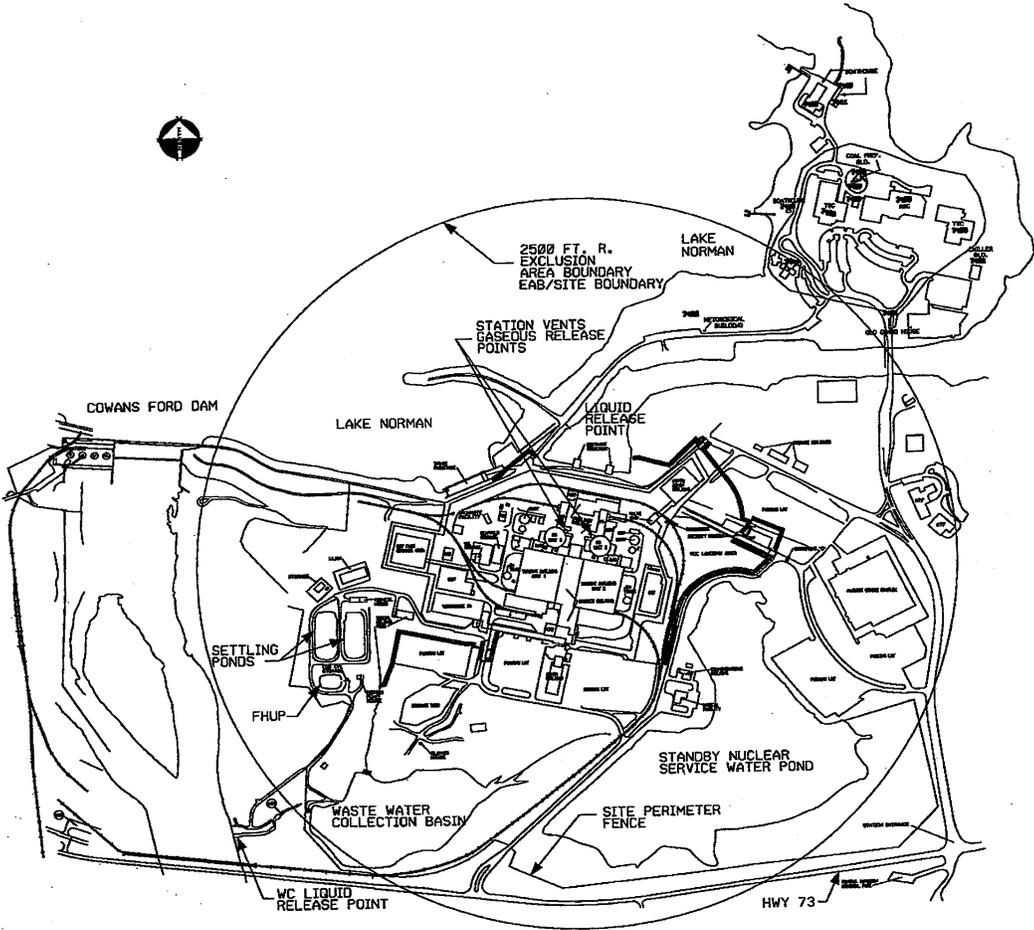


FIGURE 16.11.1-1 SITE BOUNDARY / EXCLUSION AREA BOUNDARY

BASES

This commitment is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to UNRESTRICTED AREAS will be less than 10 times the effluent concentration levels specified in 10 CFR Part 20, Appendix B, Table 2, Column 2. This limitation provides additional assurance that the levels of radioactive materials in bodies of water in UNRESTRICTED AREAS will result in exposures within: (1) the Section II.A design objectives of Appendix I, 10 CFR Part 50, to a MEMBER OF THE PUBLIC, and (2) the limits of 10 CFR Part 20.1301 to the population. The concentration limit for dissolved or entrained noble gases is based upon the assumption that Xe-135 is the controlling radioisotope and its EC in air (submersion) was converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection (ICRP) Publication 2. This commitment applies to the release of liquid effluents from all reactors at the site.

The basic requirements for the Selected Licensee Commitments concerning effluents from nuclear power reactors are stated in 10CFR50.36a. These requirements indicate that compliance with effluent Selected Licensee Commitments will keep average annual releases of radioactive material in effluents to small percentages of the limits specified in the old 10CFR20.106 (new 10CFR20.1301). These requirements further indicate that operational flexibility is allowed, compatible with considerations of health and safety, which may temporarily result in releases higher than such small percentages, but still within the limits specified in the old 10CFR20.106 which references Appendix B, Table II concentrations (MPCs). These referenced concentrations are specific values which relate to an annual dose of 500 mrem. It is further indicated in 10CFR50.36a that when using operational flexibility, best efforts shall be exerted to keep levels of radioactive materials in effluents as low as is reasonably achievable (ALARA) as set forth in 10CFR50, Appendix I.

As stated in the Introduction to Appendix B of the new 10CFR20, the effluent concentration (EC) limits given in Appendix B, Table 2, Column 2, are based on an annual dose of 50 mrem. Since a release concentration corresponding to a limiting dose rate of 500 mrem/year has been acceptable as a SLC limit for liquid effluents, which applies at all times as an assurance that the limits of 10CFR50, Appendix I are not likely to be exceeded, it should not be necessary to reduce this limit by a factor of 10.

Operational history at Catawba/McGuire/Oconee has demonstrated that the use of the concentration values associated with the old 10CFR20.106 as SLC limits has resulted in calculated maximum individual doses to members of the public that are small percentages of the limits of 10CFR50, Appendix I. Therefore, the use of concentration values which correspond to an annual dose of 500 mrem should not have a negative impact on the ability to continue to operate within the limits of 10CFR50 Appendix I and 40CFR190.

Having sufficient operational flexibility is especially important in establishing a basis for effluent monitor setpoint calculations. As discussed above, the concentrations stated in the new 10CFR20, Appendix B, Table 2, Column 2, relate to a dose of 50 mrem in a year. When applied on an instantaneous basis, this corresponds to a dose rate of 50 mrem/year. This low value is impractical upon which to base effluent monitor setpoint calculations for many liquid effluent release situations when monitor background, monitor sensitivity, and monitor performance must be taken into account.

BASES (continued)

Therefore, to accommodate operational flexibility needed for effluent releases, the limits associated with SLC 16.11.1 are based on ten times the concentrations stated in the new 10CFR20, Appendix B, Table 2, Column 2 to apply at all times. The multiplier of ten is proposed because the annual dose of 500 mrem, upon which the concentrations in the old 10CFR20, Appendix B, Table II, Column 2 are based, is a factor of ten higher than the annual dose of 50 mrem, upon which the concentrations in the new 10CFR20, Appendix B, Table 2, Column 2, are based. Compliance with the limits of the new 10CFR20.1301 will be demonstrated by operating within the limits of 10CFR50, Appendix I and 40CFR190.

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

REFERENCES

1. McGuire Nuclear Station Offsite Dose Calculation Manual (ODCM)
2. International Commission on Radiological Protection (ICRP) Publication 2

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.2 Radioactive Liquid Effluent Monitoring Instrumentation

COMMITMENT The radioactive liquid effluent monitoring instrumentation channels shown in Table 16.11.2-1 shall be FUNCTIONAL with their Alarm/Trip Setpoints set to ensure that the limits of SLC 16.11.1 are not exceeded.

AND

The Alarm/Trip Setpoints of these channels shall be determined and adjusted in accordance with the methodology and parameters in the OFFSITE DOSE CALCULATION MANUAL (ODCM).

APPLICABILITY As shown in Table 16.11.2-1.

REMEDIAL ACTIONS

-----NOTE-----
Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more radioactive liquid effluent monitoring channels Alarm/Trip setpoint less conservative than required.	A.1 Suspend the release of radioactive liquid effluents monitored by the affected channel.	Immediately
	<u>OR</u>	
	A.2 Declare the channel non-functional.	Immediately
	<u>OR</u>	
	A.3 Adjust setpoint to within limit.	Immediately
B. One or more radioactive liquid effluent monitoring instrument channels non-functional.	B.1 Enter the Remedial Action specified in Table 16.11.2-1 for the channel(s).	Immediately

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
C. One channel non-functional.	C.1.1 Analyze two independent samples per TR 16.11.1.1. <u>AND</u>	Prior to initiating a release
	C.1.2 Perform independent verification of the discharge line valving. <u>AND</u>	Prior to initiating a release
	C.1.3.1 Perform independent verification of manual portion of the computer input for the release rate calculations performed by computer. <u>OR</u>	Prior to initiating a release
	C.1.3.2 Perform independent verification of entire release rate calculations for calculations performed manually. <u>AND</u>	Prior to initiating a release
	C.1.4 Restore channel to FUNCTIONAL status. <u>OR</u>	14 days
	C.2 Suspend the release of radioactive effluents via this pathway.	Immediately

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
D. One or more channels non-functional.	D.1 Obtain grab samples from the effluent pathway.	Once per 12 hours during releases.
	<u>AND</u>	
	D.2 Perform an analysis of grab samples for radioactivity.	To meet LLD requirements per Table 16.11.1-1.
	<u>AND</u>	
	D.3 Restore the channel to FUNCTIONAL status.	30 days
E. One or more flow rate measurement channels non-functional.	E.1 -----NOTE----- Pump performance curves generated in place may be used to estimate flow. ----- Estimate the flow rate of the release.	Once per 4 hours during releases
	<u>AND</u>	
	E.2 Restore the channel to FUNCTIONAL status.	30 days
F. RC minimum flow interlock non-functional.	F.1 Verify that the number of pumps providing dilution is greater than or equal to the number of pumps required.	Once per 4 hours during releases
	<u>AND</u>	
	F.2 Restore the channel to FUNCTIONAL status.	30 days

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
G. Required Action and associated Completion Time of Condition C, D, E or F not met.	G.1 Explain why the non-functionality was not corrected within the specified Completion Time in the Annual Radioactive Effluent Release Report.	In the next scheduled Annual Radioactive Effluent Release Report

TESTING REQUIREMENTS

-----NOTE-----

Refer to Table 16.11.2-1 to determine which TRs apply for each Radioactive Liquid Effluent Monitoring channel.

TEST	FREQUENCY
TR 16.11.2.1 Perform CHANNEL CHECK.	24 hours
TR 16.11.2.2 -----NOTE----- The CHANNEL CHECK shall consist of verifying indication of flow. ----- Perform CHANNEL CHECK.	Every 24 hours during periods of release
TR 16.11.2.3 Perform SOURCE CHECK.	Prior to each release
TR 16.11.2.4 Perform SOURCE CHECK.	31 days
TR 16.11.2.5 -----NOTES----- 1. For Instrument 1, the COT shall also demonstrate that automatic isolation of the pathway occurs if the instrument indicates measured levels above the Alarm/Trip Setpoint. 2. For Instruments 1 and 2, the COT shall also demonstrate that control room alarm annunciation occurs if the instrument indicates measured levels above the Alarm/Trip Setpoint; circuit failure and, a downscale failure. ----- Perform CHANNEL OPERATIONAL TEST.	92 days
TR 16.11.2.6 Perform a CHANNEL CALIBRATION.	18 months

(continued)

TESTING REQUIREMENTS (continued)

TEST	FREQUENCY
<p>TR 16.11.2.7 -----NOTE----- The initial CHANNEL CALIBRATION shall be performed using standards certified by the National Institute of Standards and Technology (NIST) or using standards obtained from suppliers that participate in measurement assurance activities with NIST. These standards shall permit calibrating the system over its intended range of energy and measurement range. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used. ----- Perform a CHANNEL CALIBRATION.</p>	24 months

TABLE 16.11.2-1

RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

INSTRUMENT	MINIMUM CHANNELS FUNCTIONAL	REMEDIAL ACTION	APPLICABILITY	TESTING REQUIREMENTS
1. Radioactivity Monitors Providing Alarm And Automatic Termination of Release				
a. Waste Liquid Effluent Line (EMF-49)	1 per station	A, C, G	During liquid effluent releases	TR 16.11.2.1 TR 16.11.2.3 TR 16.11.2.5 TR 16.11.2.7
b. EMF-49 Minimum Flow Device (2)	1 per station	C, G	During liquid effluent releases	TR 16.11.2.5 TR 16.11.2.7
c. Containment Ventilation Unit Condensate Line (EMF-44)	1	A, D, G	At all times	TR 16.11.2.1 TR 16.11.2.4 TR 16.11.2.5 TR 16.11.2.7
d. EMF-44 Minimum Flow Device (2)	1	D, G	At all times	TR 16.11.2.5 TR 16.11.2.7
2. Radioactivity Monitors Providing Alarm But Not Automatic Termination of Release				
a. Conventional Waste Water Treatment Line or Turbine Building Sump to RC (EMF- 31)	1	A, D, G	At all times	TR 16.11.2.1 TR 16.11.2.4 TR 16.11.2.5 TR 16.11.2.7
b. EMF-31 Minimum Flow Device (2)	1	D, G	At all times	TR 16.11.2.5 TR 16.11.2.7
3. Continuous Composite Samplers				
a. Containment Ventilation Unit Condensate Line	1	D, G	At all times	TR 16.11.2.2 TR 16.11.2.5 TR 16.11.2.6
b. Conventional Waste Water Treatment Line	1 per station	D, G	At all times	TR 16.11.2.2 TR 16.11.2.5 TR 16.11.2.6
c. Turbine Building Sump to RC	1	D, G	At all times	TR 16.11.2.2 TR 16.11.2.6

(Continued)

4. Flow Rate Measurement Devices				
a. Waste Liquid Effluent Line	1 per station	E, G	During liquid effluent releases	TR 16.11.2.2 TR 16.11.2.5 TR 16.11.2.6
b. Containment Ventilation Unit Condensate Line	1	E, G	At all times	TR 16.11.2.2 TR 16.11.2.5 TR 16.11.2.6
c. Conventional Waste Water Treatment Line	1 per station	E, G	At all times	TR 16.11.2.2 TR 16.11.2.5 TR 16.11.2.6
d. Turbine Building Sump to RC	1	E, G	At all times	TR 16.11.2.2 TR 16.11.2.6
5. RC Minimum Flow Interlock (1)	1 per station	F, G	At all times	TR 16.11.2.5

NOTES:

1. Minimum flow dilution is assured by an interlock which terminates waste liquid release if the number of RC pumps running falls below the number of pumps required for dilution. The required number of RC pumps for dilution is determined per station procedures.
2. Radioactivity Monitor (EMF) shall not be declared functional unless both the EMF and the associated EMF's Minimum Flow Device are rendered functional.

BASES

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 minimum flow devices for EMFs listed in Table 16.11.2-1 are required to provide assurance of representative sampling during actual or potential releases of liquid effluents. An interlock between the EMF's minimum flow device and its associated flow rate measurement device disables the remove alarm during non-release timeframes for the purpose of the control room black board annunciator criteria that disable expected alarms. An EMF flow rate measurement device measures total flow of the effluent while the EMF minimum flow device measures the sample flow rate through the EMF. The Alarm/Trip Setpoints of these instruments shall be calculated and adjusted in accordance with the methodology and parameters in the ODCM to ensure that the Alarm/Trip will occur prior to exceeding the limits stated in SLC 16.11.1. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50. The Turbine Building Sump to RC Discharge Flow Measurement and Sampler Devices are for monitoring only and do not alarm or have any controls that require a COT.

REFERENCES

1. McGuire Nuclear Station Offsite Dose Calculation Manual (ODCM)
2. 10 CFR Part 50, Appendix A

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.3 Dose - Liquid Effluents

COMMITMENT The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released from each unit to UNRESTRICTED AREAS (see Figure 16.11.1-1) shall be limited:

- a. During any calendar quarter, to ≤ 1.5 mrem to the total body and to ≤ 5 mrem to any organ, and
- b. During any calendar year, to ≤ 3 mrem to the total body and to ≤ 10 mrem to any organ.

APPLICABILITY At all times.

REMEDIAL ACTIONS

-----NOTES-----

Enter applicable Conditions and Required Actions of SLC 16.11.12, "Total Dose," when the limits of this SLC are exceeded by twice the specified limit.

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Calculated dose from release of radioactive materials in liquid effluents exceeding above limits.</p>	<p>-----NOTE----- The Special Report shall include the results of radiological analyses of the drinking water source, and the radiological impact on finished drinking water supplies with regard to the requirements of 40 CFR 141, Safe Drinking Water Act, as applicable.</p> <p>----- A.1 Prepare and submit a Special Report to the NRC which identifies the causes for exceeding the limits, corrective actions taken to reduce releases, and actions taken to ensure that subsequent releases are within limits.</p>	<p>30 days</p>

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11.3.1 Determine cumulative dose contributions from liquid effluents for current calendar quarter and current calendar year in accordance with the methodology and parameters in the ODCM.	31 days

BASES

This commitment is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR Part 50. The commitment implements the guides set forth in Section II.A of Appendix I. The REMEDIAL ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable." Also, for fresh water sites with drinking water supplies that can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR Part 141. These requirements are applicable only if the drinking water supply is taken from the river 3 miles downstream of the plant discharge.

The dose calculation methodology and parameters in the ODCM implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977.

This commitment applies to the release of liquid effluents from each unit at the site. For units with shared Radwaste Treatment Systems, the liquid effluents from the shared system are to be proportioned among the units sharing that system in accordance with the guidance given in NUREG-0133, Chapter 3.1.

REFERENCES

1. McGuire Nuclear Station, Off site Dose Calculation Manual
2. 40 CFR Part 141, Safe Drinking Water Act
3. 10 CFR Part 50, Appendix I
4. Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977.
5. Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977.

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.4 Liquid Radwaste Treatment System

COMMITMENT The Liquid Radwaste Treatment System shall be FUNCTIONAL and appropriate portions of the system shall be used to reduce releases of radioactivity when the projected doses due to the liquid effluent from each unit to UNRESTRICTED AREAS (see Figure 16.11.1-1) would exceed 0.06 mrem to the total body or 0.2 mrem to any organ in a 31 day period.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Radioactive liquid waste being discharged without treatment and in excess of above limits.</p> <p><u>AND</u></p> <p>Any portion of Liquid Radwaste Treatment System not in operation.</p>	<p>A.1 Prepare and submit a Special Report to the NRC which identifies the reasons liquid radwaste was discharged without treatment, identification of non-functional equipment and reasons for non-functionality, corrective actions taken to restore the equipment to FUNCTIONAL status, and actions taken to prevent recurrence.</p>	<p>30 days</p>

TESTING REQUIREMENTS

-----NOTE-----

The Liquid Radwaste Treatment System shall be demonstrated FUNCTIONAL by meeting SLC 16.11.1 and 16.11.3.

TEST	FREQUENCY
TR 16.11.4.1 Project liquid release doses from each unit to UNRESTRICTED AREAS, in accordance with the methodology and parameters in the ODCM, when water systems are being released without being processed by its radwaste treatment system.	31 days

BASES

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 specification implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50 and the design objective given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the Liquid Radwaste Treatment System were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50, for liquid effluents.

This commitment applies to the release of liquid effluents from each reactor at the site. For units with shared Radwaste Treatment Systems, the liquid effluents from the shared system are to be proportioned among the units sharing that system in accordance with the guidance given in NUREG-0133, Chapter 3.1.

REFERENCES

1. McGuire Nuclear Station, Off site Dose Calculation Manual
2. 10 CFR Part 50
3. 10 CFR Part 50, Appendix I

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.5 Chemical Treatment Ponds

COMMITMENT The quantity of radioactive material contained in each chemical treatment pond shall be limited by the following expression (excluding tritium and dissolved or entrained noble gases):

$$\frac{264}{V} \cdot \sum_j \frac{A_j}{(C_j \times 10)} < 1.0$$

Where:

A_j = pond inventory limit for single radionuclide "j", in Curies

C_j = 10 CFR 20, Appendix B, Table 2, Column 2, concentration for single radionuclide "j", microCuries/ml;

V = design volume of liquid and slurry in the pond, in gallons; and

264 = conversion unit, microCuries/Curie per milliliter/gallon.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Quantity of radioactive material in any of the chemical treatment ponds exceeding above limit.</p>	<p>A.1 Suspend all additions of radioactive material to the pond.</p>	<p>Immediately</p>
	<p><u>AND</u></p> <p>A.2 Initiate corrective action to reduce the pond contents to within limits.</p>	<p>Immediately</p>

TESTING REQUIREMENTS

TEST	FREQUENCY
<p>TR 16.11.5.1 Verify quantity of radioactive material in each batch of slurry (powdex resin) to be transferred to chemical treatment ponds is within limits by analyzing a representative sample of the slurry. Each batch to be transferred to the chemical treatment ponds is limited by:</p> $\sum_j \frac{Q_j}{(C_j \times 10)} < 6.0 \times 10^5 \frac{pCi / gm}{\mu Ci / ml}$	<p>Prior to each transfer</p>

BASES

The inventory limits of the chemical treatment ponds (CTP) are based on limiting the consequences of an uncontrolled release of the pond inventory. The expression in SLC 16.11.5 assumes the pond inventory is uniformly mixed, that the pond is located in an uncontrolled area as defined in 10 CFR Part 20, and that the concentration limit in Note 4 to Appendix B of 10 CFR Part 20 applies.

The batch limits of slurry to the chemical treatment ponds assure that radioactive material in the slurry transferred to the CTP are "as low as is reasonably achievable" in accordance with 10 CFR Part 50.36a. The expression in SLC 16.11.5 assures no batch of slurry will be transferred to the CTP unless the sum-of the ratios of the activity of the radionuclides to their respective concentration limitation is less than the ratio of the 10 CFR Part 50, Appendix I, Section II.A, total body dose level to the instantaneous whole body dose rate limitation, or that:

$$\sum_j \frac{c_j}{(C_j \times 10)} < \frac{3 \text{ mrem / yr}}{500 \text{ mrem / yr}} = 0.006$$

Where:

c_j = Radioactive slurry concentration for radionuclide "j" entering the UNRESTRICTED AREA chemical treatment ponds, in microCuries/milliliter; and

C_j = 10 CFR 20, Appendix B, Table 2, Column 2, concentration for single radionuclide "j", in microCuries/milliliter.

BASES (continued)

For the design of filter/demineralizers using powder resin, the slurry wash volume and the weight of resin used per batch is fixed by the cell surface area, and the slurry volume to resin weight ratio is constant at 100 ml/gram of wet, drained resin with a moisture content of approximately 55 to 60% (bulk density of about 58 pounds per cubic feet). Therefore,

$$\sum_j \frac{c_j}{(C_j \times 10)} = \sum_j \frac{Q_j}{(C_j \times 10) (10^2 \text{ ml/gm}) (10^6 \text{ pCi/}\mu\text{Ci})} < 0.006, \text{ and}$$

$$\sum_j \frac{Q_j}{(C_j \times 10)} < 6.0 \times 10^5 \frac{\text{pCi/gm}}{\mu\text{Ci/ml}}$$

Where:

Q_j = concentration of radioactive materials in wet, drained slurry (powdex resin) for radionuclide "j", excluding tritium, dissolved or entrained noble gases, and radionuclides with less than an 8-day half-life. The analysis shall include at least Ce-144, Cs-134, Cs-137, Co-58 and Co-60, in picoCuries/gram. Estimates of the Sr-89 and Sr-90 batch concentration shall be included based on the most recent monthly composite analysis (within 3 months); and

C_j = 10 CFR 20, Appendix B, Table 2, Column 2, concentration for single radionuclide "j", in microCuries/milliliter.

The batch limits provide assurance that activity input to the chemical treatment ponds will be minimized, and a means of identifying radioactive material in the inventory limitation of SLC 16.11.5.

The basic requirements for the Selected Licensee Commitments concerning effluents from nuclear power reactors are stated in 10CFR50.36a. These requirements indicate that compliance with effluent Selected Licensee Commitments will keep average annual releases of radioactive material in effluents to small percentages of the limits specified in the old 10CFR20.106 (new 10CFR20.1301). These requirements further indicate that operational flexibility is allowed, compatible with considerations of health and safety, which may temporarily result in releases higher than such small percentages, but still within the limits specified in the old 10CFR20.106 which references Appendix B, Table II concentrations- (MPCs). These referenced concentrations are specific values which relate to an annual dose of 500 mrem. It is further indicated in 10CFR50.36a that when using operational flexibility, best efforts shall be exerted to keep levels of radioactive materials in effluents as low as is reasonably achievable (ALARA) as set forth in 10CFR50, Appendix I.

BASES (continued)

As stated in the Introduction to Appendix B of the new 10CFR20, the effluent concentration (EC) limits given in Appendix B, Table 2, Column 2, are based on an annual dose of 50 mrem. Since a release concentration corresponding to a limiting dose rate of 500 mrem/year has been acceptable as a SLC limit for liquid effluents, which applies at all times as an assurance that the limits of 10CFR50, Appendix I are not likely to be exceeded, it should not be necessary to reduce this limit by a factor of 10.

Operational history at Catawba/McGuire/Oconee has demonstrated that the use of the concentration values associated with the old 10CFR20.106 as SLC limits has resulted in calculated maximum individual doses to members of the public that are small percentages of the limits of 10CFR50, Appendix I. Therefore, the use of concentration values which correspond to an annual dose of 500 mrem should not have a negative impact on the ability to continue to operate within the limits of 10CFR50, Appendix I and 40CFR190.

Having sufficient operational flexibility is especially important in establishing a basis for effluent monitor setpoint calculations. As discussed above, the concentrations stated in the new 10CFR20, Appendix B, Table 2, Column 2, relate to a dose of 50 mrem in a year. When applied on an instantaneous basis, this corresponds to a dose rate of 50 mrem/year. This low value is impractical upon which to base effluent monitor setpoint calculations for many liquid effluent release situations when monitor background, monitor sensitivity, and monitor performance must be taken into account.

Therefore, to accommodate operational flexibility needed for effluent releases, the limits associated with SLC 16.11.1 are based on ten times the concentrations stated in the new 10CFR20, Appendix B, Table 2, Column 2 to apply at all times. The multiplier of ten is proposed because the annual dose of 500 mrem, upon which the concentrations in the old 10CFR20, Appendix B, Table II, Column 2 are based, is a factor of ten higher than the annual dose of 50 mrem, upon which the concentrations in the new 10CFR20, Appendix B, Table 2, Column 2, are based. Compliance with the limits of the new 10CFR20.1301 will be demonstrated by operating within the limits of 10CFR50, Appendix I and 40CFR190.

REFERENCES

1. McGuire Nuclear Station, Off site Dose Calculation Manual
2. 10 CFR 20, Appendix B
3. 10 CFR 50, Appendix I, Section II.A
4. 10 CFR 20
5. 10 CFR 50.36a

16.11 RADIOLOGICAL EFFLUENT CONTROL

16.11.6 Dose Rate - Gaseous Effluents

COMMITMENT The dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY (see Figure 16.11.1-1) shall be limited to the following:

- a. For noble gases: ≤ 500 mrem/yr to the whole body and ≤ 3000 mrem/yr to the skin, and
- b. For Iodine - 131 and 133, for tritium, and for all radioactive materials in particulate form with half-lives greater than 8 days: ≤ 1500 mrem/yr to any organ.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Dose rate not within limit.	A.1 Restore the release rate to within limits.	Immediately

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11.6.1 Verify dose rates due to noble gases in gaseous effluents are within limits in accordance with the methodology and parameters in the ODCM.	In accordance with the ODCM
TR 16.11.6.2 Verify dose rates due to radioactive materials, other than noble gases, in gaseous effluents are within limits in accordance with the methodology and parameters in the ODCM by obtaining representative samples and performing analyses in accordance with Table 16.11.6-1.	In accordance with Table 16.11.6-1

TABLE 16.11.6-1
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RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) ⁽¹⁾ (μCi/ml)
1. Waste Gas Storage Tanks	P Each Tank Grab Sample	P Each Tank	Principal Gas Gamma Emitters ⁽⁶⁾	1x10 ⁻⁴
	P Each PURGE Grab Sample	P Each PURGE	Principal Gas Gamma Emitters ⁽⁶⁾	1x10 ⁻⁴
2. Containment Purge	M	M	H-3	1x10 ⁻⁶
	W ⁽²⁾ Grab Sample	W	Principal Gas Gamma Emitters ⁽⁶⁾	1x10 ⁻⁴
3. Unit Vent	W Grab Sample	W	H-3	1x10 ⁻⁶
	W Grab Sample	W	Principal Gas Gamma Emitters ⁽⁶⁾	1x10 ⁻⁴
	W ⁽⁸⁾ Charcoal Sample	W ⁽⁸⁾ Charcoal Sample	I-131	1x10 ⁻¹²
4.a. Radwaste Facility Vent b. Waste Handling Building c. Equipment Staging Building	W Grab Sample	W	Principal Gas Gamma Emitters ⁽⁶⁾	1x10 ⁻⁴
	W ⁽⁸⁾ Continuous ⁽⁶⁾	W ⁽⁸⁾ Continuous ⁽⁶⁾	H-3	1x10 ⁻⁶
5. Unit Vents	W ⁽⁸⁾ Continuous ⁽⁶⁾	W ⁽⁸⁾ Particulate Sample	I-133	1x10 ⁻¹⁰
	W ⁽⁸⁾ Continuous ⁽⁶⁾	W ⁽⁸⁾ Particulate Sample	Principal Gamma Emitters ⁽⁶⁾ (I-131, Others)	1x10 ⁻¹¹
	M Continuous ⁽⁶⁾	M Composite Particulate Sample	Gross Alpha ⁽⁷⁾	1x10 ⁻¹¹
	Q Continuous ⁽⁶⁾	Q Composite Particulate Sample	Sr-89, Sr-90	1x10 ⁻¹¹

TABLE 16.11.6-1
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RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) ⁽¹⁾ (μCi/ml)
6. All Release Types as listed in 4 above.	Continuous ⁽⁶⁾	W ⁽⁸⁾ Charcoal Sample	I-131	1x10 ⁻¹²
			I-133	1x10 ⁻¹⁰
	Continuous ⁽⁶⁾	W ⁽⁸⁾ Particulate Sample	Principal Gamma Emitters ⁽⁶⁾ (I-131, Others)	1x10 ⁻¹¹
	Continuous ⁽⁶⁾	M Composite Particulate Sample	Gross Alpha ⁽⁷⁾	1x10 ⁻¹¹
Continuous ⁽⁶⁾	Q Composite Particulate Sample	Sr-89, Sr-90	1x10 ⁻¹¹	

TABLE 16.11.6-1
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NOTES:

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

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{(2.71/T) + 4.65S_b}{E \cdot V \cdot 2.22 \times 10^6 \cdot Y \cdot \exp(-\lambda\Delta t)}$$

Where:

- LLD = the "a priori" lower limit of detection as defined above (as microCurie per unit mass or volume);
- S_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute);
- E = the counting efficiency (as counts per disintegration);
- V = the sample size (in units of mass or volume);
- 2.22×10^6 = the number of disintegrations per minute per microCurie;
- Y = the fractional radiochemical yield (when applicable);
- λ = the radioactive decay constant for the particular radionuclide;
- Δt = the elapsed time between midpoint of sample collection and time of counting (for plant effluents, not environmental samples); and
- T = The background and sample counting time in minutes.

Typical values of E, V, Y and Δt shall be used in the calculation.

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

TABLE 16.11.6-1
(Page 4 of 4)

NOTES:

2. Tritium grab samples shall be taken at least once per 24 hours when the refueling canal is flooded.
3. Not used.
4. Not used.
5. The ratio of the sample flow volume to the sampled stream flow volume shall be known for the time period covered by each dose or dose rate calculation made in accordance with SLCs 16.11.6, 16.11.8 and 16.11.9.
6. The principal gamma emitters for which the LLD specification applies include 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, and Ce-141 in iodine and particulate releases. The LLD for Ce-144 is 5×10^{-9} microCi/ml. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radioactive Effluent Release Report.
7. The composite filter(s) will be analyzed for alpha activity by analyzing the filter media used during the collection period.
8. Samples shall be changed at least once per 7 days and analyses shall be completed to meet LLD after changing, or after removal from sampler. If the particulate and charcoal sample frequency is changed to a 24 hour frequency the corresponding LLDs may be increased by a factor of 10 (i.e., LLD for I-131 from 1×10^{-12} to 1×10^{-11} microCi/ml).

BASES

Specific release rate limits restrict, at all times, the corresponding gamma and beta dose rates above background to a MEMBER OF THE PUBLIC at or beyond the SITE BOUNDARY to less than or equal to 500 mrem/year to the whole body, and 3000 mrem/year to the skin from noble gases, and 1500 mrem/year to any organ from Iodine 131, Iodine 133, tritium, and all radionuclides in particulate form with half-lives greater than eight days. This commitment applies to the release of gaseous effluents from all reactors at the site. The Exclusion Area Boundary (Site Boundary) is set as the boundary for gaseous effluent release limits. The Exclusion Area Boundary (EAB) is formed by a 2500 ft radius centered on the Reactor Buildings' centerlines as shown on Figure 16.11.1-1.

The basic requirements for the Selected Licensee Commitments concerning effluents from nuclear power reactors are stated in 10CFR50.36a. These requirements indicate that compliance with effluent Selected Licensee Commitments will keep average annual releases of radioactive material in effluents to small percentages of the limits specified in the old 10CFR20.106 (new 10CFR20.1301). These requirements further indicate that operational flexibility is allowed, compatible with considerations of health and safety, which may temporarily result in releases higher than such small percentages, but still within the limits specified in the old 10CFR20.106 which references Appendix B, Table II concentrations (MPCs). These referenced concentrations are specific values which relate to an annual dose of 500 mrem. It is further indicated in 10CFR50.36a that when using operational flexibility, best efforts shall be exerted to keep levels of radioactive materials in effluents as low as is reasonably achievable (ALARA) as set forth in 10CFR50, Appendix I.

As stated in the Introduction to Appendix B of the new 10CFR20, the effluent concentration (EC) limits given in Appendix B, Table 2, Column 1, are based on an annual dose of 50 mrem for isotopes for which inhalation or ingestion is limiting or 100 mrem for isotopes for which submersion (noble gases) is limiting. Since release concentrations corresponding to limiting dose rates of less than or equal to 500 mrem/year to the whole body, 3000 mrem/year to the skin from noble gases, and 1500 mrem/year to any organ from Iodine 131, Iodine 133, tritium and for all radionuclides in particulate form with half-lives greater than eight days at the site boundary has been acceptable as a SLC limit for gaseous effluents to assure that the limits of 10CFR50, Appendix I and 40CFR190 are not likely to be exceeded, it should not be necessary to restrict the operational flexibility by incorporating the EC value for isotopes based on ingestion/inhalation (50 mrem/year) or for isotopes with the EC based on submersion (100 mrem/year).

Having sufficient operational flexibility is especially important in establishing a basis for effluent monitor setpoint calculations. As discussed above, the concentrations stated in the new 10CFR20, Appendix B, Table 2, Column 1, relate to a dose of 50 or 100 mrem in a year. When applied on an instantaneous basis, this corresponds to a dose rate of either 50 or 100 mrem/year. These low values are impractical upon which to base effluent monitor setpoint calculations for many effluent release situations when monitor background, monitor sensitivity, and monitor performance must be taken into account. Therefore, to accommodate operational flexibility needed for effluent releases, the limits associated with SLC 16.11.6 will be maintained at the current dose rate limit for noble gases of 500 mrem/year to the whole body and 3000 mrem/year to the skin, for Iodine 131, Iodine 133, tritium and all radionuclides in particulate form with half-lives greater than eight days an instantaneous dose rate limit of 1500 mrem/year to any organ.

BASES (continued)

Compliance with the limits of the new 10CFR20.1301 will be demonstrated by operating within the limits of 10CFR50, Appendix I and 40CFR190. Operational history at Catawba/McGuire/Oconee has demonstrated that the use of the dose rate values listed above (i.e. 500 mrem/year, 3000 mrem/year and 1500 mrem/year) as SLC limits has resulted in calculated maximum individual doses to members of the public that are small percentages of the limits of 10CFR50, Appendix I and 40CFR190.

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

REFERENCES

1. McGuire Nuclear Station, Off site Dose Calculation Manual
2. 10 CFR Part 20, Appendix B
3. 10 CFR Part 20
4. 10 CFR Part 50

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.7 Radioactive Gaseous Effluent Monitoring Instrumentation

COMMITMENT The radioactive gaseous effluent monitoring instrumentation channels shown in Table 16.11.7-1 shall be FUNCTIONAL with Alarm/Trip Setpoints set to ensure that the limits of SLC 16.11.6 are not exceeded.

AND

The Alarm/Trip setpoints shall be determined and adjusted in accordance with the methodology and parameters in the ODCM.

-----NOTE-----

Brief periods of routine sampling (not to exceed 15 minutes) do not make the instrumentation non-functional.

APPLICABILITY As shown in Table 16.11.7-1.

REMEDIAL ACTIONS

-----NOTE-----

Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more radioactive gaseous effluent monitoring channels Alarm/Trip setpoint less conservative than required.	A.1 Suspend the release of radioactive gaseous effluents monitored by the affected channel.	Immediately
	<u>OR</u>	
	A.2 Declare the channel non-functional.	Immediately
	<u>OR</u>	
	A.3 Adjust setpoint to within limit.	Immediately

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. One or more radioactive gaseous effluent monitoring instrument channels non-functional.	B.1 Enter the Remedial Action specified in Table 16.11.7-1 for the channel(s).	Immediately
C. One channel non-functional.	C.1.1 Analyze two independent samples of the tank contents. <u>AND</u>	Prior to initiating a release
	C.1.2 Perform independent verification of the discharge valve lineup. <u>AND</u>	Prior to initiating a release
	C.1.3.1 Perform independent verification of manual portion of the computer input for the release rate calculations performed by computer. <u>OR</u>	Prior to initiating a release
	C.1.3.2 Perform independent verification of entire release rate calculations for calculations performed manually. <u>AND</u>	Prior to initiating a release
	C.1.4 Restore channel to FUNCTIONAL status. <u>OR</u>	14 days
	C.2 Suspend the release of radioactive effluents via this pathway.	Immediately

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
D. One or more flow rate measurement channels non-functional.	D.1 Estimate the flow rate of the release.	Once per 4 hours during releases
	<u>AND</u> D.2 Restore the channel to FUNCTIONAL status.	30 days
E. One or more noble gas activity monitor channels non-functional.	E.1 Obtain grab samples from the effluent pathway.	Once per 12 hours during releases
	<u>AND</u> E.2 Perform an analysis of grab samples for radioactivity.	To meet LLD requirements per Table 16.11.6-1
	<u>AND</u> E.3 Restore the channel to FUNCTIONAL status.	30 days
F. Noble gas activity monitor providing automatic termination of release non-functional.	F.1 Suspend PURGING or VENTING of radioactive effluents via this pathway.	Immediately
G. One or more sampler channels non-functional.	G.1 Perform sampling with auxiliary sampling equipment as required by Table 16.11.6-1.	Continuously
	<u>AND</u> G.2 Restore the channel to FUNCTIONAL status.	30 days

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
H. One or more Sampler Minimum Flow Device Channels non-functional.	H.1 Verify flow through the sampling apparatus.	Once per 4 hours during releases
	<u>AND</u> H.2 Restore the channel to FUNCTIONAL status.	30 days
I. Required Action and associated Completion Time of Condition C, D, E, F, G, or H not met.	I.1 Explain why the non-functionality was not corrected within the specified Completion Time in the Annual Radioactive Effluent Release Report.	In the next scheduled Annual Radioactive Effluent Release Report

TESTING REQUIREMENTS

-----NOTE-----

Refer to Table 16.11.7-1 to determine which TRs apply for each Radioactive Gaseous Effluent Monitoring channel.

TEST	FREQUENCY
TR 16.11.7.1 Perform CHANNEL CHECK.	Prior to each release
TR 16.11.7.2 -----NOTE----- The SOURCE CHECK for these channels shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity or a simulated source of radioactivity such as a light emitting diode. ----- Perform SOURCE CHECK.	Prior to each release
TR 16.11.7.3 Perform CHANNEL CHECK.	24 hours
TR 16.11.7.4 Perform CHANNEL CHECK.	7 days

(continued)

TESTING REQUIREMENTS (continued)

TEST	FREQUENCY
<p>TR 16.11.7.5 -----NOTE-----</p> <p>The SOURCE CHECK for these channels shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity or a simulated source of radioactivity such as a light emitting diode.</p> <p>-----</p> <p>Perform SOURCE CHECK.</p>	31 days
<p>TR 16.11.7.6 -----NOTES-----</p> <ol style="list-style-type: none"> 1. For noble gas activity monitors providing automatic termination of release, the COT shall also demonstrate that automatic isolation of the pathway occurs if the instrument indicates measured levels above the Alarm/Trip Setpoint. 2. For all noble gas activity monitors, the COT shall also demonstrate that control room alarm annunciation occurs if the instrument indicates measured levels above the Alarm/Trip Setpoint; circuit failure and, a downscale failure. <p>-----</p> <p>Perform CHANNEL OPERATIONAL TEST.</p>	92 days
<p>TR 16.11.7.7 -----NOTE-----</p> <p>For all noble gas activity monitors, the initial CHANNEL CALIBRATION shall be performed using standards certified by the National Institute of Standards and Technology (NIST) or using standards obtained from suppliers that participate in measurement assurance activities with NIST. These standards shall permit calibrating the system over its intended range of energy and measurement range. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used.</p> <p>-----</p> <p>Perform a CHANNEL CALIBRATION.</p>	18 months

TABLE 16.11.7-1
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RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

INSTRUMENTS	MINIMUM CHANNELS FUNCTIONAL	REMEDIAL ACTION	APPLICABILITY	TESTING REQUIREMENTS
1. WASTE GAS HOLDUP SYSTEM				
a. Noble Gas Activity Monitor - Providing Alarm and Automatic Termination of Release (Low Range- EMF-50 or 1EMF-36, low-range)	1 per station	A, C, I	During gas effluent releases.	TR 16.11.7.1 TR 16.11.7.2 TR 16.11.7.6 TR 16.11.7.7
b. Effluent System Flow Rate Measuring Device	1 per station	D, I	At all times except when isolation valve is closed & locked.	TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7
2. Condenser Evacuation System - Noble Gas Activity Monitor (EMF-33)	1	A, E, I	When air ejectors are operable.	TR 16.11.7.3 TR 16.11.7.5 TR 16.11.7.6 TR 16.11.7.7
3. Vent System				
a. Noble Gas Activity Monitor (Low Range - EMF-36)	1	A, E, I	At all times.	TR 16.11.7.3 TR 16.11.7.5 TR 16.11.7.6 TR 16.11.7.7
b. Iodine Sampler	1	G, I	At all times, except during routine sampling.	TR 16.11.7.4
c. Particulate Sampler (EMF-35)	1	G, I	At all times, except during routine sampling.	TR 16.11.7.4
d. Unit Vent Flow Rate Monitor (Totalizer)	1	D, I	At all times.	TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7
e. Iodine Sampler Minimum Flow Device	1	H, I	At all times, except during routine sampling.	TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7
f. Particulate Sampler Minimum Flow Device (1)	1	G, I	At all times, except during routine sampling.	TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7
4. Containment Purge System - Noble Gas Activity Monitor - Providing Alarm and Automatic Termination of Release (Low Range - EMF-39)	1	A, F, I	Modes 1 through 6, except when isolation valve is closed & locked.	TR 16.11.7.2 TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7

(continued)

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RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

INSTRUMENTS	MINIMUM CHANNELS FUNCTIONAL	REMEDIAL ACTION	APPLICABILITY	TESTING REQUIREMENTS
5. Auxiliary Building Ventilation System - Noble Gas Activity Monitor (EMF-41 or EMF-36)	1	A, E, I	At all times.	TR 16.11.7.3 TR 16.11.7.5 TR 16.11.7.6 TR 16.11.7.7
6. Fuel Storage Area Ventilation System - Noble Gas Activity Monitor (EMF-42 or EMF-36)	1	A, E, I	At all times.	TR 16.11.7.3 TR 16.11.7.5 TR 16.11.7.6 TR 16.11.7.7
7. Contaminated Parts Warehouse Ventilation System				
a. Noble Gas Activity Monitor (EMF-53)	1 per station	A, E, I	During gaseous effluent releases.	TR 16.11.7.3 TR 16.11.7.5 TR 16.11.7.6 TR 16.11.7.7
b. Flow Rate Monitor	1 per station	D, I	During gaseous effluent releases.	TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7
c. EMF-53 Sampler Minimum Flow Device (1)	1 per station	H, I	During gaseous effluent releases.	TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7
8. Radwaste Facility Ventilation System				
a. Noble Gas Activity Monitor (EMF-52)	1 per station	A, E, I	During gaseous effluent releases.	TR 16.11.7.3 TR 16.11.7.5 TR 16.11.7.6 TR 16.11.7.7
b. Flow Rate Monitor	1 per station	D, I	During gaseous effluent releases.	TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7
c. EMF-52 Sampler Minimum Flow Device (1)	1 per station	H, I	During gaseous effluent releases.	TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7

(continued)

TABLE 16.11.7-1
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RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

INSTRUMENTS	MINIMUM CHANNELS FUNCTIONAL	REMEDIAL ACTION	APPLICABILITY	TESTING REQUIREMENTS
9. Equipment Staging Building Ventilation System				
a. Noble Gas Activity Monitor (EMF-59)	1 per station	A, E, I	During gaseous effluent releases.	TR 16.11.7.3 TR 16.11.7.5 TR 16.11.7.6 TR 16.11.7.7
b. Flow Rate Monitor	1 per station	D, I	During gaseous effluent releases.	TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7
c. EMF-59 Sampler Minimum Flow Device (1)	1 per station	H, I	During gaseous effluent releases.	TR 16.11.7.3 TR 16.11.7.6 TR 16.11.7.7
10. Containment Air Release and Addition System - Noble Gas Activity Monitor (EMF-39L or EMF-36L)	1	A, E, I	At all times except when isolation valve is closed & locked.	TR 16.11.7.3 TR 16.11.7.5 TR 16.11.7.6 TR 16.11.7.7

NOTES:

1. Radioactivity monitor (EMF) shall not be declared FUNCTIONAL unless both the EMF and the associated EMF's Minimum Flow Device are rendered FUNCTIONAL.

BASES

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 instrumentation consists of monitoring and sampling instrumentation. Monitors provide continuous display of process parameters with appropriate alarms and trip setpoints established. Samplers collect a portion of the desired process for subsequent laboratory analysis, and do not have alarm/trip capability. Samplers and the analysis program provide a method to assure that long term effluent release quantities do not exceed the requirements of SLC 16.11.6. Monitors provide assurance that instantaneous effluent releases do not exceed the requirements of SLC 16.11.6. The minimum flow devices for EMFs listed in Table 16.11.7-1 are required to provide assurance of representative sampling during actual or potential releases of gaseous effluents. The flow rate monitor quantifies the total gaseous effluent (both non-radioactive and radioactive) released to the environment. During routine sampling, instrumentation may be turned off for short periods of time (not to exceed 15 minutes) in order to meet analysis requirements of SLC 16.11.6. This is considered to be a normal function of the equipment. The Alarm/Trip Setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in the ODCM to ensure that the Alarm/Trip will occur prior to exceeding the limits stated in SLC 16.11.6. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

REFERENCES

1. McGuire Nuclear Station, Offsite Dose Calculation Manual
2. 10 CFR Part 50, Appendix A

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.8 Noble Gases

COMMITMENT Air dose due to noble gases released in gaseous effluents, from each unit, to areas at and beyond the SITE BOUNDARY (see Figure 16.11.1-1) shall be limited to the following:

- a. During any calendar quarter: Less than or equal to 5 mrad for gamma radiation and less than or equal to 10 mrad for beta radiation, and
- b. During any calendar year: Less than or equal to 10 mrad for gamma radiation and less than or equal to 20 mrad for beta radiation.

APPLICABILITY At all times.

REMEDIAL ACTIONS

NOTES

Enter applicable Conditions and Required Actions of SLC 16.11.12, "Total Dose," when the limits of this SLC are exceeded by twice the specified limit.

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Calculated air dose from radioactive noble gases in gaseous effluents exceeding any of above limits.</p>	<p>A.1 Prepare and submit a Special Report to the NRC which identifies the causes for exceeding the limits, corrective actions taken to reduce releases, and actions taken to ensure that subsequent releases are within limits.</p>	<p>30 days</p>

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11.8.1 Determine cumulative dose contributions from noble gases in gaseous effluents for current calendar quarter and current calendar year in accordance with the methodology and parameters in the ODCM.	31 days

BASES

This commitment is provided to implement the requirements of Sections II.B, III.A and IV.A of Appendix I, 10 CFR Part 50. The Limiting Condition for Operation implements the guides set forth in Section II.B of Appendix I.

The REMEDIAL ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable."

The TESTING REQUIREMENTS implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially under-estimated.

The dose calculation methodology and parameters 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, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors," Revision 1, July 1977.

The ODCM equations provided for determining the air doses at and beyond the SITE BOUNDARY are based upon the historical average atmospheric conditions.

This commitment applies at all times to the release of gaseous effluents from each reactor at the site. For units with shared Radwaste Treatment Systems, the gaseous effluents from the shared system are to be proportioned among the units sharing that system in accordance with the guidance given in NUREG-0133, Chapter 3.1.

REFERENCES

1. McGuire Nuclear Station, Off site Dose Calculation Manual
2. 10 CFR Part 50, Appendix I

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.9 Dose - Iodine-131 and 133, Tritium and Radioactive Materials in Particulate Form

COMMITMENT The dose to a MEMBER OF THE PUBLIC from Iodine-131 and 133, tritium, and all radioactive materials in particulate form with half-lives greater than 8 days in gaseous effluents released from each unit to areas at and beyond the SITE BOUNDARY (see Figure 16.11.1-1) shall be limited to the following:

- a. During any calendar quarter: less than or equal to 7.5 mrem to any organ, and
- b. During any calendar year: less than or equal to 15 mrem to any organ.

APPLICABILITY At all times.

REMEDIAL ACTIONS

-----NOTES-----

Enter applicable Conditions and Required Actions of SLC 16.11.12, "Total Dose," when the limits of this SLC are exceeded by twice the specified limit.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Calculated dose from the release of Iodine 131 and 133, tritium, and radioactive materials in particulate form with half-lives greater than 8 days in gaseous effluents exceeding any of the above limits.	A.1 Prepare and submit a Special Report to the NRC which identifies the causes for exceeding the limits, corrective actions taken to reduce releases, and actions taken to ensure that subsequent releases are within limits.	30 days

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11.9.1 Determine cumulative dose contributions for Iodine 131 and 133, tritium, and radioactive material in particulate form with half lives greater than 8 days in gaseous effluents for current calendar quarter and current calendar year in accordance with the methodology and parameters in the ODCM.	31 days

BASES

This commitment is provided to implement the requirements of Sections II.C, III.A and IV.A of Appendix I, 10 CFR Part 50. The Limiting Conditions for Operation are the guides set forth in Section II.C of Appendix I.

The REMEDIAL ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable.

The ODCM calculational methods specified in the TESTING REQUIREMENTS implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated.

The ODCM calculational methodology and parameters for calculating the doses due to the actual release rates of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors, Revision 1, July 1977. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate specifications for Iodine-131 and 133, tritium, and radionuclides in particulate form with half-lives greater than 8 days are dependent upon the existing radionuclide pathways to man, in the areas at and beyond the SITE BOUNDARY. The pathways that were examined in the development of these calculations were: (1) individual inhalation of airborne radionuclides; (2) deposition of radionuclides onto 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.

BASES (continued)

This commitment applies at all times to the release of gaseous effluents from each reactor at the site. For units with shared Radwaste Treatment Systems, the gaseous effluents from the shared system are to be proportioned among the units sharing that system in accordance with the guidance given in NUREG 0133, Chapter 3.1.

REFERENCES

1. McGuire Nuclear Station, Off site Dose Calculation Manual
2. 10 CFR Part 50, Appendix I

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.10 Gaseous Radwaste Treatment System

COMMITMENT The VENTILATION EXHAUST TREATMENT and WASTE GAS HOLDUP SYSTEMS shall be FUNCTIONAL and appropriate portions of these systems shall be used to reduce releases of radioactivity when the projected doses in 31 days due to gaseous effluent releases, from each unit, to areas at and beyond the SITE BOUNDARY (see Figure 16.11.1-1) would exceed:

- a. 0.2 mrad to air from gamma radiation, or
- b. 0.4 mrad to air from beta radiation, or
- c. 0.3 mrem to any organ of a MEMBER OF THE PUBLIC.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Radioactive gases being discharged without treatment and in excess of above limits.	A.1 Prepare and submit a Special Report to the NRC which identifies non-functional equipment and reasons for non-functionality, actions taken to restore the equipment to FUNCTIONAL status, and actions taken to prevent recurrence.	30 days

TESTING REQUIREMENTS

-----NOTE-----

The installed Gaseous Radwaste Treatment System shall be demonstrated FUNCTIONAL by meeting SLC 16.11.6, 16.11.8 and 16.11.9.

TEST	FREQUENCY
TR 16.11.10.1 Project gaseous release doses from each unit to areas at and beyond the SITE BOUNDARY, in accordance with the methodology and parameters in the ODCM, when gaseous systems are being released without being processed by its radwaste treatment system.	31 days

BASES

The FUNCTIONALITY of the WASTE GAS HOLDUP SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM ensures that the systems will be available for use whenever gaseous effluents require treatment prior to release to the environment. 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 commitment implements the requirements of 19 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50 and the design objectives given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the systems were specified as a suitable fraction of the dose design objectives set forth in Section II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

This commitment applies at all times to the release of radioactive materials in gaseous effluents from each unit at the site. For units with shared Radwaste Treatment Systems, the gaseous effluents from the shared system are to be proportioned among the units sharing that system in accordance with NUREG-0133, Chapter 3.1.

REFERENCES

1. McGuire Nuclear Station, Off site Dose Calculation Manual
2. 10 CFR Part 50, Appendix I
3. 10 CFR Part 50

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.11 Solid Radioactive Waste

COMMITMENT Radioactive wastes shall be processed and packaged to ensure compliance with the applicable requirements of 10 CFR Part 20, 10CFR Part 61, 10 CFR Part 71, and State regulations governing the transportation and disposal of radioactive wastes.

The Solid Radwaste System or an approved alternative process shall be used in accordance with a PROCESS CONTROL PROGRAM (PCP) for the solidification of liquid or wet radioactive wastes or the dewatering of wet radioactive wastes to be shipped for direct disposal at a 10CFR61 licensed disposal site. Wastes shipped for off site processing in accordance with the processor's specifications and transportation requirements are not required to be solidified or dewatered to meet disposal requirements.

- The PCP describes administrative and operational controls used for the solidification of liquid or wet solid radioactive wastes in order to meet applicable 10CFR61 waste form requirements.
- The PCP describes the administrative and operational controls used for the dewatering of wet radioactive wastes to meet 10CFR61 free standing water requirements.
- The process parameters used in establishing the PCP shall be based on demonstrated processing of actual or simulated liquid or wet solid wastes and must adequately verify that the final product of solidification or dewatering meets all applicable Federal, State and disposal site requirements.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Applicable regulatory requirements for solidified or dewatered wastes are not satisfied.</p>	<p>A.1 Suspend shipments of defectively packaged solid radioactive wastes from the site.</p> <p><u>AND</u></p> <p>A.2 Initiate action to correct the PROCESS CONTROL PROGRAM, procedures, or solid waste equipment as necessary to prevent recurrence.</p>	<p>Immediately</p> <p>Prior to next shipment for disposal of solidified or dewatered wastes.</p>
<p>B. A solidification test as described in the PCP fails to verify Solidification.</p>	<p>B.1 Suspend solidification of the batch under test and follow PCP guidance for test failures.</p> <p><u>AND</u></p> <p>B.2 Once a subsequent test verifies Solidification, solidification of the batch may then be resumed as directed by the PCP. The PCP shall be modified as required to assure Solidification of subsequent batches of waste</p>	<p>Immediately</p> <p>Prior to next solidification for shipment of waste for disposal at a 10CFR61 disposal site.</p>

(continued)

REMEDIAL ACTIONS (continued)

<p>C. With solidification or dewatering for disposal not performed in accordance with the PROCESS CONTROL PROGRAM.</p>	<p>C.1 Reprocess the waste in accordance with PCP requirements.</p> <p><u>OR</u></p> <p>C.2 Follow PCP or procedure guidance for alternative free standing liquid verification to ensure the waste in each container meets disposal requirements and take appropriate administrative action to prevent recurrence.</p>	<p>Prior to shipment for disposal of the inadequately processed waste that requires solidification of dewatering</p>
<p>D. With the solid waste equipment incapable of meeting SLC 16.11.11 or not in service</p>	<p>D.1 Restore the equipment to FUNCTIONAL status or provide for alternative capability to process wastes as necessary to satisfy all applicable disposal requirements</p>	<p>In a time frame that supports the COMMITMENT section of SLC 16.11.11</p>

TESTING REQUIREMENTS

TEST	FREQUENCY
<p>TR 16.11.11.1 The Process Control Program shall be used to verify the Solidification of at least one representative test specimens from at least every tenth batch of each type of radioactive waste to be solidified for disposal at a 10CFR61 disposal site per the COMMITMENT of this SLC.</p>	<p>Every tenth batch of each type of radioactive waste to be solidified.</p>

BASES:

This commitment implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50 and requirements to use a Process Control Program to meet applicable 10CFR61 waste form criteria for solidified and dewatered radioactive wastes.

REFERENCES:

1. 10CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"
2. 10 CFR Part 50, Appendix A
3. 10CFR20, "Standards for Protection Against Radiation"
4. 10CFR61, "Licensing Requirements for Land Disposal of Radioactive Waste"
5. 10CFR71, "Packaging and Transportation of Radioactive Materials"
6. DPCo Process Control Program Manual
7. NRC Generic Letter 84-12, "Compliance With 10 CFR Part 61 And Implementation Of the Radiological Effluent Technical Specifications (Rets) and Attendant Process Control Program (PCP)"
8. NRC Generic Letter 89-01, "Implementation of Programmatic Controls for Radiological 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"

TESTING REQUIREMENTS

-----NOTE-----

Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with SLC 16.11.3, 16.11.8 and 16.11.9, and in accordance with the methodology and parameters specified in the ODCM.

TEST	FREQUENCY
TR 16.11.12.1 Determine cumulative dose contributions from direct radiation from the units, the ISFSI, and from radwaste storage tanks in accordance with the methodology and parameters specified in the ODCM.	When calculated doses from effluent releases exceeds twice the limits of SLCs 16.11.3, 16.11.8 or 16.11.9

BASES

This commitment is provided to meet the dose limitations of 40 CFR Part 190 that have been incorporated into 10 CFR Part 20 by 46 FR 18525. The specification requires the preparation and submittal of a Special Report whenever the calculated doses from plant generated radioactive effluents and direct radiation exceed 25 mrem to the whole body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem. For sites containing up to four reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR Part 190 if the individual reactors remain within twice the dose design objectives of 10 CFR Part 50, Appendix I, and if direct radiation doses from the units and outside storage tanks are kept small.

This Special Report, as defined in 10 CFR Part 20.2203(a)(4), shall include an analysis that estimates the radiation exposure (dose) to a MEMBER OF THE PUBLIC from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s) covered by this report. It shall also describe levels of radiation and concentrations of radioactive material involved, and the cause of the exposure levels or concentrations. The Special Report will describe a course of action that should result in the limitation of the annual dose to a MEMBER OF THE PUBLIC to within the 40 CFR Part 190 limits. For the purposes of the Special Report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible, with the exception that 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 is estimated to exceed the requirements of 40 CFR Part 190, the Special Report with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in

BASES (continued)

accordance with the provisions of 40 CFR Part 190.11 and 10 CFR Part 20.2203(a)(4), is considered to be a timely request and fulfills the requirements of 40 CFR Part 190 and a variance is granted until NRC staff action is completed. The variance only relates to the limits of 40 CFR Part 190, and does not apply in any way to the other requirements for dose limitation of 10 CFR Part 20, as addressed in SLCs 16.11.1 and 16.11.6.

An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation that is part of the nuclear fuel cycle.

REFERENCES

1. McGuire Nuclear Station, Offsite Dose Calculation Manual
2. 10 CFR Part 20
3. 40 CFR Part 190
4. 10 CFR Part 50, Appendix I

16.11 RADIOLOGICAL EFFLUENT MONITORING

16.11.13 Radiological Environmental Monitoring Program

COMMITMENT The Radiological Environmental Monitoring Program shall be conducted as specified in Table 16.11.13-1.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Radiological Environmental Monitoring Program not being conducted as specified in Table 16.11.13-1.	A.1 Identify the reasons for not conducting the program as required and the plans for preventing a recurrence in the Annual Radiological Environmental Operating Report.	Within the next scheduled Annual Radiological Environmental Operating Report
B. Radioactivity level of environmental sampling medium at a specified location in excess of reporting limits of Table 16.11.13-2.	B.1 Prepare and submit a Special Report that 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 SLC 16.11.3, 16.11.8, and 16.11.9.	30 days

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>C. Milk or fresh leafy vegetable samples unavailable from one or more required sample locations.</p>	<p>C.1 -----NOTE----- Specific locations from which samples were unavailable may be deleted from the program. ----- Revise the Radiological Environmental Monitoring Program to identify locations for obtaining replacement samples.</p> <p><u>AND</u></p> <p>C.2 Identify the cause of the unavailability of samples and identify new location(s) for obtaining replacement samples in the next Annual Radioactive Effluent Release Report and also include in the report a revised figure(s) and table for the ODCM reflecting the new location(s).</p>	<p>30 days</p> <p>Within the next scheduled Annual Radioactive Effluent Release Report</p>

TESTING REQUIREMENTS

TEST	FREQUENCY
<p>TR 16.11.13.1 -----NOTES----- The maximum values for the lower limits of detection shall be as specified in Table 16.11.13-3. ----- The radiological environmental monitoring samples shall be collected from the locations given in the table and figure in the ODCM and shall be analyzed pursuant to the requirements of Tables 16.11.13-1.</p>	<p>In accordance with Table 16.11.13-1</p>

TABLE 16.11.13-1
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RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
1. Direct Radiation ⁽²⁾	<p>Forty routine monitoring stations either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, placed as follows:</p> <p>An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY;</p> <p>An outer ring of stations, one in each meteorological sector in the 6- to 8-km range from the site; and</p> <p>The balance of the stations placed in special interest areas such as population centers, nearby residences, schools, and in one or two areas to serve as control stations.</p>	Quarterly	Gamma dose quarterly.

(continued)

TABLE 16.11.13-1
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RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
2. Airborne Radioiodine and Particulates	<p>Samples from five locations:</p> <p>Three samples from close to the three SITE BOUNDARY locations, in different sectors, of the highest calculated annual average ground level D/Q.</p> <p>One sample from the vicinity of a community having the highest calculated annual average ground level D/Q.</p> <p>One sample from a control location, as for example 15-30 km distant and in the least prevalent wind direction⁽³⁾.</p>	<p>Continuous sampler operation with sample collection weekly, or more frequently if required by dust loading.</p>	<p><u>Radioiodine Canister:</u> I-131 analysis weekly.</p> <p><u>Particulate Sampler:</u> Gross beta radioactivity analysis following filter change⁽⁴⁾. Gamma isotopic analysis⁽⁵⁾ of composite (by location quarterly).</p>
3. Waterborne a. Surface ⁽⁶⁾	<p>One sample upstream. One sample downstream.</p>	<p>Composite sample over 1-month period⁽⁷⁾.</p>	<p>Gamma isotope analysis⁽⁵⁾ monthly. Composite for tritium analysis quarterly.</p>
b. Ground	<p>Samples from one or two sources only if likely to be affected⁽⁸⁾</p>	<p>Quarterly</p>	<p>Gamma isotopic⁽⁵⁾ and tritium analysis quarterly.</p>

(continued)

TABLE 16.11.13-1
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RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
c. Drinking	<p>One sample of each of one to three of the nearest water supplies that could be affected by its discharge.</p> <p>One sample from a control location.</p>	<p>Composite sample over 2-week period⁽⁷⁾ when I-131 analysis is performed; monthly composite otherwise.</p>	<p>I-131 analysis on each composite when the dose calculated for the consumption of the water is greater than 1 mrem per year⁽⁸⁾. Composite for gross beta and gamma isotopic analyses⁽⁵⁾ monthly. Composite for tritium analysis quarterly.</p>
d. Sediment from the shoreline	<p>One sample from downstream area with existing or potential recreational value.</p>	<p>Semiannually</p>	<p>Gamma isotopic analysis⁽⁵⁾ semiannually.</p>
4. Ingestion a. Milk	<p>Samples from milking animals in three locations within 5-km distance having the highest dose potential. If there are none, then one sample from milking animals in each of three areas between 5 to 8 km distant where doses are calculated to be greater than 1 mrem per year⁽⁹⁾.</p> <p>One sample from milking animals at a control location 15 to 30 km distant and in the least prevalent wind direction.</p>	<p>Semimonthly when animals are on pasture; monthly at other times.</p>	<p>Gamma isotopic⁽⁵⁾ and I-131 analysis semimonthly when animals are on pasture; monthly at other times.</p>

(continued)

TABLE 16.11.13-1
(Page 4 of 6)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
<p>b. Fish and Invertebrates</p>	<p>One sample each commercially and recreationally important species in vicinity of plant discharge area.</p> <p>One sample of same species in areas not influenced by plant discharge.</p>	<p>Sample in season, or semiannually if they are not seasonal</p>	<p>Gamma isotopic analysis⁽⁶⁾ on edible portions</p>
<p>c. Food Products</p>	<p>One sample of each principal class of food products from any area that is irrigated by water in which liquid plant wastes have been discharged.</p> <p>Samples of three different kinds of broad leaf vegetation grown nearest each of two different offsite locations of highest predicted annual average ground level D/Q if milk sampling is not performed.</p> <p>One sample of each of the similar broad leaf vegetation grown 15 to 30 km distant in the least prevalent wind direction if milk sampling is not performed.</p>	<p>At time of harvest⁽¹⁰⁾</p> <p>Monthly, when available.</p> <p>Monthly, when available.</p>	<p>Gamma isotopic analyses⁽⁶⁾ on edible portion.</p> <p>Gamma isotopic⁽⁶⁾ and I-131 analysis.</p> <p>Gamma isotopic⁽⁶⁾ and I-131 analysis.</p>

TABLE 16.11.13-1

(Page 5 of 6)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

NOTES:

1. Specific parameters of distance and direction sector from the centerline of one reactor, and additional description where pertinent, shall be provided for each and every sample location in Table 16.11.13-1 in a table and figure(s) in the ODCM. Refer to NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978, and to Radiological Assessment Branch Technical Position, Revision 1, November 1979. Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment and other legitimate reasons. If specimens are unobtainable due to sampling equipment malfunction, every effort 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. It is recognized that, at times, it may not be possible or practical 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. In lieu of an Licensee Event Report, identify the cause of the unavailability of samples for that pathway and identify the new location(s) for obtaining replacement samples in the next Annual Radioactive Effluent Release Report and also include in the report a revised figure(s) and table for the ODCM reflecting the new location(s).
2. One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dosimeters. For the purposes of this table, a thermoluminescent dosimeter (TLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation. The forty stations is not an absolute number. The number of direct radiation monitoring stations may be reduced according to geographical limitations; e.g., at an ocean site, some sections will be over water so that the number of dosimeters may be reduced accordingly. The frequency of analysis or readout for TLD systems will depend upon the characteristics of the specific system used and should be selected to obtain optimum dose information with minimal fading.
3. The purpose of this sample is to obtain background information. If it is not practical to establish control locations in accordance with the distance and wind direction criteria, other sites that provide valid background data may be substituted.
4. Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air particulate samples is greater than ten times the yearly mean of control samples, gamma isotopic analysis shall be performed on the individual samples.

TABLE 16.11.13-1

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RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

NOTES (continued):

5. Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.
6. The "upstream sample" shall be taken at a distance beyond significant influence of the discharge. The "downstream" sample shall be taken in an area beyond but near the mixing zone. "Upstream" samples in an estuary must be taken far enough upstream to be beyond the plant influence. Salt water shall be sampled only when the receiving water is utilized for recreational activities.
7. A composite sample is one in which the quantity (aliquot) of liquid sampled is proportional to the quantity of flowing liquid and in which the method of sampling employed results in a specimen that is representative of the liquid flow. In this program composite sample aliquots shall be collected at time intervals that are very short (e.g., hourly) relative to the compositing period (e.g., monthly) in order to assure obtaining a representative sample.
8. Groundwater samples shall be taken when this source is tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination.
9. The dose shall be calculated for the maximum organ and age group, using the methodology and parameters in the ODCM.
10. If harvest occurs more than once a year, sampling shall be performed during each discrete harvest. If harvest occurs continuously, sampling shall be monthly. Attention shall be paid to including samples of tuborous and root food products.

TABLE 16.11.13-2
(Page 1 of 1)

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

ANALYSIS	REPORTING LEVELS					
	WATER (pCi/l)	AIRBOURNE PARTICULATE OR GASES (pCi/m ³)	FISH (pCi/kg, wet)	MILK (pCi/l)	BROAD LEAF VEGETATION (pCi/kg, wet)	
H-3	20,000 ⁽¹⁾	N/A	N/A	N/A	N/A	
Mn-54	1,000	N/A	30,000	N/A	N/A	
Fe-59	400	N/A	10,000	N/A	N/A	
Co-58	1,000	N/A	30,000	N/A	N/A	
Co-60	300	N/A	10,000	N/A	N/A	
Zn-65	300	N/A	20,000	N/A	N/A	
Zr-Nb-95	400	N/A	N/A	N/A	N/A	
I-131	2	0.9	N/A	3	100	
Cs-134	30	10	1,000	60	1,000	
Cs-137	50	20	2,000	70	2,000	
Ba-La-140	200	N/A	N/A	300	N/A	

NOTES:

1. For drinking water samples. This is 40 CFR Part 141 value. If no drinking water pathway exists, a value of 30,000 pCi/l may be used.

TABLE 16.11.13-3
(Page 1 of 3)

MAXIMUM VALUES FOR THE LOWER LIMITS OF DETECTION (LLD) ⁽¹⁾⁽²⁾⁽³⁾

ANALYSIS	WATER (pCi/l)	AIRBORNE PARTICULATE OR GASES (pCi/m ³)	FISH (pCi/kg, wet)	MILK (pCi/l)	BROAD LEAF VEGETATION (pCi/kg, wet)	SEDIMENT (pCi/kg, dry)
Gross Beta	4	0.01	N/A	N/A	N/A	N/A
H-3	2000*	N/A	N/A	N/A	N/A	N/A
Mn-54	15	N/A	130	N/A	N/A	N/A
Fe-59	30	N/A	260	N/A	N/A	N/A
Co-58, 60	15	N/A	130	N/A	N/A	N/A
Zn-65	30	N/A	260	N/A	N/A	N/A
Zr-95	15	N/A	N/A	N/A	N/A	N/A
Nb-95	15	N/A	N/A	N/A	N/A	N/A
I-131	1 ⁽⁴⁾	0.07	N/A	1	60	N/A
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-140	15	N/A	N/A	15	N/A	N/A
La-140	15	N/A	N/A	15	N/A	N/A

* If no drinking water pathway exists, a value of 3000 pCi/l may be used.

TABLE 16.11.13-3
(Page 2 of 3)

MAXIMUM VALUES FOR THE LOWER LIMITS OF DETECTION (LLD)

NOTES:

1. The LLD is defined, for purposes of these commitments, 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 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{(2.71/T) + 4.65S_b}{E \cdot V \cdot 2.22 \cdot Y \cdot \exp(-\lambda\Delta t)}$$

Where:

LLD is the "a priori" lower limit of detection as defined above (as picoCurie per unit mass or volume),

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute),

E is the counting efficiency (as counts per disintegration),

V is the sample size (in units of mass or volume),

2.22 is the number of disintegrations per minute per picoCurie,

Y is the fractional radiochemical yield (when applicable),

λ is the radioactive decay constant for the particular radionuclide,

Δt is the elapsed time between sample collection (or end of the sample collection period) and time of counting (for environmental samples, not plant effluent samples), and

T is the background and sample counting time in minutes.

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. Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report.

TABLE 16.11.13-3
(Page 3 of 3)

MAXIMUM VALUES FOR THE LOWER LIMITS OF DETECTION (LLD)

NOTES (continued):

2. This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report.
3. Required detection capabilities for thermoluminescent dosimeters used for environmental measurements shall be in accordance with the recommendations of Regulatory Guide 4.13.
4. LLD for drinking water samples. If no drinking water pathway exists, the LLD of gamma isotopic analysis may be used.

BASES

The Radiological Environmental Monitoring Program is established to monitor the radiation and radionuclides in the environs of the plant. The program provides representative measurements of radioactivity in the highest potential exposure pathways, and verification of the accuracy of the effluent monitoring program and modeling of environmental exposure pathways. The program is contained in SLC 16.11.13 – 16.11.16 and conforms to the guidance of Appendix I to 10 CFR Part 50. The program includes the following:

1. Monitoring, sampling, analysis, and reporting of radiation and radionuclides in the environment in accordance with the methodology and parameters in the ODCM,
2. A Land Use Census to ensure that changes in the use of areas at and beyond the SITE BOUNDARY are identified and that modifications to the monitoring program are made if required by the results of this census, and
3. Participation in an Interlaboratory Comparison Program to ensure that independent checks on the precision and accuracy of the measurements of radioactive materials in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring.

The portion of the Radiological Environmental Monitoring Program required by this commitment provides representative measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposures of MEMBERS OF THE PUBLIC resulting from the station operation. This monitoring program implements Section IV.B.2 of Appendix I to 10 CFR Part 50 and thereby supplements the Radiological Effluent Monitoring Program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the modeling of the environmental exposure pathways. Guidance for this monitoring program is provided by the Radiological Assessment Branch Technical Position on Environmental Monitoring. The initially specified monitoring program will be effective for at least the first 3 years of commercial operation. Following this period, program changes may be initiated based on operational experience.

The required detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLDs). The LLDs required by Table 16.11.13-3 are 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.

With the level of radioactivity in an environmental sampling medium at a specified location exceeding the reporting levels of Table 16.11.13-3 when averaged over any calendar quarter, in lieu of a Licensee Event Report, prepare and submit to the Commission within 30 days a Special Report that defines the corrective actions to be

BASES (continued)

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 SLCs 16.11.6, 16.11.8, and 16.11.9. When more than one of the radionuclides in Table 16.11.13-2 are detected in the sampling medium, this report shall be submitted if:

$$\frac{\text{concentration (1)}}{\text{limit level (1)}} + \frac{\text{concentration (2)}}{\text{limit level (2)}} + \dots \geq 1.0$$

When radionuclides other than those in Table 16.11.13-2 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 SLCs 16.11.6, 16.11.8 and 16.11.9. 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 Operating Report. The methodology and parameters used to estimate the potential annual dose to a MEMBER OF THE PUBLIC shall be indicated in this report.

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).

REFERENCES

1. McGuire Nuclear Station, Off site Dose Calculation Manual
2. 10 CFR Part 50, Appendix I

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.14 Land Use Census

COMMITMENT 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:

- a. the nearest milk animal,
- b. the nearest residence, and
- c. the nearest garden of greater than 50 m² (500 ft²) producing broad leaf vegetation.

For elevated releases as defined in Regulatory Guide 1.111, Revision 1, July 1977, the land use census shall identify within a distance of 5 km (3 miles) the location in each of the 16 meteorological sectors of:

- a. all milk animals, and
- b. all gardens of greater than 50 m² producing broad leaf vegetation.

-----NOTE-----
Broad leaf vegetation sampling of three different kinds of vegetation may be performed at the SITE BOUNDARY in each of two different direction sectors with the highest predicted D/Qs in lieu of the garden census. Specifications for broad leaf vegetation sampling in Table 16.11.13-1 4c shall be followed, including analysis of control samples.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Location(s) identified which yields a calculated dose/dose commitment greater than values currently calculated in SLC 16.11.9.	A.1 Identify the new location in the Annual Radioactive Effluent Release Report.	In next scheduled Annual Radioactive Effluent Release Report

(continued)

BASES

This commitment is provided to ensure that changes in the use of areas at and beyond the SITE BOUNDARY are identified and that modifications to the Radiological Environmental Monitoring Program are made if required by the results of this census. The best information from the door-to-door survey, from aerial survey, or from consulting with local agricultural authorities shall be used. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the census to gardens of greater than 50 m² 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/m².

With a land use census identifying a location(s) which yields a calculated dose or dose commitment (via the same exposure pathway) 20% greater than at a location from which samples are currently being obtained in accordance with SLC 16.11.13, add the new location to the Radiological Environmental Monitoring Program. The sampling location(s), excluding the control station location, having the lowest calculated dose or dose commitment (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.

REFERENCES

1. McGuire Nuclear Station, Off site Dose Calculation Manual
2. 10 CFR Part 50, Appendix I

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.15 Interlaboratory Comparison Program

COMMITMENT Analyses shall be performed on radioactive materials, supplied as part of an Interlaboratory Comparison Program (ICP), that correspond to samples required by SLC 16.11.13.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Analyses not being performed as required.	A.1 Report corrective actions taken to prevent recurrence in the Annual Radiological Environmental Operating Report.	In next scheduled Annual Radiological Environmental Operating Report

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11.15.1 Report a summary of the results of the Interlaboratory Comparison Program in the Annual Radiological Environmental Operating Report.	12 months

BASES

This requirement for participation in an Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring in order to demonstrate that the results are valid for the purposes of Section IV.B.2 of Appendix I to 10 CFR Part 50.

The Interlaboratory Comparison Program (ICP) shall be described in the Annual Radiological Environmental Operating Report.

REFERENCES

1. 10 CFR Part 50, Appendix I

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.16 Annual Radiological Environmental Operating Report

COMMITMENT Routine Annual Radiological Environmental Operating Reports covering the operation of the unit during the previous calendar year shall be submitted by May 15 of each year. |

The Annual Radiological Environmental Operating Reports shall include summaries, interpretations, and an analysis of trends of the results of the radiological environmental surveillance activities for the report period, including a comparison with pre-operational studies, with operational controls as appropriate, and with previous environmental surveillance reports, and an assessment of the observed impacts of the plant operation on the environment. The reports shall also include the results of land use censuses required by SLC 16.11.14.

The Annual Radiological Environmental Operating Reports shall include the results of analysis of all radiological environmental samples and of all environmental radiation measurements taken during the period pursuant to the locations specified in the Table and Figures in the ODCM, as well as summarized and tabulated results of these analyses and measurements in the format of the table in the Radiological Assessment Branch Technical Position, Revision 1, November 1979. In the event that some individual results are not available for inclusion with the report, the report shall be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted as soon as possible in a supplementary report.

The reports shall also include the following:

- a summary description of the Radiological Environmental Monitoring Program;
- at least two legible maps covering all sampling locations keyed to a table giving distances and directions from the centerline of one reactor (one map shall cover stations near the site boundary; a second shall include the more distant stations);
- the results of licensee participation in the Interlaboratory Comparison Program, required by SLC 16.11.15;
- a discussion of all deviations from the sampling schedule of Table 16.11.13-1; and

COMMITMENT (continued)

- a discussion of all analyses in which the LLD required by Table 16.11.13-3 was not achievable.

A single submittal may be made for a multiple unit station..

APPLICABILITY

At all times.

REMEDIAL ACTIONS

None

TESTING REQUIREMENTS

None

BASES

None

REFERENCES

1. Technical Specification 5.6.2

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.17 Radioactive Effluent Release Reports

COMMITMENT Routine Radioactive Effluent Release Reports covering the operation of the unit during the previous calendar year of operation shall be submitted before May 1 of each year.

The Radioactive Effluent Release Reports shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the unit as outlined in 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, with data provided for the reporting period using Appendix B as guidance.

The Radioactive Effluent Release Report shall include an annual summary of hourly meteorological data collected over the previous calendar year. This annual summary may be either in the form of an hour-by-hour listing on magnetic tape of wind speed, wind direction, atmospheric stability, and precipitation (if measured), or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability. This same report shall include an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the unit or station during the previous calendar year. A five year average of representative onsite meteorological data shall be used in the gaseous effluent dose pathway calculations. Dispersion factors (X/Qs) and deposition factors (D/Qs) shall be generated using the computer code XOQDOQ (NUREG/CR-2919) which implements NRC Regulatory Guide 1.111. The meteorological conditions concurrent with the time of release shall be reviewed annually to determine if the five-year average values should be revised. The assessment of radiation doses shall be performed in accordance with the methodology and parameters in the OFFSITE DOSE CALCULATION MANUAL (ODCM).

The Radioactive Effluent Release Report shall also include an assessment of radiation doses to the likely most exposed MEMBER OF THE PUBLIC from reactor releases and other nearby uranium fuel cycle sources, including doses from primary effluent pathways and direct radiation, for the previous calendar year to show conformance with 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operation." Acceptable methods for calculating the dose contribution from liquid and gaseous effluents are given in Regulatory Guide 1.109, Rev. 1, October 1977.

COMMITMENT (continued)

The Radioactive Effluent Release Reports shall include the following information for each type of solid waste shipped offsite or disposed of in the site landfill during the report period:

- a. Total container volume, in cubic meters,
- b. Total Curie quantity (determined by measurement or estimate),
- c. Principal radionuclides (determined by measurement or estimate),
- d. Type of waste (e.g., dewatered spent resin, compacted dry waste, evaporator bottoms),
- e. Number of shipments, and
- f. Solidification agent or absorbent (e.g., cement, or other approved agents (media)).

The Radioactive Effluent Release Reports shall include a list and description of unplanned releases from the site to UNRESTRICTED AREAS of radioactive materials in gaseous and liquid effluents made during the reporting period.

The Radioactive Effluent Release Reports shall include any changes made during the reporting period to the PROCESS CONTROL PROGRAM (PCP) and to the OFFSITE DOSE CALCULATION MANUAL (ODCM), as well as a listing of new locations for dose calculations and/or environmental monitoring identified by the land use census pursuant to SLC 16.11.14.

The Radioactive Effluent Release Reports shall also identify any licensee initiated major changes to the Radioactive Waste Systems (liquid, gaseous, and solid). Otherwise, this information may be included in the annual UFSAR update. The discussion of each change shall contain:

- a. A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR Part 50.59;
- b. Sufficient detailed information to totally support the reason for the change without benefit of additional or supplemental information;
- c. A detailed description of the equipment, components, and processes involved and the interfaces with other plant systems;
- d. An evaluation of the change, which shows the predicted releases of radioactive materials in liquid and gaseous effluents and/or quantity of solid waste that differ from those previously predicted in the License application and amendments thereto;

COMMITMENT (continued)

- e. An evaluation of the change, which shows expected maximum exposures to individual in the UNRESTRICTED AREA and to the general population that differ from those previously estimated in the License application and amendments thereto;
- f. A comparison of the predicted releases of radioactive materials, in liquid and gaseous effluents and in solid waste, to the actual releases for the period prior to when the changes are to be made;
- g. An estimate of the exposure to plant operating personnel as a result of the change; and
- h. Documentation of the fact that the change was reviewed and found acceptable by the Station Manager or the Chemistry Manager.

A single submittal may be made for a multiple unit station. The submittal should combine those sections that are common to all units at the station; however, for units with separate Radwaste Systems, the submittal shall specify the releases of radioactive material from each unit.

APPLICABILITY

At all times

REMEDIAL ACTIONS

None

TESTING REQUIREMENTS

None

BASES

None

REFERENCES

1. Technical Specification 5.6.3

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.18 Liquid Holdup Tanks

COMMITMENT The quantity of radioactive material contained in each unprotected outdoor radwaste tank shall be limited to ≤ 10 Curies, excluding tritium and dissolved or entrained noble gases.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Quantity of radioactive material in tank not within limit.	A.1 Suspend all additions of radioactive material to the tank.	Immediately
	<u>AND</u>	
	A.2 Reduce the tank contents to within limit.	48 hours
	<u>AND</u>	
	A.3 Describe the events leading to this condition in the next Annual Radioactive Effluent Release Report.	Within the next scheduled Annual Radioactive Effluent Release Report

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11.18.1 Verify the quantity of radioactive material contained in unprotected outdoor radwaste tanks is within limits by analyzing a representative sample of the tank's contents when radioactive materials are being added to the tank.	7 days

BASES

The tanks applicable to this SLC include all those outdoor radwaste tanks that are not surrounded by liners, dikes, or walls capable of holding the tank contents and that do not have tank overflows and surrounding area drains connected to the Liquid Radwaste Treatment System.

Restricting the quantity of radioactive material contained in the specified tanks provides assurance that in the event of an uncontrolled release of the tanks' contents, the resulting concentrations would be less than the limits of 10 CFR Part 20, Appendix B, Table II, Column 2, at the nearest potable water supply and the nearest surface water supply in an UNRESTRICTED AREA.

REFERENCES

None

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.19 Explosive Gas Mixture

COMMITMENT The concentration of oxygen in the WASTE GAS HOLDUP SYSTEM shall be limited to $\leq 2\%$ by volume whenever the hydrogen concentration exceeds 4% by volume.

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Concentration of oxygen in the WASTE GAS HOLDUP SYSTEM $> 2\%$ but $\leq 4\%$ by volume.	A.1 Reduce oxygen concentration to within limits.	48 hours
B. Concentration of oxygen in the WASTE GAS HOLDUP SYSTEM $> 4\%$ and hydrogen concentration $> 4\%$ by volume.	B.1 Suspend all additions of waste gases to the system.	Immediately
	<u>AND</u> B.2 Reduce the concentration of oxygen to $\leq 4\%$ by volume.	Immediately
	<u>AND</u> B.3 Reduce oxygen concentration to within limits.	48 hours

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11.19.1 Verify the concentrations of hydrogen and oxygen in the WASTE GAS HOLDUP SYSTEM is within limits by monitoring waste gases in the WASTE GAS HOLDUP SYSTEM with the hydrogen and oxygen monitors required by SLC 16.7.8.	During WASTE GAS HOLDUP SYSTEM operation

BASES

This specification is provided to ensure that the concentration of potentially explosive gas mixtures contained in the WASTE GAS HOLDUP SYSTEM is maintained below the flammability limits of hydrogen and oxygen. Automatic control features are included in the system to prevent the hydrogen and oxygen concentrations from reaching these flammability limits. These automatic control features include isolation of the source of hydrogen and/or oxygen, automatic diversion to recombiners, or injection of dilutants to reduce the concentration below the flammability limits. Maintaining the concentration of hydrogen and oxygen below their flammability limits provides assurance that the releases of radioactive materials will be controlled in conformance with the requirements of General Design Criterion 60 of Appendix A to 10 CFR Part 50.

REFERENCES

None

16.11 RADIOLOGICAL EFFLUENT CONTROLS

16.11.20 Gas Storage Tanks

COMMITMENT The quantity of radioactivity contained in each gas storage tank shall be limited \leq 49,000 Curies noble gases (considered as Xe-133).

APPLICABILITY At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Quantity of radioactive material in tank not within limit.	A.1 Suspend all additions of radioactive material to the tank.	Immediately
	<u>AND</u> A.2 Reduce the tank contents to within limit.	48 hours

TESTING REQUIREMENTS

TEST	FREQUENCY
TR 16.11.20.1 Verify the quantity of radioactive material contained in each gas storage tank is within limit when radioactive materials are being added to the tank.	24 hours

BASES

This SLC considers postulated radioactive releases due to a waste gas system leak or failure, and limits the quantity of radioactivity in each pressurized gas storage tank in the WASTE GAS HOLDUP SYSTEM to assure that a release would be substantially below the dose guideline values of 10 CFR Part 100 for a postulated event.

Restricting the quantity of radioactivity contained in each gas storage tank provides assurance that in the event of an uncontrolled release of the tank's contents, the resulting total body exposure to a MEMBER OF THE PUBLIC at the nearest exclusion area boundary will not exceed 0.5 rem. This is consistent with Standard Review Plan 11.3, Branch Technical Position ETSB 11-5, "Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure," in NUREG-0800, July 1981.

REFERENCES

None

Attachment 10
Summary of Changes to the Process Control Program

McGuire Nuclear Station Units 1 & 2
Period 1/1/2017 - 12/31/2017

ATTACHMENT 10

Summary of Changes to the Process Control Program

This attachment includes a summary of changes to the PCP.

Attachment 10
Summary of Changes to the Process Control Program

McGuire Nuclear Station Units 1 & 2
Period 1/1/2017 - 12/31/2017

The McGuire Nuclear Station PCP was not revised in 2019. The most recent revision was provided with the McGuire Nuclear Station 2018 ARERR.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 11

Summary of Major Modifications to the Radioactive Waste Treatment Systems

This attachment includes a description of major modifications to the radioactive waste treatment systems that are anticipated to affect effluent releases.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

No major modifications to McGuire Nuclear Station liquid, gaseous, solid, or mobile radioactive waste treatment systems occurred in 2019.

Attachment 12
Errata to a Previous Year's ARERR

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 12

Errata to a Previous Year's ARERR

This attachment includes any amended pages from a previous year's ARERR.

Attachment 12
Errata to a Previous Year's ARERR

McGuire Nuclear Station Units 1 & 2
Period 1/1/2019 - 12/31/2019

There are no changes to a previous year's ARERR.

Enclosure 5
RA-20-0078

ENCLOSURE 5: [ONS Annual Radioactive Effluent Release Report](#)



Oconee Nuclear Station Units 1, 2, and 3

Annual Radioactive Effluent Release Report

January 1, 2019 through December 31, 2019

Dockets 50-269, 50-270, and 50-287



Introduction

The Annual Radioactive Effluent Release Report is pursuant to Oconee Nuclear Station Technical Specification 5.6.3 and Selected Licensee Commitment 16.11-9. The below listed attachments to this report provide the required information. In addition, the ODCM is included pursuant to Oconee Nuclear Station Technical Specification 5.5.1.

- Attachment 1 Summary of Gaseous and Liquid Effluents
- Attachment 2 Supplemental Information
- Attachment 3 Solid Radioactive Waste Disposal
- Attachment 4 Meteorological Data
- Attachment 5 Unplanned Offsite Releases
- Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public
- Attachment 7 Information to Support the NEI Ground Water Protection Initiative
- Attachment 8 Inoperable Equipment
- Attachment 9 Summary of Changes to the Offsite Dose Calculation Manual
- Attachment 10 Summary of Changes to the Process Control Program
- Attachment 11 Summary of Major Modifications to the Radioactive Waste Treatment Systems
- Attachment 12 Errata to a Previous Year's ARERR

Attachment 1
Summary of Gaseous and Liquid Effluents

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 1

Summary of Gaseous and Liquid Effluents

This attachment includes a summary of the quantities of radioactive liquid and gaseous effluents as outlined in Regulatory Guide 1.21, Appendix B.

Attachment 1
Summary of Gaseous and Liquid Effluents

Oconee Nuclear Station Units 1, 2, & 3
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
1. Total Release	Ci	2.96E+00	8.81E-01	9.24E-01	3.82E+00	8.58E+00
2. Avg. Release Rate	µCi/sec	3.80E-01	1.12E-01	1.16E-01	4.81E-01	2.72E-01
B. Iodines and Halogens						
1. Total Release	Ci	0.00E+00	0.00E+00	5.66E-08	3.08E-05	3.09E-05
2. Avg. Release Rate	µCi/sec	0.00E+00	0.00E+00	7.12E-09	3.88E-06	9.80E-07
C. Particulates Half-Life ≥ 8 days						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	µCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
1. Total Release	Ci	3.89E+01	2.29E+01	3.60E+01	5.53E+01	1.53E+02
2. Avg. Release Rate	µCi/sec	5.00E+00	2.91E+00	4.53E+00	6.95E+00	4.85E+00
E. Carbon-14						
1. Total Release	Ci	6.05E+00	6.11E+00	6.07E+00	5.30E+00	2.35E+01
2. Avg. Release Rate	µCi/sec	7.78E-01	7.77E-01	7.63E-01	6.67E-01	7.46E-01
F. Gross Alpha						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	µCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Attachment 1
Summary of Gaseous and Liquid Effluents**

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Mixed Mode - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
Xe-133	Ci	2.95E+00	8.47E-01	8.80E-01	2.68E+00	7.35E+00
Total for Period	Ci	2.95E+00	8.47E-01	8.80E-01	2.68E+00	7.35E+00
B. Iodines and Halogens						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life ≥ 8 days						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
H-3	Ci	3.59E+01	2.05E+01	2.77E+01	5.08E+01	1.35E+02
E. Carbon-14						
C-14	Ci	1.82E+00	1.83E+00	1.82E+00	1.59E+00	7.06E+00
F. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

* 30% of total C-14 released is assumed to be in continuous mode. See Attachment 2, Supplemental Information, of this report.

Attachment 1
Summary of Gaseous and Liquid Effluents

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Mixed Mode Releases - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
Ar-41	Ci	5.26E-03	2.30E-02	3.68E-02	6.14E-01	6.79E-01
Kr-88	Ci	0.00E+00	0.00E+00	0.00E+00	8.04E-06	8.04E-06
Xe-131m	Ci	0.00E+00	0.00E+00	0.00E+00	1.17E-04	1.17E-04
Xe-133	Ci	5.37E-03	1.07E-02	6.82E-03	5.13E-01	5.36E-01
Xe-133m	Ci	0.00E+00	7.80E-05	0.00E+00	5.30E-04	6.08E-04
Xe-135	Ci	0.00E+00	1.44E-04	4.65E-04	1.34E-02	1.40E-02
Total for Period	Ci	1.06E-02	3.39E-02	4.41E-02	1.14E+00	1.23E+00
B. Iodines and Halogens						
Br-82	Ci	0.00E+00	0.00E+00	5.66E-08	0.00E+00	5.66E-08
I-131	Ci	0.00E+00	0.00E+00	0.00E+00	1.18E-08	1.18E-08
I-132	Ci	0.00E+00	0.00E+00	0.00E+00	3.08E-05	3.08E-05
I-133	Ci	0.00E+00	0.00E+00	0.00E+00	1.47E-09	1.47E-09
Total for Period	Ci	0.00E+00	0.00E+00	5.66E-08	3.09E-05	3.09E-05
C. Particulates Half-Life ≥ 8 days						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
H-3	Ci	1.66E-03	4.91E-02	1.07E-01	7.56E-01	9.14E-01
E. Carbon-14						
C-14	Ci	4.23E+00	4.28E+00	4.25E+00	3.71E+00	1.65E+01
F. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

* 70% of total C-14 released is assumed to be in batch mode. See Attachment 2, Supplemental Information, of this report.

Attachment 1
Summary of Gaseous and Liquid Effluents

Oconee Nuclear Station Units 1, 2, & 3
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground Releases - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Iodines and Halogens						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life ≥ 8 days						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
H-3	Ci	2.95E+00	2.32E+00	8.13E+00	3.66E+00	1.71E+01
E. Carbon-14						
C-14	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Oconee Nuclear Station Units 1, 2, & 3
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground Releases - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Iodines and Halogens						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life \geq 8 days						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
H-3	Ci	2.40E-02	2.37E-02	2.76E-02	2.75E-02	1.03E-01
E. Carbon-14						
C-14	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products *						
1. Total Release	Ci	2.19E-04	1.51E-04	1.08E-04	0.00E+00	4.78E-04
2. Avg. Diluted Conc.	µCi/ml	5.95E-14	3.32E-14	3.19E-14	0.00E+00	0.00E+00
3. Batch Releases	µCi/ml	2.61E-11	1.79E-11	1.27E-11	0.00E+00	0.00E+00
B. Tritium						
1. Total Release	Ci	1.51E+02	1.04E+02	2.78E+02	4.09E+02	9.43E+02
2. Avg. Diluted Conc.	µCi/ml	6.14E-08	3.78E-08	1.03E-07	1.92E-07	0.00E+00
3. Batch Releases	µCi/ml	1.80E-05	1.23E-05	3.25E-05	4.78E-05	0.00E+00
C. Dissolved & Entrained Gases						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Diluted Conc.	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Batch Releases	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Diluted Conc.	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Batch Releases	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E. Volume of Liquid Waste						
1. Batch Releases	liters	1.33E+06	7.94E+05	1.19E+06	2.51E+06	5.82E+06
2. Continuous Releases	liters	5.82E+08	4.27E+08	4.71E+08	7.10E+08	2.19E+09
F. Volume of Dilution Water						
1. Batch Releases	liters	8.37E+09	8.46E+09	8.55E+09	8.55E+09	3.39E+10
2. Continuous Releases	liters	8.37E+09	8.46E+09	8.55E+09	8.55E+09	3.39E+10

* Excludes tritium, dissolved and entrained noble gases, and gross alpha.

**Attachment 1
Summary of Gaseous and Liquid Effluents**

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Tritium						
H-3	Ci	1.82E-01	1.33E-01	1.93E-01	2.20E-01	7.28E-01
C. Dissolved & Entrained Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

Oconee Nuclear Station Units 1, 2, & 3
 Period 1/1/2019 - 12/31/2019

Liquid Effluents - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
Mn-54	Ci	0.00E+00	5.36E-06	0.00E+00	0.00E+00	5.36E-06
Fe-55	Ci	0.00E+00	0.00E+00	8.04E-05	0.00E+00	8.04E-05
Co-58	Ci	1.85E-04	4.20E-05	0.00E+00	0.00E+00	2.26E-04
Co-60	Ci	3.40E-05	3.61E-05	1.00E-05	0.00E+00	8.02E-05
Ni-63	Ci	0.00E+00	1.87E-05	1.80E-05	0.00E+00	3.67E-05
Nb-95	Ci	0.00E+00	3.58E-05	0.00E+00	0.00E+00	3.58E-05
Zr-95	Ci	0.00E+00	1.34E-05	0.00E+00	0.00E+00	1.34E-05
Total for Period	Ci	2.19E-04	1.51E-04	1.08E-04	0.00E+00	4.78E-04
B. Tritium						
H-3	Ci	1.51E+02	1.04E+02	2.78E+02	4.09E+02	9.43E+02
C. Dissolved & Entrained Gases						
None	Ci	-	-	-	-	-
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Attachment 2
Supplemental Information**

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 2

Supplemental Information

This attachment includes supplemental information to the gaseous and liquid effluents report.

Attachment 2 Supplemental Information

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

I. Regulatory Limits - Per Unit

A. Noble Gases - Air Dose

1. Calendar Quarter Gamma Dose	= 5	mRAD
2. Calendar Quarter Beta Dose	= 10	mRAD
3. Calendar Year Gamma Dose	= 10	mRAD
4. Calendar Year Beta Dose	= 20	mRAD

B. Liquid Effluents - Dose

1. Calendar Quarter Total Body Dose	= 1.5	mREM
2. Calendar Quarter Organ Dose	= 5	mREM
3. Calendar Year Total Body Dose	= 3	mREM
4. Calendar Year Organ Dose	= 10	mREM

C. Gaseous Effluents - Iodine-131 & 133, Tritium, and Particulates with Half-lives > 8 days

1. Calendar Quarter Organ Dose	= 7.5	mREM
2. Calendar Year Organ Dose	= 15	mREM

II. Maximum Permissible Effluent Concentrations

A. Gaseous Effluents

1. Information found in Offsite Dose Calculation Manual

B. Liquid Effluents

1. Information found in 10 CFR Part 20, Appendix B, Table 2, Column 2

III. Average Energy

(not applicable)

IV. Measurements and Approximations of Total Radioactivity

Analyses of specific radionuclides in selected or composited samples as described in the Selected Licensee Commitments are used to determine the radionuclide composition of the effluent. A summary description of the method used for estimating overall errors associated with radioactivity measurements is provided as part of this attachment.

V. Batch Releases

A. Liquid Effluents

1. Total Number of Batch Releases	=	65
2. Total Time (min) for Batch Releases	=	1.22E+04
3. Maximum Time (min) for a Batch Release	=	2.14E+02
4. Average Time (min) for Batch Releases	=	1.87E+02
5. Minimum Time (min) for a Batch Release	=	1.29E+02
6. Average Dilution Water Flow During Release (lpm)	=	6.46E+04

B. Gaseous Effluents

1. Total Number of Batch Releases	=	66
2. Total Time (min) for Batch Releases	=	6.45E+04
3. Maximum Time (min) for a Batch Release	=	2.04E+04
4. Average Time (min) for Batch Releases	=	9.78E+02
5. Minimum Time (min) for a Batch Release	=	1.00E+00

VI. Abnormal Releases

See Attachment 5, Unplanned Offsite Releases.

Attachment 2 Supplemental Information

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Carbon-14

Carbon-14 (C-14), with a half-life of 5730 years, is a naturally occurring isotope of carbon produced by cosmic ray interactions in the atmosphere. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. C-14 is also produced in commercial nuclear reactors, but the amounts produced are much less than those produced naturally or from weapons testing.

In Regulatory Guide 1.21, Revision 2, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste", the NRC recommends U.S. nuclear power plants evaluate whether C-14 is a "principal radionuclide", and if so, report the amount of C-14 released. Improvements over the years in effluent management practices and fuel performance have resulted in a decrease in gaseous radionuclide (non-C-14) concentrations, and a change in the distribution of gaseous radionuclides released to the environment. As a result, many sites show C-14 has become a "principal radionuclide" for the gaseous effluent pathway, as defined in Regulatory Guide 1.21, Rev. 2. Oconee Nuclear Station 2018 ARERR contains estimates of C-14 radioactivity released in 2018, and estimates of public dose resulting from the C-14 effluent.

Because the dose contribution of C-14 from liquid radioactive waste is much less than that contributed by gaseous radioactive waste, evaluation of C-14 in liquid radioactive waste is not required (Ref. Reg. Guide 1.21, Rev. 2). The quantity of gaseous C-14 released to the environment can be estimated by use of a C-14 source term scaling factor based on power generation (Ref. Reg. Guide 1.21, Rev. 2). Many documents provide information related to the magnitude of C-14 in typical effluents from commercial nuclear power plants. Those documents suggest that nominal annual releases of C-14 in gaseous effluents are approximately 5 to 7.3 curies from PWRs (Ref. Reg. Guide 1.21, Rev. 2). A more recent study recommends a higher C-14 gaseous source term scaling factor of approximately 9.0 to 9.8 Ci/GWe-yr for a PWR (Westinghouse) (Ref. EPRI 1021106). For the Oconee Nuclear Station 2018 ARERR a source term scaling factor of 9.4 Ci/GWe-yr is assumed. Using a source term scaling factor of 9.4 Ci/GWe-yr and actual electric generation (MWe-hrs) from Oconee Nuclear Station in 2018 results in a site total C-14 gaseous release estimate to the environment of 2.29E+01 Curies. 70% of the C-14 gaseous effluent is assumed to be from batch releases and 30% of C-14 gaseous effluent is assumed to be from continuous releases through the unit vents (ref. IAEA Technical Reports Series no. 421, "Management of Waste Containing Tritium and Carbon-14", 2004).

C-14 releases in PWRs occur primarily as a mix of organic carbon and carbon dioxide released from the waste gas system. Since the PWR operates with a reducing chemistry, most, if not all, of the C-14 species initially produced are organic (e.g., methane). As a general rule, C-14 in the primary coolant is essentially all organic with a large fraction as a gaseous species. Any time the RCS liquid or gas is exposed to an oxidizing environment (e.g. during shutdown or refueling), a slow transformation from an organic to an inorganic chemical form can occur. Various studies documenting measured C-14 releases from PWRs suggest a range of 70% to 95% organic with an average of 80% organic with the remainder being CO₂ (Ref. EPRI TR-105715). For the Oconee Nuclear Station 2018 ARERR a value of 80% organic C-14 is assumed.

Public dose estimates from airborne C-14 are performed using dose models in NUREG-0133 and Regulatory Guide 1.109. The dose models and assumptions used are documented in the Oconee ODCM. The estimated C-14 dose impact on the maximum organ dose from airborne effluents released from Oconee Nuclear Station in 2018 is well below the 10CFR50, Appendix I, ALARA design objective (i.e., 15 mrem/yr per unit).

Attachment 2
Supplemental Information

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Overall Estimate of Error for Effluent Radioactivity Release Reported

The estimated percentage of overall error for both Liquid and Gaseous effluent release data at Oconee Nuclear Station has been determined to be $\pm 30.3\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

1. Flow Rate Determining Devices = $\pm 20\%$
2. Counting Statistical Error = $\pm 20\%$
3. Calibration Error = $\pm 10\%$
4. Calibration Source Error = $\pm 2.5\%$
5. Sample Preparation Error = $\pm 3\%$

Attachment 2
Supplemental Information

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Summary of Changes in Land Use Census Affecting Effluent Dose Calculations

The 2019 Land Use Census was performed May 22-23, 2019, and the results were certified and made available for use on June 18, 2019. The following are changes to residences, gardens, and milk animals from the previous year.

Residences

The residence in the ENE Sector (1.34 miles) was replaced by a new residence at 1.24 miles.
The residence in the W Sector (1.58 miles) was replaced by a new residence at 1.49 miles.

Gardens

Broad leaf vegetation samples are taken in lieu of a garden census for Oconee Nuclear Station. For dose calculation purposes a garden is assumed to exist at the site boundary and beyond for every sector since a garden location cannot be ruled out.

Milk Animals

There were no existing milk animals, nor any new milk animals identified during the 2019 Land Use Census.

Environmental Monitoring Locations

No changes to environmental monitoring locations in each sector due to 2019 Land Use Census.

Attachment 3
Solid Radioactive Waste Disposal

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 3

Solid Radioactive Waste Disposal

This attachment includes a summary of the solid waste shipped off-site for burial and/or disposal, including:

- Container volume
- Total Curie content
- Principal Radionuclides
- Source/Type of waste
- Solidification agent or absorbent
- Type of shipping container
- Number of shipments
- Other relevant information as necessary

Attachment 3 Solid Radioactive Waste Disposal

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Type of Waste Shipped	Number of Shipments	Number of Containers	Waste Class	Container Type	Solidification Agent	Volume (m ³)	Total Activity (Curies)
1. <u>Waste from Liquid Systems</u>							
a. Dewatered Secondary Resins	1	3	A-U	GDP	N/A	15.89	2.62E-01
b. Dewatered Primary Resins	2	2	A-U	Type A	N/A	6.82	1.36E+01
	3	3	B	Type A	N/A	10.23	7.05E+01
c. Evaporator Concentrates	None	-	-	-	-	-	-
d. Dewatered Mechanical Filters	1	1	C	Type A	N/A	3.41	6.04E+00
e. Dewatered Demineralizers	None	-	-	-	-	-	-
f. Solidified (cement) Acids, Oils, Sludge	None	-	-	-	-	-	-
2. <u>Dry Solid Waste</u>							
a. Dry Active Waste (compacted)	None	-	-	-	-	-	-
b. Dry Active Waste (non-compacted)	19	35	A-U	GDP	N/A	808.36	1.85E+00
c. Dry Active Waste (brokered)	None	-	-	-	-	-	-
d. Irradiated Components	None	-	-	-	-	-	-
3. <u>Total Solid Waste</u>	26	44	-	-	-	844.70	7.87E+01

Attachment 3 Solid Radioactive Waste Disposal

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Type of Waste Shipped	Radionuclide	% Abundance
1. <u>Waste from Liquid Systems</u>		
a. Dewatered Secondary Resins	Ag-110m	2.14E-01
	C-14	3.11E+00
	Co-57	5.81E-02
	Co-58	6.04E-01
	Co-60	2.20E+00
	Cs-137	2.25E-01
	H-3	8.75E+01
	Mn-54	1.66E-01
	Nb-95	1.64E-02
	Ni-63	5.23E+00
	Sb-124	1.84E-02
	Sb-125	1.60E-01
	Tc-99	3.65E-01
	Zn-65	7.57E-02
	Zr-95	7.1E-03
b. Dewatered Primary Resins	AG-110m	3.85E-01
	AM-241	8.42E-04
	Ba-133	7.53E-03
	Be-7	1.68E+00
	C-14	1.27E+00
	CE-144	2.93E-02
	CM-242	3.55E-04
	CM-243/44	5.68E-04
	CO-57	2.93E-01
	CO-58	1.00E+01
	CO-60	1.61E+01
	CR-51	4.04E-02
	CS-134	1.35E-01
	CS-137	4.15E+00
	FE-55	2.70E+01
	FE-59	9.32E-03
	H-3	2.20E-01
	MN-54	4.93E+00
	NB-95	5.85E-01
	NI-59	1.91E-01
	NI-63	3.07E+01
	PU-238	8.52E-04
	PU-239/40	2.00E-04
	PU-241	6.82E-03
	SB-124	3.04E-02
	SB-125	3.08E-02
	SR-89	7.80E-03
	SR-90	5.16E-02
	TC-99	1.10E-02
	ZN-65	1.77E+00
	ZR-95	3.07E-01
c. Evaporator Concentrates	N/A	N/A

Attachment 3 Solid Radioactive Waste Disposal

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

d. Dewatered Mechanical Filters	AG-110m	3.26E-01
	C-14	1.18E+01
	CE-144	5.63E-01
	CM-242	1.81E-10
	CM-243/44	2.60E-06
	CO-57	1.72E-01
	CO-58	6.31E+00
	CO-60	2.04E+01
	CR-51	6.54E-02
	CS-137	1.28E+00
	FE-55	1.89E+01
	FE-59	4.64E-03
	H-3	2.68E-01
	MN-54	1.21E+00
	NB-95	1.16E+00
	NI-59	3.46E-03
	NI-63	3.64E+01
	SB-124	3.74E-02
	SN-113	1.39E-10
	SR-89	2.75E-19
	SR-90	5.53E-03
	TC-99	2.25E-01
	ZN-65	4.52E-01
	ZR-95	4.34E-01
e. Dewatered Demineralizers	N/A	N/A
f. Solidified (cement) Acids, Oils, Sludge	N/A	N/A

2. Dry Solid Waste

a. Dry Active Waste (compacted)	N/A	N/A
b. Dry Active Waste (non-compacted)	C-14	1.14E+00
	CO-57	3.02E-01
	CO-58	2.17E+01
	CO-60	7.30E+00
	CS-137	7.62E+00
	H-3	2.89E+01
	MN-54	3.50E+00
	NB-95	1.68E+00
	NI-63	2.70E+01
	ZR-95	7.70E-01
c. Dry Active Waste (brokered)	N/A	N/A
d. Irradiated Components	N/A	N/A

**Attachment 4
Meteorological Data**

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 4

Meteorological Data

This attachment includes a summary of meteorological joint frequency distributions of wind speed, wind direction, and atmospheric stability (hours of occurrence).

Attachment 4 Meteorological Data

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Lower Level

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
A	0.46-0.75	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0
	0.76-1.00	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
	1.01-1.25	0	1	0	0	0	1	0	1	1	1	2	0	0	0	1	2
	1.26-1.50	1	3	2	1	1	0	0	0	0	4	6	4	6	1	0	2
	1.51-2.00	15	10	6	3	1	3	1	5	4	28	60	17	7	5	4	4
	2.01-3.00	4	3	7	14	10	3	0	0	8	55	109	33	8	6	4	1
	3.01-4.00	0	0	0	4	2	0	0	0	0	16	14	3	1	1	0	0
	4.01-5.00	0	0	0	0	0	0	0	0	0	0	2	2	2	1	1	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
B	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.01-1.25	0	0	1	0	0	0	0	0	0	1	2	0	1	1	0	0
	1.26-1.50	7	7	2	1	0	1	0	0	1	5	8	5	1	7	1	1
	1.51-2.00	4	10	7	3	0	1	0	2	6	16	35	26	12	7	4	0
	2.01-3.00	1	2	4	13	5	2	2	6	6	33	31	21	6	2	1	1
	3.01-4.00	0	0	1	3	0	0	0	0	1	13	20	5	0	4	1	0
	4.01-5.00	0	0	0	0	0	0	0	0	0	0	3	3	4	2	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	1	3	2	1	0	1
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	2	1	4	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Attachment 4 Meteorological Data

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Lower Level

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
C	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.76-1.00	1	0	2	0	0	0	0	0	0	1	1	0	0	0	1	0
	1.01-1.25	5	3	2	1	0	0	0	0	0	3	5	3	1	5	2	2
	1.26-1.50	7	10	7	0	0	0	0	0	1	3	14	5	7	3	1	6
	1.51-2.00	10	16	6	5	7	7	1	0	3	18	28	19	7	7	2	2
	2.01-3.00	2	1	10	20	13	3	2	3	7	34	39	10	2	2	1	0
	3.01-4.00	0	0	1	7	1	0	1	0	1	12	10	8	0	1	3	0
	4.01-5.00	0	0	0	1	0	0	0	0	0	0	3	3	1	0	2	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	2	3	3	8	2	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	1	1	5	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
D	0.46-0.75	5	4	0	2	1	0	2	3	1	2	4	2	7	4	2	3
	0.76-1.00	10	5	16	2	8	7	5	3	5	11	14	8	14	25	14	12
	1.01-1.25	25	16	14	18	11	8	12	6	8	14	23	21	21	31	25	42
	1.26-1.50	18	29	20	37	26	15	14	23	28	25	50	28	36	25	21	31
	1.51-2.00	20	15	55	118	73	29	25	25	42	53	62	40	15	22	17	16
	2.01-3.00	9	10	108	191	84	15	16	22	15	96	91	41	21	26	17	13
	3.01-4.00	1	5	10	28	8	1	1	0	1	38	49	53	31	19	16	4
	4.01-5.00	1	1	4	0	1	0	0	0	3	8	37	38	37	21	11	2
	5.01-6.00	0	0	1	0	0	0	0	0	0	0	16	22	9	12	9	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	3	22	2	11	9	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Attachment 4 Meteorological Data

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Lower Level

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NN E	NE	ENE	E	ESE	SE	SSE	S	SS W	SW	WSW	W	WNW	NW	NNW
E	0.46-0.75	38	24	19	19	8	6	12	9	14	9	22	23	29	42	30	39
	0.76-1.00	100	66	50	47	34	32	35	23	30	29	42	51	66	112	107	116
	1.01-1.25	58	32	31	44	55	42	34	34	44	21	34	28	26	37	67	103
	1.26-1.50	41	11	41	51	61	57	59	57	31	31	34	22	15	25	30	55
	1.51-2.00	21	12	43	96	65	44	30	65	48	46	41	34	22	14	13	19
	2.01-3.00	3	8	41	57	39	7	11	13	15	57	46	37	19	9	13	9
	3.01-4.00	0	0	17	9	0	1	0	1	8	19	19	14	12	4	0	0
	4.01-5.00	0	0	16	0	0	0	0	0	0	6	7	8	7	4	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	1	4	1	2	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
F	0.46-0.75	6	1	2	1	1	1	3	2	0	0	1	3	10	14	7	0
	0.76-1.00	9	5	3	1	4	7	7	2	1	3	6	15	13	44	31	6
	1.01-1.25	1	1	0	4	8	5	2	1	4	1	3	2	2	39	35	8
	1.26-1.50	0	0	1	1	3	5	2	1	0	3	4	2	1	19	34	2
	1.51-2.00	1	0	1	0	1	14	7	1	1	0	6	4	0	1	4	2
	2.01-3.00	0	0	1	0	1	1	2	1	0	1	2	1	0	2	1	0
	3.01-4.00	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	4.01-5.00	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Attachment 4 Meteorological Data

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Lower Level

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
G	0.46-0.75	1	0	0	0	1	0	0	0	0	1	1	1	2	3	1	0
	0.76-1.00	1	0	0	0	0	0	0	0	0	0	1	1	5	12	5	0
	1.01-1.25	0	0	0	0	0	0	1	0	0	0	0	1	4	12	2	0
	1.26-1.50	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0
	1.51-2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2.01-3.00	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	3.01-4.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4.01-5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Attachment 4 Meteorological Data

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Upper Level

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
A	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.01-1.25	1	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0
	1.26-1.50	3	0	0	0	0	0	1	0	0	3	2	2	0	0	0	0
	1.51-2.00	6	3	3	1	0	1	0	0	0	5	11	9	2	4	3	0
	2.01-3.00	7	15	5	10	3	1	1	4	8	38	72	30	5	1	2	1
	3.01-4.00	1	3	6	8	10	2	0	0	4	31	44	11	1	5	1	1
	4.01-5.00	1	0	0	2	3	0	0	1	3	25	29	1	1	1	3	0
	5.01-6.00	1	1	0	1	5	1	0	0	1	11	17	1	1	1	0	0
	6.01-8.00	0	0	0	0	1	0	0	0	0	2	14	2	2	1	4	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	2	1	0	7	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	0	
B	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	1.01-1.25	0	0	0	0	0	0	0	0	0	2	1	0	1	0	0	0
	1.26-1.50	0	0	2	0	0	0	0	0	0	1	3	1	1	3	1	1
	1.51-2.00	3	8	2	1	0	0	1	0	2	6	13	15	5	6	1	3
	2.01-3.00	1	8	9	5	3	2	0	2	8	23	32	27	2	4	1	1
	3.01-4.00	0	2	3	6	3	1	2	6	4	21	15	3	1	1	1	0
	4.01-5.00	1	1	0	6	1	3	0	0	5	11	7	3	2	2	0	0
	5.01-6.00	1	0	0	3	0	0	0	0	1	5	9	3	0	1	1	0
	6.01-8.00	0	0	0	0	0	0	0	0	1	2	17	4	5	2	1	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	3	4	2	2	0	1
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	3	3	1	0	

Attachment 4 Meteorological Data

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Upper Level

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
C	0.46-0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.76-1.00	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	1.01-1.25	1	2	0	0	0	0	0	0	0	3	0	0	2	0	2	0
	1.26-1.50	5	1	1	1	0	0	0	0	0	2	8	6	9	2	1	2
	1.51-2.00	7	13	6	2	1	0	0	0	1	5	11	15	6	4	3	1
	2.01-3.00	4	16	12	8	11	6	3	2	4	26	31	7	1	1	1	1
	3.01-4.00	2	2	5	14	5	5	0	3	5	20	13	2	1	1	2	0
	4.01-5.00	0	0	2	5	4	1	1	1	1	11	8	3	0	0	0	0
	5.01-6.00	0	0	0	1	5	0	1	0	0	7	7	4	0	1	2	1
	6.01-8.00	0	0	0	1	0	0	0	0	1	4	18	5	2	4	3	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	2	4	4	8	3	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	
D	0.46-0.75	0	0	0	0	0	0	1	1	1	3	3	1	2	1	0	1
	0.76-1.00	5	2	3	2	2	4	5	4	1	4	4	8	4	10	7	2
	1.01-1.25	12	9	4	2	0	4	5	2	1	4	11	12	15	13	13	11
	1.26-1.50	19	15	12	3	6	8	3	4	6	11	23	21	23	19	20	17
	1.51-2.00	26	34	15	14	20	8	16	16	20	37	26	27	15	11	18	21
	2.01-3.00	38	31	46	64	63	31	30	16	50	53	42	38	18	9	23	32
	3.01-4.00	14	14	103	92	78	12	14	17	21	49	52	28	11	10	17	9
	4.01-5.00	7	7	57	86	33	3	4	3	5	25	49	17	11	14	13	8
	5.01-6.00	1	6	17	30	14	1	2	2	3	18	58	36	17	17	14	6
	6.01-8.00	1	1	8	9	8	2	0	0	2	17	67	56	45	38	21	4
	8.01-10.00	0	0	2	0	0	0	0	0	2	2	27	30	3	19	12	0
10.01-max	0	0	0	0	0	0	0	0	0	0	7	10	4	6	6	0	

Attachment 4 Meteorological Data

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Upper Level

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
E	0.46-0.75	2	0	1	0	2	1	1	0	0	2	1	3	0	1	2	1
	0.76-1.00	13	10	7	5	4	5	2	3	6	3	4	6	6	11	15	7
	1.01-1.25	22	10	10	12	7	8	5	4	8	7	6	11	15	20	30	28
	1.26-1.50	39	35	14	10	4	5	6	7	9	12	13	25	20	30	46	54
	1.51-2.00	170	98	34	28	15	21	20	18	17	20	25	33	32	46	67	99
	2.01-3.00	289	173	114	78	68	43	48	26	39	44	65	60	36	34	53	107
	3.01-4.00	32	23	68	49	38	20	13	37	36	49	67	38	14	12	21	26
	4.01-5.00	5	6	36	44	28	6	6	10	19	37	33	19	9	6	11	5
	5.01-6.00	1	1	13	15	5	3	1	2	4	19	21	11	10	13	3	2
	6.01-8.00	0	0	23	3	0	0	0	1	3	10	39	14	13	8	1	0
	8.01-10.00	0	0	7	0	0	0	0	0	0	2	12	4	1	3	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	
F	0.46-0.75	0	1	0	1	0	1	1	0	2	2	0	0	1	1	0	1
	0.76-1.00	3	2	2	2	0	1	3	0	0	2	0	3	0	2	1	6
	1.01-1.25	6	3	4	4	4	3	0	1	0	2	0	2	4	1	2	4
	1.26-1.50	14	6	4	3	1	4	0	0	0	1	4	1	4	1	6	6
	1.51-2.00	23	24	8	3	3	3	0	3	2	2	3	7	4	8	6	10
	2.01-3.00	37	52	10	3	4	4	4	6	4	5	6	7	2	4	1	4
	3.01-4.00	1	8	0	2	3	5	2	4	1	2	8	1	2	1	2	1
	4.01-5.00	1	0	1	0	3	1	1	0	0	1	4	5	0	2	1	0
	5.01-6.00	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0
	6.01-8.00	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Attachment 4 Meteorological Data

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Upper Level

Stability Class	Wind Speed (m/s)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
G	0.46-0.75	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	0.76-1.00	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
	1.01-1.25	0	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0
	1.26-1.50	0	0	2	1	1	1	0	0	1	1	1	0	0	1	0	2
	1.51-2.00	0	0	1	0	2	1	1	1	1	0	1	2	0	1	2	3
	2.01-3.00	3	1	0	0	0	0	1	2	3	3	3	1	0	1	0	1
	3.01-4.00	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	0
	4.01-5.00	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	5.01-6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6.01-8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.01-10.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10.01-max	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

**Attachment 5
Unplanned Offsite Releases**

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 5

Unplanned Offsite Releases

This attachment includes a summary of the unplanned offsite releases of gaseous and liquid radioactive effluents.

Attachment 5
Unplanned Offsite Releases

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Oconee Nuclear Station had zero (0) unplanned liquid offsite release radioactive effluents in 2019.

Oconee Nuclear Station had zero (0) unplanned gaseous offsite release of radioactive effluents in 2019.

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 6

Assessment of Radiation Dose from Radioactive Effluents to Members of the Public
(includes fuel cycle dose calculation results)

This attachment includes an assessment of radiation doses to the maximum exposed member of the public due to radioactive liquid and gaseous effluents released from the site for each calendar quarter for the calendar year of the report as well as the total dose for the calendar year.

This attachment also includes an assessment of radiation doses to the maximum exposed member of the public from all uranium fuel cycle sources within 8 km of the site for the calendar year of this report to show conformance with 40 CFR Part 190.

Methods for calculating the dose contribution from liquid and gaseous effluents are given in the Offsite Dose Calculation Manual (ODCM).

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Oconee Nuclear Station Units 1, 2, & 3
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Noble Gases						
1. Maximum Gamma Air	mRAD	5.78E-05	2.74E-05	3.48E-05	3.64E-04	4.84E-04
(a) Limit	mRAD	1.50E+01	1.50E+01	1.50E+01	1.50E+01	3.00E+01
(b) % of Limit		3.85E-04	1.83E-04	2.32E-04	2.43E-03	1.61E-03
2. Maximum Beta Air	mRAD	1.65E-04	5.17E-05	5.58E-05	2.86E-04	5.59E-04
(a) Limit	mRAD	3.00E+01	3.00E+01	3.00E+01	3.00E+01	6.00E+01
(b) % of Limit		5.51E-04	1.72E-04	1.86E-04	9.54E-04	9.32E-04

Receptor Location **1.0 miles SW**

B. Iodine, H-3, & Particulates

1. Maximum Organ Dose	mREM	9.01E-02	9.10E-02	9.03E-02	7.89E-02	3.50E-01
(a) Limit	mREM	2.25E+01	2.25E+01	2.25E+01	2.25E+01	4.50E+01
(b) % of Limit		4.00E-01	4.04E-01	4.02E-01	3.51E-01	7.79E-01

Receptor Location **1.0 miles SW**

Critical Age **CHILD**

Critical Organ **BONE**

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Oconee Nuclear Station Units 1, 2, & 3
 Period 1/1/2019 - 12/31/2019

Liquid Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Batch & Continuous Mode						
1. Maximum Organ Dose	mREM	2.09E-02	2.75E-02	3.84E-02	5.64E-02	1.39E-01
(a) Limit	mREM	1.50E+01	1.50E+01	1.50E+01	1.50E+01	3.00E+01
(b) % of Limit		1.39E-01	1.84E-01	2.56E-01	3.76E-01	4.63E-01
(c) Critical Age		Child	Adult	Child	Child	Adult
(d) Critical Organ		GILLI	GILLI	Liver	GILLI	GILLI
2. Maximum Total Body Dose	mREM	2.08E-02	1.44E-02	3.83E-02	5.64E-02	1.30E-01
(a) Limit	mREM	4.50E+00	4.50E+00	4.50E+00	4.50E+00	9.00E+00
(b) % of Limit		4.63E-01	3.20E-01	8.52E-01	1.25E+00	1.44E+00
(c) Critical Age		Child	Child	Child	Child	Child

Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

40 CFR Part 190 Uranium Fuel Cycle Dose Calculation Results

In accordance with the requirements of 40 CFR Part 190, the annual dose commitment to any member of the general public shall be calculated to assure that doses are limited to 25 millirems to the total body or any organ with the exception of the thyroid which is limited to 75 millirems. The fuel cycle dose assessment for Oconee Nuclear Station includes liquid and gaseous effluent dose contributions from Oconee Nuclear Station and direct and air-scatter dose from the onsite ISFSI. No other uranium fuel cycle facility contributes significantly to the maximum exposed individual. Included in the gaseous effluent dose calculations is an estimate of the dose contributed by Carbon-14 (Ref. Attachment 2, Supplemental Information, of this report for further information). The combined dose to a maximum exposed individual from effluent releases and direct and air-scatter dose from the ISFSI is below 40 CFR Part 190 limits as shown by the following summary.

Note: The 40 CFR Part 190 effluent dose analysis to the maximum exposed individual from liquid and gas releases includes the dose from noble gases (i.e., total body and skin).

40 CFR Part 190 Effluent Dose Summary

A. Maximum Organ Dose (other than TB)	3.51E-01 mRem
1. Location	1.0 miles SW
2. Critical Age	CHILD
3. Critical Organ	BONE
4. Gas Contribution %	99.87%
5. Liquid Contribution %	0.13%
B. Maximum Total Body Dose	2.49E-01 mRem
1. Location	1.0 miles SW
2. Critical Age	CHILD
3. Gas non-NG Contribution %	47.52%
4. Gas Contribution %	0.18%
5. Liquid Contribution %	52.30%

Direct and air-scatter radiation dose contributions from the onsite ISFSI have been determined from 10 CFR 72.212 Evaluation Report for Phase VIII Standardized NUHOMS® Cask System Rev. 01. The maximum dose rate to the nearest real individual from the ISFSI is conservatively calculated to be less than 11 mrem/yr.

The attached excerpt from the 10 CFR 72.212 Evaluation Report for Phase VIII Standardized NUHOMS® Cask System Rev. 01 is provided to document the method used to calculate the dose from ISFSI as less than 11 mrem/yr to the nearest real individual.

Total dose from liquid and gaseous effluents from Oconee Nuclear Station and direct and air-scatter dose from the onsite ISFSI is conservatively estimated to be less than 12 mrem/yr to the nearest real individual. This meets the 40 CFR Part 190 requirements of an annual dose commitment to any member of the general public of less than 25 mrem total body or any organ and 75 mrem to the thyroid.

Attachment 6

Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

6.0 10 CFR 72.212(b)(5)(iii) - Radioactive Materials in Effluents and Direct Radiation

6.1 Purpose

10 CFR 72.212(b)(5)(iii) requires the general licensee to perform written evaluations, before use and before applying the changes authorized by an amended CoC to a cask loaded under the initial CoC or an earlier amended CoC, that establish that the requirements of 10 CFR 72.104 have been met. A copy of this record shall be retained until spent fuel is no longer stored under the general license issued under 10 CFR 72.210.

10 CFR 72.104 provides the regulatory criteria for radioactive materials in effluents and direct radiation from an independent spent fuel storage installation (ISFSI) during normal operation and anticipated occurrences. Specifically, 10 CFR 72.104(a) limits the annual dose equivalent to any real individual who is located beyond the controlled area to 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other critical organ. This dose equivalent must include contributions from (1) planned discharges of radioactive materials (radon and its decay products excepted) to the general environment, (2) direct radiation from ISFSI operations, and (3) any other radiation from uranium fuel cycle operations within the region. In addition, 10 CFR 72.104(b) requires that operational restrictions be established to meet as low as is reasonably achievable (ALARA) objectives for radioactive materials in effluents and direct radiation levels associated with ISFSI operations. Also, 10 CFR 72.104(c) requires that operational limits be established for radioactive materials in effluents and direct radiation levels associated with ISFSI operations to meet the above-mentioned dose limits.

This section provides the written evaluation required by 10 CFR 72.212(b)(5)(iii), demonstrating Duke Energy's compliance with the requirements of 10 CFR 72.104 for the ONS ISFSI.

6.2 Evaluation

This evaluation addresses the radiological dose rate from a composite population of all ONS ISFSI cask types.

6.2.1 §72.104(a) – Dose Limits

10 CFR 72.104, as clarified by ISG-13¹ stipulates that the licensee perform dose evaluations which establish that any real individual beyond the controlled area boundary not sustain a dose equivalent in excess of 0.25 mSv (25 mrem/year) due to direct radiation from the Independent Spent Fuel Storage Installation and other fuel cycle operations in the area. This same dose limit is stipulated by the EPA for the fuel cycle in 40 CFR 190.10(a). Also operational restrictions for ALARA and limits for effluents must be established.

In accordance with these requirements, Duke Energy Corporation has performed dose calculations that model the characteristics (initial enrichment, burnup and cooling time) of existing fuel in Phases I – VI, together with the characteristics of assumed “design basis” fuel for canisters in Phase VII and Phase VIII of the Oconee ISFSI². Calculation OSC-8675³ develops the radiation source terms used in subsequent shielding and skyshine calculations using the SCALE Code System. More specifically, the SAS2 Module of the SCALE Code System⁴ was used to create a problem-dependent pin-cell model for the purpose of building cell-weighted, multigroup cross section sets for use in subsequent depletion calculations. The ORIGEN-S Module⁵ of the SCALE Code System was used to perform the fuel depletion and characterization calculations using the cross section sets created by SAS2. These characterization calculations yielded the photon and neutron source terms to be used as input to subsequent shielding calculations. As mentioned above, problem-dependent cross section sets were developed for these analyses since ORIGEN-S was used within the SAS2 sequence. Duke Energy Corporation Radiological Engineering is experienced in the use of the SCALE Code System, and the SCALE Code System is installed and maintained under the purview of the pertinent software and data quality assurance program.

The results of the radiation source term calculation were used as input to Calculation OSC-8706⁶ to evaluate the shielding characteristics of a single Horizontal Storage Module. The MCNP Monte Carlo particle transport computer code⁷ was used to perform the transport calculations and to write a surface flux file for use in subsequent skyshine calculations.

Attachment 6

Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Oconee Nuclear Station Units 1, 2, & 3 Period 1/1/2019 - 12/31/2019

Appropriate software quality controls have been implemented for the computer codes and data used in these analyses (specifically, Calculation DPC-1201.30-00-0010⁸ contains the verification and validation for MCNP5, while SDQA-30269-NGO⁹ documents the quality control measures in place for MCNP5).

6.2.2 §72.104(b) – Operational Restrictions

Operational restrictions must be established to meet ALARA objectives for direct radiation levels associated with ISFSI.

Calculation OSC-8716¹⁰, Table 34.1-1, summarizes dose rate versus distance, showing a dose rate of 10.80 mRem per year at 500 meters, which is the longest distance at which results converge. The closest residence to the ISFSI is in the SW-SSW direction approximately 1 mile (~1600 meters) from the ISFSI, or 1.36 miles from the centerline of the site.¹¹ This is conservatively farther than the distance used for computation of dose rates. The 2016 40CFR190 Uranium Fuel Cycle Dose Calculation Results for the ONS site show a maximum total body dose of less than 1 mrem per year (last reported dose was 0.268 mrem¹²). The total dose rate from all operations to the nearest real individual is therefore less than 12 mRem per year.

This calculation need not consider any effluent from Phase VIII. The Phase VIII HSMs use the NUHOMS-24PTH-S-LC DSCs, which are designed as "leak-tight." Per Appendix P, Section P.11.2.8 of the NUHOMS FSAR¹³, accidental releases are not credible.

6.2.3 §72.104(c) – Operational Limits

Operational limits must be established for direct radiation levels associated with ISFSI to meet the limits given in 72.104(a).

The ISFSI is sited in such a way that direct radiation to the surroundings are minimized.

The station Radiation Protection Program limits for ISFSI boundary dose rates are established to maintain dose rates surrounding the ISFSI and at the owner control fence.

Calculation OSC-8716¹⁰ uses the surface flux files developed in OSC-8706⁶ in a repeating array. A skyshine calculation is performed to obtain near- and far-field dose results the Oconee ISFSI. This calculation need not consider any effluent from Phase VIII. The Phase VIII HSMs use the NUHOMS-24PTH-S-LC DSCs, which are designed as "leak-tight." Per Appendix P, Section P.11.2.8 of the NUHOMS FSAR¹³, accidental releases are not credible.

6.3 Regulatory Compliance/Conclusion

The evaluation summarized above demonstrates that Duke Energy meets the requirements of 10 CFR 72.212(b)(5)(iii) and 10 CFR 72.104 for the ONS ISFSI.

6.4 References

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

1. United States Nuclear Regulatory Commission, Spent Fuel Project Office, Interim Staff Guidance - 13, "Real Individual."
2. "Design Basis" fuel (considering fuel burnup and initial enrichment) is assumed to reside in Phases VII-VIII of the Oconee ISFSI. The assumption of 5 years cooling time applies only to the most recent six dry storage casks, while the balance of the casks are assumed to have been loaded in increments of six dry storage canisters per year. This is consistent with reasonable engineering practice.
3. Calculation OSC-8675, "Oconee ISFSI Spent Fuel Radiation Source Terms," Revision 3.
4. O. W. Hermann, C. V. Parks, "SAS2H: A Coupled One-Dimensional Depletion and Shielding Analysis Module," NUREG/CR-0200, Revision 6, Volume 1, Section S2, ORNLINUREG/CSD-2N21R6.
5. O. W. Hermann, R. M. Westfall, "ORIGEN-S: SCALE System Module to Calculate Fuel Depletion, Actinide Transmutation, Fission Product Buildup and Decay, and Associated Radiation Source Terms," NUREG/CR-0200, Revision 6, Volume 2, Section F7, ORNLINUREG/CSD-2N21R6.
6. Calculation OSC-8706, "Oconee Horizontal Storage Module Shielding Evaluation," Revision 2.
7. LA-CP-03-0245, "MCNP - A General Monte Carlo N-Particle Transport Code, Version 5 (Volume 1: Overview and Theory, Volume II: User's Guide, Volume III: Developer's Guide).
8. Calculation DPC-1201.30-00-0010, Revision 0, "MCNP5 Computer Code Verification and Validation."
9. SDQA-30269-NGO, MCNP 5 Version 1.6
10. Calculation OSC-8716, "Oconee ISFSI Dose Rate Evaluations," Revision 2.
11. Dale E. Holden to Libby Wehrman, "2005 Oconee Annual Land Use Census," August 31, 2005, File No: OS-778.05 (Oconee Master File Record Retention No. 000377).
12. Thomas D. Ray to U.S. Nuclear Regulatory Commission, "2016 Annual Radioactive Effluent Release Report (ARERR)", May 1, 2017.
13. NUH-003, "Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," Revision 14.

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 7

Information to Support the NEI Ground Water Protection Initiative

This attachment includes a summary of voluntary reports made in accordance with the NEI Ground Water Protection Initiative and a summary of ground water well sample data.

Attachment 7 Information to Support the NEI Ground Water Protection Initiative

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Duke Energy implemented a Ground Water Protection program in 2007. This initiative was developed to ensure timely and effective management of situations involving inadvertent releases of licensed material to ground water. As part of this program, Oconee Nuclear Station monitored 62 wells in 2019. Tritium activity in wells GM-7R and GM-7DR was reported according to NEI 07-07, Industry Ground Water Protection Initiative, in February 2010. The probable source of this activity was determined to be discharges from the turbine building sumps to Chemical Treatment Pond #3 through the east yard drain. Discharges from the turbine building sump through this pathway were discontinued in 2008. Installation of a recovery well, currently RW-1, in 2011 has resulted in decreased tritium concentrations in well GM-7DR to below MDA.

Wells are typically sampled quarterly, semi-annually, or annually. Ground water samples are regularly analyzed for tritium and gamma emitters, with select wells being analyzed for difficult-to-detect radionuclides. No gamma or difficult-to-detect radionuclides, other than naturally occurring radionuclides, were identified in well samples during 2019. Results from sampling during 2019 confirmed existing knowledge of tritium concentrations in site ground water.

Results from sampling during 2019 are shown in the table below.

No events meeting the criteria for voluntary notification per NEI 07-07, Industry Ground Water Protection Initiative, occurred at Oconee Nuclear Station in 2019.

Key to below table.

NS	-	Not scheduled to be sampled, not sampled due to insufficient volume in well, or well inaccessible during outage.
pCi/l	-	picocuries per liter.
< MDA	-	less than minimum detectable activity, typically 250 pCi/l.
20,000 pCi/l	-	the Environmental Protection Agency drinking water standard for tritium. This standard applies only to water used for drinking.
1,000,000 pCi/l	-	the 10 CFR Part 20, Appendix B, Table 2, Column 2, Effluent Concentration Limit for tritium.

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Oconee Nuclear Station Units 1, 2, & 3
 Period 1/1/2019 - 12/31/2019

Well Name	Location / Description	Tritium Concentration (pCi/l)				# of Samples
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	
A-1	ONS GWPI / A-1 / CTP 1/2	NS	<MDA	NS	<MDA	2
A-10	ONS GWPI / A-10 / CTP 3	NS	3.41E+02	NS	2.58E+02	2
A-11	ONS GWPI / A-11 / CTP 3	NS	<MDA	NS	<MDA	2
A-13	ONS GWPI / A-13 / CTP 1/2	NS	3.19E+02	NS	3.90E+02	2
A-14	ONS GWPI / A-14 / CTP 1/2	NS	<MDA	NS	<MDA	2
A-2	ONS GWPI / A-2 / CTP 1/2	NS	<MDA	NS	<MDA	2
BG-4	ONS GWPI / BG-4 / Ball Field	NS	<MDA	NS	<MDA	2
GM-10	ONS GWPI / GM-10 / 525 kv Sw Yard	<MDA	<MDA	<MDA	<MDA	4
GM-10R	ONS GWPI / GM-10R / 525 kv Sw Yard	NS	<MDA	NS	<MDA	2
GM-11	ONS GWPI / GM-11 / ONS Garage	NS	<MDA	NS	NS	1
GM-11R	ONS GWPI / GM-11R / ONS Garage	NS	<MDA	NS	NS	1
GM-12	ONS GWPI / GM-12 / E of Access Rd.	NS	<MDA	NS	NS	1
GM-12R	ONS GWPI / GM-12R / E of Access Rd.	NS	<MDA	NS	NS	1
GM-13	ONS GWPI / GM-13 / 525 kv Sw Yard	NS	<MDA	NS	NS	1
GM-13R	ONS GWPI / GM-13R / 525 kv Sw Yard	NS	<MDA	NS	NS	1
GM-14	ONS GWPI / GM-14 / Mnt. Trg. Facility	NS	<MDA	NS	<MDA	2
GM-14R	ONS GWPI / GM-14R / Mnt. Trg. Facility	NS	<MDA	NS	<MDA	2
GM-15	ONS GWPI / GM-15	NS	<MDA	NS	<MDA	2
GM-15R	ONS GWPI / GM-15R	NS	<MDA	NS	NS	1
GM-16DDR	ONS GWPI / GM-16DDR	NS	2.17E+02	NS	NS	1
GM-16DR	ONS GWPI / GM-16DR	5.71E+03	5.26E+03	5.11E+03	5.20E+03	4
GM-16R	ONS GWPI / GM-16R	1.33E+03	1.39E+03	1.37E+03	1.16E+03	4
GM-17DR	ONS GWPI / GM-17DR	1.92E+03	1.66E+03	1.81E+03	1.74E+03	4
GM-17R	ONS GWPI / GM-17R	NS	1.12E+03	NS	1.17E+03	2
GM-18R	ONS GWPI / GM-18R	3.39E+03	3.21E+03	3.30E+03	2.95E+03	4
GM-19	ONS GWPI / GM-19	1.58E+03	1.33E+03	1.58E+03	1.36E+03	4
GM-19R	ONS GWPI / GM-19R	1.69E+03	1.79E+03	1.72E+03	1.61E+03	4
GM-1R	ONS GWPI / GM-1R / CTP 1/2	<MDA	<MDA	<MDA	<MDA	4
GM-20	ONS GWPI / GM-20	NS	<MDA	NS	NS	1
GM-20R	ONS GWPI / GM-20R	NS	<MDA	NS	NS	1
GM-21	ONS GWPI / GM-21	NS	<MDA	NS	NS	1
GM-22	ONS GWPI / GM-22	NS	<MDA	NS	NS	1
GM-23	ONS GWPI / GM-23	3.47E+02	3.01E+02	3.54E+02	3.68E+02	4
GM-24R	ONS GWPI / GM-24R	1.48E+03	1.23E+03	1.34E+03	1.15E+03	4
GM-25R	ONS GWPI / GM-25R	4.85E+02	2.26E+02	4.09E+02	3.21E+02	4
GM-2DR	ONS GWPI / GM-2DR / U-1/2 SFP	1.93E+02	2.06E+02	4.28E+02	3.66E+02	4
GM-2R	ONS GWPI / GM-2R / U-1/2 SFP	1.68E+03	7.19E+02	7.59E+02	7.59E+02	4
GM-3DR	ONS GWPI / GM-3DR / U-3 SFP	NS	2.09E+02	NS	2.75E+02	2
GM-3R	ONS GWPI / GM-3R / U-3 SFP	2.19E+02	2.31E+02	2.55E+02	3.19E+02	4

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Oconee Nuclear Station Units 1, 2, & 3
 Period 1/1/2019 - 12/31/2019

Well Name	Location / Description	Tritium Concentration (pCi/l)				# of Samples
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	
GM-4	ONS GWPI / GM-4 / Rad. Mat. WH	5.47E+02	4.83E+02	6.07E+02	6.13E+02	4
GM-5	ONS GWPI / GM-5 / Rdwst. Bldg.	2.21E+02	2.01E+02	2.15E+02	<MDA	4
GM-5R	ONS GWPI / GM-5R / Rdwst. Bldg.	NS	<MDA	NS	<MDA	2
GM-6	ONS GWPI / GM-6 / Outflow to CTP-3	<MDA	<MDA	<MDA	<MDA	4
GM-6R	ONS GWPI / GM-6R / Outflow to CTP-3	NS	<MDA	NS	<MDA	2
GM-7	ONS GWPI / GM-7 / 525 kv Sw Yard	NS	2.14E+02	NS	3.59E+02	2
GM-7DR	ONS GWPI / GM-7DR	NS	<MDA	NS	NS	1
GM-7R	ONS GWPI / GM-7R / 525 kv Sw Yard	1.05E+03	1.02E+03	1.16E+03	1.18E+03	4
GM-8	ONS GWPI / GM-8 / E of U-3 TB	<MDA	2.41E+02	2.88E+02	2.09E+02	4
GM-8R	ONS GWPI / GM-8R / E of U-3 TB	NS	<MDA	NS	<MDA	2
GM-9	ONS GWPI / GM-9 / E of U-2 TB	2.95E+02	3.62E+02	4.23E+02	3.52E+02	4
GM-9R	ONS GWPI / GM-9R / E of U-2 TB	NS	<MDA	NS	<MDA	2
MW-11	ONS GWPI / MW-11 / Landfill	<MDA	NS	NS	NS	1
MW-11D	ONS GWPI / MW-11D / Landfill	<MDA	NS	NS	NS	1
MW-13	ONS GWPI / MW-13 / Landfill	<MDA	NS	NS	NS	1
MW-16	ONS GWPI / MW-16 / Landfill	<MDA	NS	NS	NS	1
MW-3R	ONS GWPI / MW-3R / Landfill	<MDA	NS	NS	NS	1
MW-RP01	ONS GWPI / MW-RP01 / Landfarm/Burial	NS	<MDA	NS	NS	1
MW-RP02	ONS GWPI / MW-RP02 / Landfarm/Burial	NS	<MDA	NS	NS	1
MW-RP03	ONS GWPI / MW-RP03 / Landfarm/Burial	NS	<MDA	NS	NS	1
013	ONS / 013 / WH 5	<MDA	2.54E+02	<MDA	<MDA	4
015	ONS / 015 / Brown's Bottom	<MDA	<MDA	<MDA	<MDA	4
RW-1	525 kv Sw. Yard	5.66E+02	5.62E+02	4.31E+02	3.81E+02	4

**Attachment 8
Inoperable Equipment**

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 8

Inoperable Equipment

This attachment includes an explanation of inoperable instruments related to effluent monitoring in excess of allowed time defined by licensing bases and an explanation of temporary outside liquid storage tanks exceeding 10 Curies total activity (excluding tritium and dissolved or entrained noble gases).

Attachment 8
Inoperable Equipment

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

Oconee Nuclear Station did not experience inoperable equipment relevant to effluent monitoring in excess of SLC limits during 2019.

Oconee Nuclear Station did not experience temporary outside liquid storage tanks exceeding 10 Curies total activity (excluding tritium and dissolved or entrained noble gases) during 2019.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 9

Summary of Changes to the Offsite Dose Calculation Manual

This attachment includes a summary of changes to the ODCM and Radiological Effluent Controls.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ODCM Revision 59

The Oconee ODCM was not revised in 2019. The most recent ODCM revision is 59 and was provided with the 2018 ARERR.

Radiological Effluent Controls (SLC 16.11)

The Oconee Nuclear Station Radiological Effluent Controls are contained in SLC 16.11 and are attached to the ARERR.

SLC 16.11.11, Iodine Radiation Monitoring Filters, was revised in 2019. The frequency of surveillance requirement SR 16.11.11.2 to discard spare iodine radiation monitoring filters was changed to after manufacturer expiration date. Condition report 01908961 identified that the previous frequency of after 24 months of shelf life was no longer applicable to the type of filters presently in use. This change aligned the disposal frequency with current filters expiration. The SLC 16.11.11 bases were changed to include a statement that plant procedures are used to prevent filter use after manufacturer expiration date.

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16.0	005	08/16/17
16.1	000	10/15/07
16.2	000	08/25/14
16.3	001	06/29/15
16.4	---	PENDING
16.5.1	000	11/26/12
16.5.2	000	11/15/12
16.5.3	000	02/21/07
16.5.4	---	Deleted 03/28/18
16.5.5	---	Deleted 05/16/09
16.5.6	---	Deleted 02/10/14
16.5.7	000	12/13/06
16.5.8	000	01/31/07
16.5.8a	---	Deleted 05/19/05
16.5.9	---	Deleted 06/06/19
16.5.10	000	10/08/03
16.5.11	000	01/31/00
16.5.12	001	10/17/18
16.5.13	000	03/27/99
16.6.1	001	12/05/19
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16.6.4	000	11/15/12
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16.6.7	000	03/27/99
16.6.8	000	03/27/99
16.6.9	000	11/15/12
16.6.10	000	11/15/12
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16.6.14	000	04/21/14
16.6.15	000	11/15/12
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16.7.2	000	11/15/12
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16.7.5	000	11/15/12
16.7.6	000	04/08/14
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16.7.11	000	11/15/12
16.7.12	000	06/30/04
16.7.13	000	12/05/12
16.7.14	000	11/15/12
16.7.15	000	04/08/14
16.7.16	000	10/14/15
16.7.17	000	07/14/16
16.8.1	000	08/09/01
16.8.2	000	02/10/05
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16.9.2	002	08/16/16
16.9.3	---	Deleted 01/08/18
16.9.4	003	07/17/18
16.9.5	002	08/16/16
16.9.6	007	12/19/19
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16.9.8	---	Deleted 09/26/18
16.9.8a	000	02/07/05
16.9.9	002	08/16/17

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16.9.10	000	01/12/04
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16.9.11a	001	06/06/17
16.9.12	001	09/21/15
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16.9.16	000	10/15/14
16.9.17	000	05/23/01
16.9.18	000	07/15/14
16.9.19	000	03/31/05
16.9.20	003	07/17/18
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16.9.22	---	Deleted 08/16/17
16.9.23	001	08/16/17
16.9.24	003	11/18/16
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16.10.1	000	11/15/12
16.10.2	000	12/02/03
16.10.3	000	03/27/99
16.10.4	000	11/15/12
16.10.5	---	Deleted 08/24/04
16.10.6	000	03/27/99
16.10.7	001	09/21/15
16.10.8	000	11/27/06
16.10.9	000	11/25/09
16.11.1	000	03/15/11
16.11.2	000	01/31/00
16.11.3	000	11/20/08
16.11.4	000	06/30/14
16.11.5	000	10/30/02
16.11.6	000	11/08/13
16.11.7	000	01/31/00
16.11.8	000	12/21/09
16.11.9	000	03/22/10

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16.11.13	000	03/27/99
16.11.14	000	03/27/99
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16.12.3	000	05/01/03
16.12.4	000	03/27/99
16.12.5	000	03/27/99
16.12.6	000	11/08/07
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16.13.4	000	03/27/99
16.13.5	---	Deleted 11/30/99
16.13.6	000	03/27/99
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16.14.4.a	000	03/15/11
16.15.1	000	04/12/06
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Note: With the introduction of Fusion in June 2015, all controlled documents require a three-digit revision number. Thus, the revision numbers were set to "000" in the summer of 2015. As such, the revision dates for Revision 000 are based on the implementation dates for revisions in effect prior to this change.

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.1 Radioactive Liquid Effluents

COMMITMENT Establish conditions for the controlled release of radioactive liquid effluents. Implement the requirements of 10 CFR 20, 10 CFR 50.36a, Appendix A to 10 CFR 50, Appendix I to 10 CFR 50, 40 CFR 141 and 40 CFR 190.

a. Concentration

The concentration of radioactive material released at anytime from the site boundary for liquid effluents to Unrestricted Areas [denoted in Figure 2-5 of the Oconee Nuclear Station Updated Final Safety Analysis Report] shall be limited to 10 times the effluent concentrations specified in 10 CFR Part 20, Appendix B, Table 2, Column 2 for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases the concentration shall be limited to 2×10^{-4} $\mu\text{Ci/ml}$ total activity.

b. Dose

The dose or dose commitment to a Member Of The Public from radioactive materials in liquid effluents to Unrestricted Areas shall be limited to:

1. during any calendar quarter:

≤ 4.5 mrem to the total body

≤ 15 mrem to any organ; and

2. during any calendar year:

≤ 9 mrem to the total body

≤ 30 mrem to any organ.

c. Liquid Waste Treatment

The appropriate subsystems of the liquid radwaste treatment system shall be used to reduce the radioactive materials in liquid waste prior to their discharge, if the projected dose due to liquid effluent releases to unrestricted areas, when averaged over 31 days would exceed 0.18 mrem to the total body or 0.6 mrem to any organ.

-----NOTE-----
 Appendix I dose limits for radioactive liquid effluent releases are applicable only during normal operating conditions which include expected operational occurrences, and are not applicable during unusual operating conditions that result in activation of the Oconee Emergency Plan.

APPLICABILITY: At all times

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Concentration of radioactive material released in liquid effluents to Unrestricted Areas exceeds the limits specified in Commitment a.	A.1 Restore concentration to within the limit.	Immediately

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>B. Calculated dose from the release of radioactive materials in liquid effluents exceeds any of the limits in Commitment b.</p>	<p>B.1 -----NOTE----- Not required during unusual operating conditions that result in activation of the Oconee Emergency Plan. -----</p> <p>Submit report to the regional NRC Office which includes the following:</p> <ul style="list-style-type: none"> a. Cause(s) for exceeding the limit(s). b. A description of the program of corrective action initiated to: reduce the releases of radioactive materials in liquid effluents, and to keep these levels of radioactive materials in liquid effluents in compliance with the above limits, or as low as reasonably achievable. c. Results of radiological analyses of the drinking water source and the radiological impact on finished drinking water supplies with regard to the requirements of 40 CFR 141. 	<p>30 days from the end of the quarter during which the release occurred</p>

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>C. Radioactive liquid waste is discharged without treatment and in excess of the specified limit.</p>	<p>C.1 Submit report to the regional NRC Office which includes the following:</p> <ul style="list-style-type: none"> a. Cause of equipment or subsystem inoperability. b. Corrective action to restore equipment and prevent recurrence. 	<p>30 days</p>

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
<p>SR 16.11.1.1 N/A</p>	<p>N/A</p>

BASES

The concentration commitment is provided to ensure that the concentration of radioactive materials released in liquid waste effluents from the site to unrestricted areas will be less than 10 times the effluent concentration levels specified in 10 CFR Part 20, Appendix B, Table 2, Column 2. The concentration limit for noble gases is based upon the assumption that Xe-135 is the controlling radioisotope and its EC in air (submersion) was converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection (ICRP) Publication 2.

The basic requirements for Selected Licensee Commitments concerning effluent from nuclear power reactors are stated in 10 CFR 50.36a. Compliance with effluent Selected Licensee Commitments will ensure that average annual releases of radioactive material in effluents will be small percentages of the limits specified in the old 10 CFR 20.106 (new 10 CFR 20.1302). The requirements contained in 10 CFR 50.36a further indicate that operational flexibility is allowed, compatible with considerations of health and safety, which may temporarily result in releases higher than such small percentages, but still within the limits specified in the old 10 CFR 20.106 which references Appendix B, Table II concentrations (MPCs). These referenced concentrations are specific values which relate to an annual dose of 500 mrem. It is further indicated in 10 CFR 50.36a that when using operational flexibility, best efforts shall be exerted to keep levels of radioactive materials in effluents as low as reasonably achievable (ALARA) as set forth in 10 CFR 50 Appendix I. Also, for fresh water sites with drinking water supplies which can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR 141. Therefore, to accommodate operational flexibility needed for effluent releases, the limits associated with this SLC are based on ten times the instantaneous dose rate value of 50 mrem/year to apply at all times. Compliance with the limits of the new 10 CFR 20.1001 will be demonstrated by operating within the limits of 10 CFR 50, Appendix I, 40 CFR 141 and 40 CFR 190.

Section I of Appendix I of 10 CFR 50 states that this appendix provides specific numerical guides for design objectives and limiting conditions for operation, to assist holders of licenses for light water cooled nuclear power reactors in meeting the requirements to keep releases of radioactive material to unrestricted areas as low as practical and reasonably achievable, during normal reactor operations, including expected operational occurrences. Using the flexibility granted during unusual operating conditions, and the stated applicability of the design objectives for the Oconee Nuclear Station, Appendix I dose limits for radioactive liquid effluent releases are concluded to be not applicable during unusual operating conditions that result in the activation of the Oconee Emergency Plan.

For units with shared radwaste treatment systems, the liquid effluents from the shared system are proportioned among the units sharing that system.

The requirements 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 SLC implements the requirements of 10 CFR Part 50.36a. General Design Criterion 60 of Appendix A to 10 CFR Part 50 and design objective Section II.D of Appendix A to 10 CFR Part 50.

REFERENCES:

1. 10 CFR Part 20, Appendix B.
2. 40 CFR Part 141.
3. 10 CFR Part 50, Appendices A and I.
4. 40 CFR Part 190.
5. Offsite Dose Calculation Manual.
6. Regulatory Guide 1.109.
7. NUREG-1301

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.2 Radioactive Gaseous Effluents

COMMITMENT Establish conditions for the controlled release of radioactive gaseous effluents. Implement the requirements of 10 CFR 20, 10 CFR 50.36a, Appendix A to 10 CFR 50, Appendix I to 10 CFR 50, and 40 CFR 190.

a. Dose Rate

The instantaneous dose rate at the site (exclusion area) boundary for gaseous effluents [Figure 2.1-4(a) of the Oconee Nuclear Station Updated Final Safety Analysis Report] due to radioactive materials released in gaseous effluents from the site shall be limited to the following values:

1. The dose rate limit for noble gases shall be:
 ≤ 500 mrem/yr to the total body
 ≤ 3000 mrem/yr to the skin; and
2. The dose rate limit for all radioiodines and for all radioactive materials in particulate form and radionuclides other than noble gases with half-lives greater than 8 days shall be ≤ 1500 mrem/yr to any organ.

b. Dose

1. The air dose due to noble gases released in gaseous effluent from the site shall be limited to the following:
 - i. During any calendar quarter:
 ≤ 15 mrad for gamma radiation
 ≤ 30 mrad for beta radiation
 - ii. During any calendar year:
 ≤ 30 mrad for gamma radiation
 ≤ 60 mrad for beta radiation
2. The dose to a Member Of The Public from radioiodines, tritium and radioactive materials in particulate form with half-lives greater than 8 days in gaseous effluents released from the site, shall be limited to the following:

- i. During any calendar quarter:
 - ≤ 22.5 mrem to any organ
 - ii. During any calendar year:
 - ≤ 45 mrem to any organ.
- c. Gaseous Radwaste Treatment
- 1. The Gaseous Radwaste Treatment System shall be used to reduce the noble gases in gaseous wastes prior to their discharge, if the projected gaseous effluent air dose due to gaseous effluent release from the site, when averaged over 31 days exceeds 0.6 mrad for gamma radiation and 1.2 mrad for beta radiation.
 - 2. The Ventilation Treatment Exhaust System shall be used to reduce radioactive materials other than noble gases in gaseous waste prior to their discharge when the projected doses due to effluent releases to unrestricted areas when averaged over 31 days would exceed 0.9 mrem to any organ.
- d. Used Oil Incineration

During incineration of used oil contaminated by radioactive material in the Station Auxiliary Boiler, the dose to a Member Of The Public from radioiodines, tritium and radioactive materials in particulate form with half-lives greater than 8 days in gaseous effluents released from the Station Auxiliary Boiler shall be ≤ 0.045 mrem to any organ in any calendar year.

-----NOTE-----
The requirement of c.2 does not apply to the Auxiliary Building Exhaust System since it is not "treated" prior to release.

APPLICABILITY: At all times

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Dose rate exceeds the limits specified in Commitment a.	A.1 Restore release rate to within limits.	Immediately
B. Calculated dose exceeds specified limits.	B.1 Submit report to the regional NRC Office which includes the following: <ul style="list-style-type: none"> a. Cause(s) for exceeding the limit(s), and b. A description of the program of corrective action initiated to: reduce the releases of radioactive materials in gaseous effluents, and to keep these levels of radioactive materials in gaseous effluents in compliance with the specified limits or as low as reasonably achievable. 	30 days from the end of the quarter during which the release occurred

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>C. Radioactive gaseous waste is discharged greater than limits specified in Commitment c.1 or c.2.</p> <p><u>AND</u></p> <p>Radioactive gaseous waste is discharged without treatment for more than 31 days.</p>	<p>C.1 Submit a report to the regional NRC Office which includes the following:</p> <ul style="list-style-type: none"> a. Cause of equipment or subsystems inoperability, and b. Corrective action to restore equipment and prevent recurrence. 	<p>30 days</p>

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
<p>SR 16.11.2.1 N/A</p>	<p>N/A</p>

BASES

The basic requirements for Selected Licensee Commitments concerning effluent from nuclear power reactors are stated in 10CFR50.36. Compliance with effluent Selected Licensee Commitments will ensure that average annual releases of radioactive material in effluents will be small percentages of the limits specified in the old 10CFR20.106 (new 10CFR20.1302). The requirements contained in 10CFR50.36a further indicate that operational flexibility is allowed, compatible with considerations of health and safety, which may temporarily result in releases higher than such small percentages, but still within the limits specified in the old 10CFR20.106 which references Appendix B, Table II concentrations (MPCs). These referenced concentrations are specific values which relate to an annual dose of 500 mrem to the total body, 3000 mrem to the skin, and 1500 mrem to an infant via the milk animal-milk-infant pathway. It is further indicated in 10CFR50.36a that when using operational flexibility, best efforts shall be exerted to keep levels of radioactive materials in effluents as low as reasonably achievable (ALARA) as set forth in 10CFR50 Appendix I. Therefore, to accommodate operational flexibility needed for effluent releases, the limits associated with gaseous release rate SLCs will be maintained at the current instantaneous dose rate limit for noble gases of 500 mrem/year to the total body and 3000 mrem/year to the skin; and for Iodine-131, for Iodine-133, for tritium, and for all radionuclides in particulate form with half-lives greater than 8 days. an instantaneous dose rate limit of 1500 mrem/year.

The ODCM calculational methods for calculating the doses due to the actual release rates of the subject materials will be consistent with the methodology provided in Regulatory Guide 1.109, "Calculating of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1., October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors."

Equations in the ODCM are provided for determining the actual doses based upon the historical average atmospheric conditions. The release rate commitments for radioiodines, radioactive material in particulate form and radionuclides other than noble gases are dependent on the existing radionuclide pathways to man, in the unrestricted area. The pathways which are examined in the development of these calculations are: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides into 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.

The requirement that the appropriate portions of these systems be used when specified provides reasonable assurance that the release of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." This commitment implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and design objective Section IID of Appendix I to 10 CFR Part 50.

REFERENCES:

1. 10 CFR Part 20, Appendix 8.
2. 10 CFR Part 50, Appendices A and I.
3. Regulatory Guide 1.109.
4. 40 CFR Part 190.
5. Offsite Dose Calculation Manual.

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.3 Radioactive Effluent Monitoring Instrumentation

COMMITMENT Radioactive Effluent Monitoring Instrumentation shall be OPERABLE as follows:

a. Liquid Effluents

The radioactive liquid effluent monitoring instrumentation channels shown in Table 16.11.3-1 shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of SLC 16.11.1.a are not exceeded.

b. Gaseous Process and Effluents

The radioactive gaseous process and effluent monitoring instrumentation channels shown in Table 16.11.3-2 shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of SLC 16.11.2.a are not exceeded.

c. The setpoints shall be determined in accordance with the methodology described in the ODCM and shall be recorded.

-----NOTE-----
Correction to setpoints determined in accordance with Commitment c may be permitted without declaring the channel inoperable.

APPLICABILITY: According to Table 16.11.3-1 and Table 16.11.3-2.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Alarm/trip setpoint less conservative than required for one or more effluent monitoring instrument channels.	A.1 Declare channel inoperable.	Immediately
	<u>OR</u> A.2 Suspend release of effluent monitored by the channel.	Immediately

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. One or more required liquid effluent monitoring instrument channels inoperable.	B.1 Enter the Condition referenced in Table 16.11.3-1 for the function.	Immediately
	<u>AND</u>	
	B.2 Restore the instrument(s) to OPERABLE status.	30 days
C. One or more required gaseous effluent monitoring instrument channels inoperable.	C.1 Enter the Condition referenced in Table 16.11.3-2 for the function.	Immediately
	<u>AND</u>	
	C.2 Restore the instrument(s) to OPERABLE status.	30 days
D. Required Action and associated Completion Time of Required Action B.2 or C.2 not met.	D.1 Explain in next Annual Radiological Effluent Release Report why inoperability was not corrected in a timely manner.	April 30 of following calendar year

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>E. As required by Required Action B.1 and referenced in Table 16.11.3-1. (RIA-33)</p>	<p>E.1.1 Analyze two independent samples in accordance with SLC 16.11.4.</p> <p><u>AND</u></p> <p>E.1.2 Conduct two independent data entry checks for release rate calculations</p> <p><u>AND</u></p> <p>E.1.3 Conduct two independent valve lineups of the effluent pathway.</p> <p><u>OR</u></p> <p>E.2 Suspend release of radioactive effluents by this pathway.</p>	<p>Prior to initiating subsequent release</p> <p>Prior to initiating subsequent release</p> <p>Prior to initiating subsequent release</p> <p>Immediately</p>
<p>F. As required by Required Action B.1 and referenced in Table 16.11.3-1. (RIA-54)</p>	<p>F.1 Suspend release of radioactive effluents by this pathway.</p> <p><u>OR</u></p> <p>F.2 Collect and analyze grab samples for gross radioactivity (beta and/or gamma) at a lower limit of detection of at least 10^{-7} $\mu\text{Ci/ml}$.</p>	<p>Immediately</p> <p>Prior to each discrete release of the sump</p>

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>H. As required by Required Action B.1 and referenced in Table 16.11.3-1. (RIA-35, #3 Chemical Treatment Pond Composite Sampler and Sampler Flow Monitor (Turbine Building Sumps Effluent))</p>	<p>-----NOTE----- Not required during short, controlled outages of liquid effluent monitoring instrumentation. Short controlled outages are defined as planned removals from service for durations not to exceed 1 hour, for purposes of sample filter changeouts, setpoint adjustments, service checks, and/or routine maintenance procedures. This guidance may be applied successively, provided that time between successive short, controlled outages is always at least equal to duration of immediately preceding outage. -----</p> <p>H.1 Suspend release of radioactive effluents by this pathway.</p> <p><u>OR</u></p> <p>H.2 Collect and analyze grab samples for gross radioactivity (beta and/or gamma) at a lower limit of detection of at least 10^{-7} $\mu\text{Ci/ml}$.</p>	<p>Immediately</p> <p>Immediately</p> <p><u>AND</u> Once per 12 hours thereafter</p>

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>I. As required by Required Action C.1 and referenced in Table 16.11.3-2 for effluent releases from waste gas tanks (RIA-37, RIA-38) or containment purges (RIA-45).</p>	<p style="text-align: center;">-----NOTE-----</p> <p>Not required during short, controlled outages of gaseous effluent monitoring instrumentation. Short controlled outages are defined as planned removals from service for durations not to exceed 1 hour, for purposes of sample filter changeouts, setpoint adjustments, service checks, and/or routine maintenance procedures. This guidance may be applied successively, provided that time between successive short, controlled outages is always at least equal to duration of immediately preceding outage.</p> <p style="text-align: center;">-----</p>	
	<p>I.1.1 Analyze two independent samples.</p> <p style="text-align: center;"><u>AND</u></p>	Prior to initiating subsequent release
	<p>I.1.2 Conduct two independent data entry checks for release rate calculations</p> <p style="text-align: center;"><u>AND</u></p>	Prior to initiating subsequent release
	<p>I.1.3 Conduct two independent valve lineups of the effluent pathway.</p> <p style="text-align: center;"><u>OR</u></p>	Prior to initiating subsequent release
	<p>I.2 Suspend release of radioactive effluents by this pathway.</p>	Immediately

CONDITION	REQUIRED ACTION	COMPLETION TIME
J. As required by Required Action C.1 and referenced in Table 16.11.3-2. (Effluent Flow Rate Monitor (Unit Vent, Containment Purge, Interim Radwaste Exhaust, Hot Machine Shop Exhaust, Radwaste Facility Exhaust, Waste Gas Discharge))	-----NOTE----- Not required during short, controlled outages of gaseous effluent monitoring instrumentation. Short controlled outages are defined as planned removals from service for durations not to exceed 1 hour, for purposes of sample filter changeouts, setpoint adjustments, service checks, and/or routine maintenance procedures. This guidance may be applied successively, provided that time between successive short, controlled outages is always at least equal to duration of immediately preceding outage. -----	
	J.1 Suspend release of radioactive effluents by this pathway.	Immediately
	<u>OR</u>	
J.2 Estimate flow rate	Immediately	
	<u>AND</u>	Once per 4 hours thereafter

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>K. As required by Required Action C.1 and referenced in Table 16.11.3-2. (RIA-45, RIA-53, 4RIA-45)</p>	<p>-----NOTE----- Not required during short, controlled outages of gaseous effluent monitoring instrumentation. Short controlled outages are defined as planned removals from service for durations not to exceed 1 hour, for purposes of sample filter changeouts, setpoint adjustments, service checks, and/or routine maintenance procedures. This guidance may be applied successively, provided that time between successive short, controlled outages is always at least equal to duration of immediately preceding outage. -----</p> <p>K.1 Suspend release of radioactive effluents by this pathway.</p> <p><u>OR</u></p> <p>K.2.1 Collect grab sample.</p> <p><u>AND</u></p> <p>K.2.2 Analyze grab samples for gross activity (beta and/or gamma).</p>	<p>Immediately</p> <p>Immediately</p> <p><u>AND</u> Once per 8 hours</p> <p>24 hours from collection of sample</p>

CONDITION	REQUIRED ACTION	COMPLETION TIME
L. As required by Required Action C.1 and referenced in Table 16.11.3-2. (Unit Vent Monitoring Iodine Sampler, Unit Vent Monitoring Particulate Sampler, Interim Radwaste Building Ventilation Monitoring Iodine Sampler, Interim Radwaste Building Ventilation Monitoring Particulate Sampler, Hot Machine Shop Iodine Sampler, Hot Machine Shop Particulate Sampler, Radwaste Facility Iodine Sampler, Radwaste Facility Particulate Sampler)	-----NOTE----- Not required during short, controlled outages of gaseous effluent monitoring instrumentation. Short controlled outages are defined as planned removals from service for durations not to exceed 1 hour, for purposes of sample filter changeouts, setpoint adjustments, service checks, and/or routine maintenance procedures. This guidance may be applied successively, provided that time between successive short, controlled outages is always at least equal to duration of immediately preceding outage. -----	
	L.1 Suspend release of radioactive effluents by this pathway.	Immediately
	<u>OR</u>	
	L.2.1 -----NOTE----- The collection time of each sample shall not exceed 7 days. ----- Collect samples continuously using auxiliary sampling equipment.	Immediately
<u>AND</u>		
L.2.2 Analyze each sample.	48 hours from end of each sample collection	

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>M. As required by Required Action C.1 and referenced in Table 16.11.3-2 for effluent from ventilation system or condenser air ejectors. (RIA-40)</p>	<p>-----NOTE-----</p> <p>Not required during short, controlled outages of gaseous effluent monitoring instrumentation. Short controlled outages are defined as planned removals from service for durations not to exceed 1 hour, for purposes of sample filter changeouts, setpoint adjustments, service checks, and/or routine maintenance procedures. This guidance may be applied successively, provided that time between successive short, controlled outages is always at least equal to duration of immediately preceding outage.</p> <p>-----</p>	
	<p>M.1 Continuously monitor release through the unit vent.</p>	Immediately
	<u>OR</u>	
	<p>M.2 Suspend release of radioactive effluents by this pathway.</p>	Immediately
	<u>OR</u>	
<p>M.3.1 Collect grab sample.</p>	Immediately	
	<u>AND</u>	
<p>M.3.2 Analyze grab sample for gross activity (beta and/or gamma).</p>	Once per 8 hours	
	<u>AND</u>	
	<p>M.3.2 Analyze grab sample for gross activity (beta and/or gamma).</p>	24 hours from collection of grab sample

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
<p>SR 16.11.3.1 -----NOTE----- The Channel Response check shall consist of verifying indications during periods of release. Channel response checks shall be made at least once per calendar day on days in which continuous, periodic or batch releases are made. ----- Perform Channel Response Check.</p>	<p>During each release via this pathway</p>
<p>SR 16.11.3.2 -----NOTE----- The Channel Response check shall consist of verifying indications during periods of release. Channel response checks shall be made at least once per calendar day on days in which continuous, periodic or batch releases are made. ----- Perform Channel Response Check.</p>	<p>24 hours</p>
<p>SR 16.11.3.3 Perform Source Check.</p>	<p>24 hours</p>
<p>SR 16.11.3.4 Perform Source Check.</p>	<p>31 days</p>
<p>SR 16.11.3.5 Perform Source Check.</p>	<p>92 days</p>

SURVEILLANCE	FREQUENCY
<p>SR 16.11.3.6 -----NOTE----- The CHANNEL FUNCTIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room annunciation occurs if any of the following conditions exist:</p> <ol style="list-style-type: none"> 1. Instrument indicates measured levels above the alarm/trip setpoint. 2. Circuit failure (downscale only). <p>-----</p> <p>Perform CHANNEL FUNCTIONAL TEST.</p>	<p>92 days</p>
<p>SR 16.11.3.7 -----NOTE----- The CHANNEL FUNCTIONAL TEST shall also demonstrate that control room annunciation occurs if any of the following conditions exist:</p> <ol style="list-style-type: none"> 1. Instrument indicates measured levels above the alarm/trip setpoint. 2. Circuit failure (downscale only). <p>-----</p> <p>Perform CHANNEL FUNCTIONAL TEST.</p>	<p>92 days</p>
<p>SR 16.11.3.8 Perform CHANNEL FUNCTIONAL TEST.</p>	<p>92 days</p>

SURVEILLANCE	FREQUENCY
<p>SR 16.11.3.9</p> <p>-----NOTE----- The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Bureau of Standards or using standards that have been obtained from suppliers that participate in measurement assurance activities with the National Institute of Standards and Technology (NIST). The standards shall permit calibrating the system over its intended range of energy and measurement. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used. (Operating plants may substitute previously established calibration procedures for these requirements.) -----</p> <p>Perform CHANNEL CALIBRATION.</p>	<p>12 months</p>
<p>SR 16.11.3.10</p> <p>Perform CHANNEL CALIBRATION.</p>	<p>12 months</p>
<p>SR 16.11.3.11</p> <p>Perform leak test.</p>	<p>When cylinder gates or wicket gates are reworked</p>
<p>SR 16.11.3.12</p> <p>Perform Source Check.</p>	<p>Within 24 hours prior to each release via associated pathway</p>

Table 16.11.3-1
LIQUID EFFLUENT MONITORING INSTRUMENTATION
OPERATING CONDITIONS AND SURVEILLANCE REQUIREMENTS

INSTRUMENT	MINIMUM OPERABLE CHANNELS	APPLICABILITY	SURVEILLANCE REQUIREMENTS	CONDITION REFERENCED FROM REQUIRED ACTION B.1
1. Monitors Providing Automatic Termination of Release				
a. Liquid Radwaste Effluent Line Monitor, RIA-33	1	At all times	SR 16.11.3.1 SR 16.11.3.3 SR 16.11.3.6 SR 16.11.3.9	E
b. Turbine Building Sump, RIA-54	1	At all times	SR 16.11.3.2 SR 16.11.3.4 SR 16.11.3.7 SR 16.11.3.9	F
2. Monitors not Providing Automatic Termination of Release				
Low Pressure Service Water RIA-35	1	At all times	SR 16.11.3.2 SR 16.11.3.4 SR 16.11.3.7 SR 16.11.3.9	H
3. Flow Rate Measuring Devices				
a. Liquid Radwaste Effluent Line Flow Rate Monitor (OLW CR0725 or OLW SS0920)	1	At all times	SR 16.11.3.1 SR 16.11.3.10	G
b. Liquid Radwaste Effluent Line Minimum Flow Device	NA	NA	SR 16.11.3.1 SR 16.11.3.10	NA
c. Turbine Building Sump Minimum Flow Device	NA	NA	SR 16.11.3.1 SR 16.11.3.10	NA
d. Low Pressure Service Water Minimum Flow Device	NA	NA	SR 16.11.3.1 SR 16.11.3.10	NA

Table 16.11.3-1
LIQUID EFFLUENT MONITORING INSTRUMENTATION
OPERATING CONDITIONS AND SURVEILLANCE REQUIREMENTS

INSTRUMENT	MINIMUM OPERABLE CHANNELS	APPLICABILITY	SURVEILLANCE REQUIREMENTS	CONDITION REFERENCED FROM REQUIRED ACTION B.1
e. Keowee Hydroelectric Tailrace Discharge ^(a)	NA	NA	SR 16.11.3.11	NA
4. Continuous Composite Sampler				
#3 Chemical Treatment Pond Composite Sampler and Sampler Flow Monitor (Turbine Building Sumps Effluent)	1	At all times	SR 16.11.3.2 SR 16.11.3.10	H

(a) Flow is determined from the number of hydro units operating. If no hydro units are operating, leakage flow will be assumed to be 38 cfs based on historical data.

Radioactive Effluent Monitoring Instrumentation

16.11.3

Table 16.11.3-2
GASEOUS EFFLUENT MONITORING INSTRUMENTATION
OPERATING CONDITIONS AND SURVEILLANCE REQUIREMENTS

INSTRUMENT	MINIMUM OPERABLE CHANNELS (PER RELEASE PATH)	APPLICABILITY	SURVEILLANCE REQUIREMENTS	CONDITION REFERENCED FROM REQUIRED ACTION C.1
1. Unit Vent Monitoring System				
a. Noble Gas Activity Monitor Providing Alarm and Automatic Termination of Containment Purge Release (RIA-45 - Purge Isolation Function)	1	At All Times	SR 16.11.3.2 SR 16.11.3.4 SR 16.11.3.7 SR 16.11.3.9	I
b. Noble Gas Activity Monitor Providing Alarm. (RIA-45 - Vent Stack Monitor Function)	1	At all times	SR 16.11.3.2 SR 16.11.3.4 SR 16.11.3.7 SR 16.11.3.9	K
c. Iodine Sampler	1	At All Times	SR 16.11.3.2	L
d. Particulate Sampler	1	At All Times	SR 16.11.3.2	L
e. Effluent Flow Rate Monitor (Unit Vent Flow) (MSC CR0001)	1	At All Times	SR 16.11.3.2 SR 16.11.3.10	J
f. Sampler Flow Rate Monitor ^(a) (Annunciator)	1	At All Times	SR 16.11.3.2 SR 16.11.3.10	NA
g. Effluent Flow Rate Monitor (Containment Purge)(MSC CR0001)	1	During Containment Purge Operation	SR 16.11.3.2 SR 16.11.3.10	J
h. CSAE Off Gas Monitor (RIA-40)	1	During Operation of CSAE	SR 16.11.3.2 SR 16.11.3.5 SR 16.11.3.8 SR 16.11.3.9	M
2. Interim Radwaste Building Ventilation Monitoring System				
a. Noble Gas Activity Monitor (RIA - 53)	1	At All Times	SR 16.11.3.2 SR 16.11.3.4 SR 16.11.3.7 SR 16.11.3.9	K
b. Iodine Sampler	1	At All Times	SR 16.11.3.2	L
c. Particulate Sampler	1	At All Times	SR 16.11.3.2	L
d. Effluent Flow Rate Monitor (Interim Radwaste Exhaust) (GWD FT0082)	1	At All Times	SR 16.11.3.2 SR 16.11.3.10	J
e. Sampler Flow Rate Monitor ^(a) (Annunciator)	1	At All Times	SR 16.11.3.2 SR 16.11.3.10	NA

Radioactive Effluent Monitoring Instrumentation

16.11.3

Table 16.11.3-2
GASEOUS EFFLUENT MONITORING INSTRUMENTATION
OPERATING CONDITIONS AND SURVEILLANCE REQUIREMENTS

INSTRUMENT	MINIMUM OPERABLE CHANNELS (PER RELEASE PATH)	APPLICABILITY	SURVEILLANCE REQUIREMENTS	CONDITION REFERENCED FROM REQUIRED ACTION C.1
3. Hot Machine Shop Ventilation Sampling System				
a. Iodine Sampler	1	At All Times	SR 16.11.3.2	L
b. Particulate Sampler	1	At All Times	SR 16.11.3.2	L
c. Effluent Flow Rate Monitor (Hot Machine Shop Exhaust) (Totalizer)	1	At All Times	SR 16.11.3.2 SR 16.11.3.10	J
d. Sampler Flow Rate Monitor ^(a) (Annunciator)	1	At All Times	SR 16.11.3.2 SR 16.11.3.10	NA
4. Radwaste Facility Ventilation Monitoring System				
a. Noble Gas Activity Monitor (4-RIA-45)	1	At All Times	SR 16.11.3.2 SR 16.11.3.4 SR 16.11.3.7 SR 16.11.3.9	K
b. Iodine Sampler	1	At All Times	SR 16.11.3.2	L
c. Particulate Sampler	1	At All Times	SR 16.11.3.2	L
d. Effluent Flow Rate Monitor (Radwaste Facility Exhaust) (OVS CR2060)	1	At All Times	SR 16.11.3.2 SR 16.11.3.10	J
e. Sampler Flow Rate Monitor ^(a) (Annunciator)	1	At All Times	SR 16.11.3.2 SR 16.11.3.10	NA
5. Waste Gas Holdup Tanks				
a. Noble Gas Activity Monitor - Providing Alarm and Automatic Termination of Release (RIA-37,-38) ^b	1	During Waste Gas Holdup Tank Releases	SR 16.11.3.1 SR 16.11.3.6 SR 16.11.3.9 SR 16.11.3.12	I
b. Effluent Flow Rate Monitor (Waste Gas Discharge Flow) (MSC CR0001)	1	During Waste Gas Holdup Tank Releases	SR 16.11.3.1 SR 16.11.3.10	J

(a)Alarms indicating low flow may be substituted for flow measuring devices.

(b)Either Normal or High Range monitor is required dependent upon activity in tank being released.

BASES

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. The alarm/trip setpoints for these instruments shall be calculated in accordance with NRC approved methods in the ODCM to assure that the alarm/trip will occur prior to exceeding 10 times the limits of 10 CFR Part 20. The operability and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

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. The alarm/trip setpoints for these instruments shall be calculated in accordance with NRC approved methods in the ODCM to assure that the alarm/trip will occur prior to exceeding applicable dose limits in SLC 16.11.2. The operability end use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

For certain applicable cases, grab samples or flow estimates are required at frequencies between every 4 hours and every 12 hours upon RIA removal from service. SLC 16.11.3 does not explicitly require Action (grab samples or flow estimates) to be initiated immediately upon RIA removal from service, when removal is for the purposes of sample filter changeouts, setpoint adjustments, service checks, or routine maintenance. Therefore, during the defined short, controlled outages, Action is not required.

For the cases in which Action is defined as continuous sampling by auxiliary equipment (Action L) initiation of continuous sampling by auxiliary sampling equipment requires approximately 1 hour. One hour is the accepted reasonable time to initiate collect and change samples. Therefore, for the defined short, controlled outages (not to exceed 1 hour), Action is not required.

Failures such as blown instrument fuses, defective indicators, and faulted amplifiers are, in many cases, revealed by alarm or annunciator action. Comparison of output and/or state of independent channels measuring the same variable supplements this type of built-in surveillance. Based on experience in operation of both conventional and nuclear systems, when the unit is in operation, the minimum checking frequency stated is deemed adequate.

REFERENCES:

1. 10 CFR Part 20.
2. 10 CFR Part 50, Appendix A.
3. Offsite Dose Calculation Manual.
4. UFSAR, Section 7.2.3.4.

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.4 Operational Safety Review

COMMITMENT Required sampling should be performed as detailed in Table 16.11.4-1.

APPLICABILITY: At all times

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. NA	A.1 NA	NA

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 16.11.4.1 N/A	N/A

Table 16.11.4-1
Minimum Sampling Frequency and Analysis Program

Item	Check	Frequency	Lower Limit of Detection ^(b) of Lab Analysis for Waste
1. Decant Monitor Tank, Turbine Building Sump Monitor Tanks, Waste and Recycle Monitor Tanks	a. Principal Gamma Emitters ^(c) including Dissolved Noble Gases	Composite Grab Sample prior to release of each batch ^(h)	<5E-06 μ Ci/ml (Ce-144) <5E-07 μ Ci/ml (Other Gamma Nuclides) <1E-05 μ Ci/ml (Dissolved Gases) <1E-06 μ Ci/ml (I-131)
	b. Radiochemical Analysis Sr-89 and Sr-90	Quarterly from all composited batches ^(f)	<5E-08 μ Ci/ml
	c. Tritium	Monthly Composite	<1E-05 μ Ci/ml
	d. Gross Alpha Activity	Monthly Composite	<1E-07 μ Ci/ml
2. Unit Vent Sampling (Includes Waste Gas Decay Tanks, Reactor Building Purges, Auxiliary Building Ventilation, Spent Fuel Pool Ventilation, Air Ejectors)	a. Iodine Spectrum ^(a)	Continuous monitor, weekly sample ^(e)	<1E-10 μ Ci/cc (I-133) ^(j) <1E-12 μ Ci/cc (I-131) ^(j)
	b. Particulates ^(a)		
	i. Ce-144 & Mo-99	Weekly Composite ^(e)	<5E-10 μ Ci/cc ^{(j)(k)}
	ii. Other Principle Gamma Emitters ^(d)	Weekly Composite ^(e)	<1E-11 μ Ci/cc ^(j)
	iii. Gross Alpha Activity	Monthly, using composite samples of one week	<1E-11 μ Ci/cc
	iv. Radiochemical Analysis Sr-89, Sr-90	Quarterly Composite	<1E-11 μ Ci/cc
	c. Gases by Principle Gamma Emitters ^(d)	Weekly Grab Sample	<1E-04 μ Ci/cc
	d. Tritium	Weekly Grab Sample	<1E-06 μ Ci/cc
3. Waste Gas Decay Tank	a. Principle Gamma Emitters ^(d)	Grab Sample prior to release of each batch	<1E-04 μ Ci/cc (gases) <1E-10 μ Ci/cc (particulates and iodines) <5E-09 μ Ci/cc (Ce-144 and Mo-99)
	b. Tritium	Grab Sample prior to release of each batch	<1E-06 μ Ci/cc
4. Reactor Building	a. Principle Gamma Emitters ^(d)	Grab sample each purge	<1E-04 μ Ci/cc (gases) <1E-10 μ Ci/cc (particulates and iodines) <5E-09 μ Ci/cc (Ce-144 and Mo-99)
	b. Tritium	Grab sample each purge	<1E-06 μ Ci/cc

Table 16.11.4-1
Minimum Sampling Frequency and Analysis Program

Item	Check	Frequency	Lower Limit of Detection ^(b) of Lab Analysis for Waste	
5.	Not Used			
6.	#3 Chemical Treatment Pond Effluent ⁽ⁱ⁾	a. Principle Gamma Emitters ^(c)	Weekly Continuous Composite ^(g)	<5E-07 $\mu\text{Ci/ml}$
		b. I-131	Weekly Continuous Composite ^(g)	<1E-06 $\mu\text{Ci/ml}$
		c. Tritium	Monthly Continuous Composite ^(g)	<1E-05 $\mu\text{Ci/ml}$
		d. Gross Alpha Activity	Monthly Continuous Composite ^(g)	<1E-07 $\mu\text{Ci/ml}$
		e. Sr-89 & Sr-90	Quarterly Continuous Composite ^(g)	<5E-08 $\mu\text{Ci/ml}$
		f. Dissolved and Entrained gases (Gamma Emitters)	Monthly Grab	<1E-05 $\mu\text{Ci/ml}$
7.	Radwaste Facility Ventilation	a. Iodine Spectrum ^(a)	Continuous monitor, weekly sample ^(e)	(I-133) <1E-09 $\mu\text{Ci/cc}$ (I-131) <1E-11 $\mu\text{Ci/cc}$
		b. Particulate ^(a)		
		i. Ce-144 and Mo-99	Weekly Composite ^(e)	<5E-10 $\mu\text{Ci/cc}^{(f)}$
		ii. Other Principle Gamma Emitters ^(d)	Weekly Composite ^(e)	<1E-11 $\mu\text{Ci/cc}^{(f)}$
		iii. Gross Alpha Activity	Monthly, using composite samples of one week	<1E-11 $\mu\text{Ci/cc}$
		iv. Radiochemical Analysis Sr-89, Sr-90	Quarterly Composite	<1E-11 $\mu\text{Ci/cc}$
		c. Gases by Principle Gamma ^(d) Emitters	Weekly Grab Sample	<1E-04 $\mu\text{Ci/cc}$
		d. Tritium	Weekly Grab Sample	<1E-06 $\mu\text{Ci/cc}$

Table 16.11.4-1
Minimum Sampling Frequency and Analysis Program

Item	Check	Frequency	Lower Limit of Detection ^(b) of Lab Analysis for Waste
8. Hot Machine Shop Ventilation	a. Iodine Spectrum	Weekly Sample ^(e)	(I-133) <1E-10 $\mu\text{Ci/cc}^{(j)}$ (I-131) <1E-12 $\mu\text{Ci/cc}^{(j)}$
	b. Particulate		
	i. Ce-144 and Mo-99	Weekly Composite ^(e)	<5E-10 $\mu\text{Ci/cc}^{(j)(k)}$
	ii. Other Principle Gamma Emitters ^(d)	Weekly Composite ^(e)	<1E-11 $\mu\text{Ci/cc}^{(j)}$
	iii. Gross Alpha Activity	Monthly, using composite samples of one week	<1E-11 $\mu\text{Ci/cc}$
	iv. Radiochemical Analysis Sr-89, Sr-90	Quarterly Composite	<1E-11 $\mu\text{Ci/cc}$
	c. Gases by Principle Gamma Emitters	NA	NA
	d. Tritium	NA	NA
9. Interim Radwaste Building Ventilation	a. Iodine Spectrum	Weekly sample ^(e)	(I-133) <1E-10 $\mu\text{Ci/cc}^{(j)}$ (I-131) <1E-12 $\mu\text{Ci/cc}^{(j)}$
	b. Particulate		
	i. Ce-144 and Mo-99	Weekly Composite ^(e)	<5E-10 $\mu\text{Ci/cc}^{(j)}$
	ii. Other Principle Gamma Emitters ^(d)	Weekly Composite ^(e)	<1E-11 $\mu\text{Ci/cc}^{(j)}$
	iii. Gross Alpha Activity	Monthly, using composite samples of one week	<1E-11 $\mu\text{Ci/cc}$
	iv. Radiochemical Analysis Sr-89, Sr-90	Quarterly Composite	<1E-11 $\mu\text{Ci/cc}$
	c. Gases by Principle Gamma ^(d) Emitters	Weekly Grab Sample	<1E-04 $\mu\text{Ci/cc}$
	d. Tritium	Weekly Grab Sample	<1E-06 $\mu\text{Ci/cc}$

- (a) Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing, or after removal from sampler. Sampling 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 does not apply if (1) analyses show that the DOSE EQUIVALENT I-131 concentration in the reactor coolant has not increased more than a factor of 3; and (2) the noble gas monitor shows that effluent activity has not increased more than a factor of 3.
- (b) The LLD is defined for purposes of these commitments as the smallest concentration of radioactive material in a sample that would be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation) :

$$LLD = \frac{(2.71 / T) + 4.65 s_b}{E \times V \times 2.22E06 \times Y \times \exp(-\lambda \Delta t)}$$

Where:

LLD is the "a priori" lower limit of detection as defined above (as micro Curies per unit mass or volume),

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute),

E is the counting efficiency (as counts per disintegration),

V is the sample size (in units of mass or volume),

2.22E06 is the number of disintegrations per minute per micro Curie,

Y is the fractional radiochemical yield (when applicable),

λ is the radioactive decay constant for the particular nuclide

Δt is the elapsed time between midpoint of sample collection and time of counting (for plant effluents, not environmental samples). NOTE: This assumes decay correction is applied (at the time of analysis) for the duration of sample collection, for the time between collection and analysis, and for the duration of the counting. Additionally, it does not apply to isolated systems such as Waste Gas Decay Tanks and Waste Monitor Tanks.

T is the sample counting time in minutes

Typical values of E, V, Y and Δt should be used in the calculation.

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

- (c) The principal gamma emitters for which the LLD control applies include the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, and Ce-141. Ce-144 shall also be measured, but with a LLD of 5E-06 μ Ci/ml. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with the above nuclides shall also be analyzed and reported in the Annual Radioactive Effluent Release Report.
- (d) The principal gamma emitters for which the LLD commitment applies exclusively are the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 for gaseous emissions and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144 for particulates. This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides shall also be identified and reported.
- (e) 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 SLC 16.11.2.a, SLC 16.11.2.b.1, and SLC 16.11.2.b.2.
- (f) 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.

- (g) To be representative of the quantities and concentrations of radioactive materials in liquid effluents, samples shall be collected continuously in proportion to the rate of flow of the effluent stream. Prior to analysis, all samples taken for the composite shall be thoroughly mixed in order for the composite sample to be representative of the effluent release.
- (h) A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analysis, each batch shall be isolated, and then thoroughly mixed, to assure representative sampling.
- (i) A continuous release is the discharge of liquid wastes of a non-discrete volume, e.g., from a volume of a system that has an input flow during the continuous release. Samples shall be analyzed within 48 hours after changing (on or after removal from sampler).
- (j) When samples collected for 24 hours are analyzed, the corresponding LLDs may be increased by a factor of 10. Samples shall be analyzed within 48 hours after changing (on or after removal from sampler).
- (k) Ce-144 and Mo-99 LLD as approved by NRC SER dated January 16, 1984 (Reference 1).

BASES

N/A

REFERENCES:

1. Safety Evaluation Report dated January 16, 1984, supporting Amendment Nos. 125, 125, and 122 for Oconee Nuclear Station to revise Technical Specifications to incorporate changes to the Radiological Effluent Technical Specifications (RETS) in order to bring them into compliance with Appendix I of 10 CFR Part 50.

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.5 Solid Radioactive Waste

COMMITMENT Radioactive wastes shall be processed and packaged to ensure compliance with the applicable requirements of 10 CFR Part 20, 10 CFR Part 61, 10 CFR Part 71, and State regulations governing the transportation and disposal of radioactive wastes.

The Solid Radwaste System or an approved alternative process shall be used in accordance with a Process Control Program (PCP), for the solidification of liquid or wet radioactive wastes or the dewatering of wet radioactive wastes to be shipped for direct disposal at a 10 CFR 61 licensed disposal site. Wastes shipped for off site processing in accordance with the processor's specifications and transportation requirements are not required to be solidified or dewatered to meet disposal requirements.

- The PCP describes administrative and operational controls used for the solidification of liquid or wet solid radioactive wastes in order to meet applicable 10 CFR 61 waste form requirements.
- The PCP describes the administrative and operational controls used for the dewatering of wet radioactive wastes to meet 10 CFR 61 free standing water requirements.
- The process parameters used in establishing the PCP shall be based on demonstrated processing of actual or simulated liquid or wet solid wastes and must adequately verify that the final product of solidification or dewatering meets all applicable Federal, State and disposal site requirements.

APPLICABILITY: At all times

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Applicable regulatory requirements for solidified or dewatered wastes are not satisfied.</p>	<p>A.1 Suspend shipments of defectively packaged solid radioactive wastes from the site.</p> <p><u>AND</u></p> <p>A.2 Initiate action to correct PCP, procedures, or solid waste equipment as necessary to prevent recurrence.</p>	<p>Immediately</p> <p>Prior to next shipment for disposal of solidified or dewatered wastes</p>
<p>B. A solidification test as described in the PCP fails to verify Solidification.</p>	<p>B.1 Suspend solidification of the batch under test and follow PCP guidance for test failures until solidification of the batch is verified by subsequent tests.</p> <p><u>AND</u></p> <p>B.2 The PCP shall be modified as required to assure Solidification of subsequent batches of waste.</p>	<p>Immediately</p> <p>Prior to next solidification for shipment of waste for disposal at a 10 CFR 61 disposal site</p>

CONDITION	REQUIRED ACTION	COMPLETION TIME
C. With solidification or dewatering for disposal not performed in accordance with the PCP.	C.1 Reprocess or repackage the waste in accordance with PCP requirements. <u>OR</u> C.2 Follow PCP or procedure guidance for alternative free standing liquid verification to ensure the waste in each container meets disposal requirements and take appropriate administrative action to prevent recurrence.	Prior to shipment for disposal of the inadequately processed waste that requires solidification or dewatering
D. With the solid waste equipment incapable of meeting commitment or not in service.	D.1 Restore the equipment to OPERABLE status or provide for alternative capability to process wastes as necessary to satisfy all applicable disposal requirements.	In a time frame that supports the commitment

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 16.11.5.1 The Process Control Program shall be used to verify the solidification of at least one representative test specimen from at least every tenth batch of each type of radioactive waste to be solidified for disposal at a 10 CFR 61 disposal site.	Every tenth batch of each type of radioactive waste to be solidified.

BASES

This commitment implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of 10 CFR Part 50, Appendix A and requirements to use a Process Control Program to meet applicable 10CFR61 waste form criteria for solidified and dewatered radioactive wastes.

REFERENCES:

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities".
2. 10 CFR Part 50, Appendix A.
3. 10 CFR20, "Standards for Protection Against Radiation".
4. 10 CFR61, "Licensing Requirements for Land Disposal of Radioactive Waste".
5. 10 CFR71, "Packaging and Transportation of Radioactive Materials".
6. DPCo Process Control Program Manual.
7. NRC Generic Letter 87-12, "Compliance with 10 CFR Part 61 And Implementation Of the Radiological Effluent Technical Specifications (Rets) and Attendant Process Control Program (PCP)".
8. NRC Generic Letter 89-01, "Implementation of Programmatic Controls for Radiological 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".

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.6 Radiological Environmental Monitoring

- COMMITMENT
- a. The radiological environmental monitoring samples shall be collected in accordance with Table 16.11.6-1 and shall be analyzed pursuant to the requirements of Tables 16.11.6-1 and 16.11.6-2.
 - b. A land use census shall be conducted and shall identify the location of the nearest milk animal and the nearest residence in each of the 16 meteorological sectors within a distance of eight kilometers (five miles). Broad leaf vegetation sampling shall be performed at the site boundary in the direction sector with the highest D/Q in lieu of the garden census.
 - c. Analyses shall be performed on radioactive materials supplied as part of an Interlaboratory Comparison Program. A summary of the results obtained as part of the Interlaboratory Comparison Program shall be included in the Annual Radiological Environmental Operating Report. The Interlaboratory Comparison Program shall be described in the Annual Radiological Environmental Operating Report.
 - d. The results of the land use census shall be included in the Annual Radiological Environmental Operating Report.

-----NOTE-----
 If samples required by Commitment part a, become permanently unavailable from any of the required sample locations, the locations from which samples were unavailable may then be deleted from the program provided replacement samples were obtained and added to the environmental monitoring program, if available. These new locations will be identified in the Annual Radioactive Effluent Release Report.

APPLICABILITY: At all times

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Radiological environmental monitoring program is not conducted as required.</p>	<p>A.1 Submit a description of the reason for not conducting the program as required and plans to prevent a recurrence shall be included in the Annual Radiological Environmental Operating Report.</p>	<p>May 15 of following calendar year</p>
<p>B. Land use census identifies a Location which yields a calculated dose or dose commitment (via the same exposure pathway) 20% greater than a location from which samples are currently being obtained.</p>	<p>B.1 -----NOTE----- The sampling location having the lowest calculated dose or dose commitment (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. ----- Add new location to the radiological environmental monitoring program.</p> <p><u>AND</u></p> <p>B.2 Identify new locations in the next Annual Radioactive Effluent Release Report.</p>	<p>30 days</p> <p>April 30 of following calendar year</p>

ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
C. Interlaboratory Comparison Program analyses not performed as required.	C.1 Report corrective actions in the Annual Radiological Environmental Operating Report.	May 15 of following calendar year
D. Radioactivity level resulting from plant effluents in environmental sampling medium at a specified location in excess of reporting limits of Table 16.11.6-3 when averaged over a calendar quarter.	D.1 Prepare and submit a Special report that identifies the cause for exceeding the limits 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 SLC 16.11.1 or 16.11.2.	30 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 16.11.6.1 Conduct land use census during growing season 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.	12 months

Table 16.11.6-1
Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Sample Locations (b)	Sampling and Collection Frequency (d)	Time and Frequency of Analysis
1. AIRBORNE			
Radioiodine and Particulates	5	Continuous sampler operation with sample collection weekly, or more frequently if required by dust loading.	Radioiodine canister: I-131 analysis weekly. Particulate sampler: Gross beta radioactivity analysis following filter change; and gamma isotopic analysis of composite (by location) quarterly. (c)
2. DIRECT RADIATION	40	Quarterly.	Gamma dose quarterly.
3. WATERBORNE			
a. Surface	2	Composite (a) sample over a 1-month period.	Gamma isotopic analysis monthly. Composite for tritium analysis quarterly.
b. Drinking	3	Composite (a) sample over a 1-month period.	Composite for gross beta and gamma isotopic analyses monthly. Composite for tritium analysis quarterly.
c. Sediment from Shoreline	2	Semiannually.	Gamma isotopic analysis semiannually.

Table 16.11.6-1
Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Sample Locations (b)	Sampling and Collection Frequency (d)	Time and Frequency of Analysis
4. INGESTION			
a. Milk	4(e)	Semimonthly when animals are on pasture; monthly at other times.	Gamma isotopic and I-131 analysis semimonthly when animals are on pasture; monthly at other times.
b. Fish	2	Semiannually. One sample each commercially and recreationally important species.	Gamma isotopic analysis semiannually on edible portion.
c. Broad-leaf Vegetation	2	Monthly.	Gamma isotopic analysis monthly.

- (a) Composite samples shall be collected by collecting an aliquot at intervals not exceeding 2 hours.
- (b) Sample locations are identified in the ODCM.
- (c) Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow 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.
- (d) Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, or to malfunction of automatic sampling equipment. If the latter, every effort shall be made to complete corrective action prior to the end of the next sampling period.
- (e) Samples from milking animals in three locations within 5 km distance having the highest dose potential. If there are none, then one sample from milking animals in each of three areas between 5 to 8 km distant where doses are calculated to be greater than 1 mrem per year. One sample from milking animals at a control location, as for example 15 to 30 km distant and in the least prevalent wind direction.

Table 16.11.6-2
Maximum Values for the Lower Limits of Detection (LLD) (a) (c)

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m ³)	Fish (pCi/kg, wet)	Milk (pCi/l)	Broad-leaf Vegetation (pCi/kg, wet)	Sediment (pCi/kg, dry)
Gross Beta	4	1E-02				
H ₃	2,000					
Mn-54	15		130			
Fe-59	30		260			
Co-58	15		130			
Co-60	15		130			
Zn-65	30		260			
Zr-95	15					
Nb-95	15					
I-131	15(b)	7E-02		1	60	
Cs-134	15	5E-02	130	15	60	150
Cs-137	18	6E-02	150	18	80	180
Ba-140	15			60		
La-140	15			15		

- (a) The LLD is defined, for purposes of these commitments, as the smallest concentration of radioactive material in a sample with 95% probability of detection and with 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{(2.71 / T) + 4.65 s_b}{E \times V \times 2.22 \times Y \times \exp(-\lambda \Delta t)}$$

Where:

LLD is the lower limit of detection as defined above (as pCi per unit mass or volume)

S_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute)

Table 16.11.6-2
Maximum Values for the Lower Limits of Detection (LLD) (a) (c)

E is the counting efficiency (as counts per disintegration)

V is the sample size (in units of mass or volume)

2.22 is the number of disintegrations per minute per picocurie

Y is the fractional radiochemical yield (when applicable)

λ is the radioactive decay constant for the particular radionuclide

Δt is the elapsed time between sample collection (or end of the sample collection period) and time of counting

T is the sample counting time in minutes

Typical values of E, V, Y and Δt should be used in the calculation.

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

Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidably small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances, may render these LLDs unachievable. In such cases, the contributing factors will be identified and described in the Annual Radiological Environmental Operating Report.

- (b) LLD for gamma isotopic analysis for I-131 in drinking water samples. Low level I-131 analysis on drinking water will not be routinely performed because the calculated dose from I-131 in drinking water at all locations is less than 1 mrem per year. Low level I-131 analyses will be performed if abnormal releases occur which could reasonably result in > 1 pCi/liter of I-131 in drinking water. For low level analyses of I-131 an LLD of 1 pCi/liter will be achieved.
- (c) Other peaks which are measurable and identifiable, together with the radionuclides in Table 16.11.6-2, shall be identified and reported.

Table 16.11.6-3
Reporting Levels for Radioactivity Concentrations in Environmental Samples (c) (d)

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m ³)	Fish (pCi/kg, wet)	Milk (pCi/l)	Broad-leaf Vegetation (pCi/kg, wet)
H-3	2E04(a)				
Mn-54	1E03		3E04		
Fe-59	4E02		1E04		
Co-58	1E03		3E04		
Co-60	3E02		1E04		
Zn-65	3E02		2E04		
Zr-Nb-95	4E02				
I-131	2(b)	0.9		3	1E02
Cs-134	30	10	1E03	60	1E03
Cs-137	50	20	2E03	70	2E03
Ba-La-140	2E02			3E02	

- (a) For drinking water samples. This is 40 CFR Part 141 value.
- (b) If low level I-131 analyses are performed.
- (c) Report shall be submitted when any single radionuclide exceeds the reporting level in Table 16.11.6-3 or when more than one of the radionuclides in Table 16.11.6-3 are detected in sampling medium and
- $$\frac{\text{concentration (1)}}{\text{reporting level (1)}} + \frac{\text{concentration (2)}}{\text{reporting level (2)}} + \dots \geq 1.0$$
- (d) Report shall be submitted when radionuclides other than those in table 16.11.6-3 are detected and are the result of plant effluents if the potential annual dose to a MEMBER OF THE PUBLIC from all radionuclides is equal to or greater than the calendar year limits of SLC 16.11.1 or 16.11.2.

BASES

The environmental monitoring program required by this commitment provides measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides which lead to the highest potential radiation exposures of individuals resulting from the station operation. This monitoring program thereby supplements the radiological effluent monitoring program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and modeling of exposure pathways. The initially specified monitoring program will be effective for at least the first three years of commercial operation. Following this period, program changes may be initiated based on operational experience.

The detection capabilities required by Table 16.11.6-2 are considered optimum for routine environmental measurements in industrial laboratories. The specified lower limits of detection correspond to less than the 10 CFR 50. Appendix I, design objective dose-equivalent of 45 mrem/year for atmospheric releases to the most sensitive organ and individual. The land use census commitment is provided to assure that changes in the use of unrestricted areas are identified and that modifications to the monitoring program are provided if required by the results of this census.

The requirements for participation in an Interlaboratory Comparison Program is provided to assure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of a quality assurance program for environmental monitoring in order to demonstrate that the results are reasonably valid.

With the level of radioactivity in an environmental sampling medium at a specified location exceeding the reporting levels of Table 16.11.6-3 when averaged over any calendar quarter, in lieu of a Licensee Event Report, prepare and submit to the Commission within 30 days a Special Report that defines the corrective action 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 SLC 16.11.1 or SLC 16.11.2. When more than one of the radionuclides in Table 16.11.6-3 are detected in the sampling medium, this report shall be submitted if

$$\frac{\text{concentration (1)}}{\text{reporting level (1)}} + \frac{\text{concentration (2)}}{\text{reporting level (2)}} + \dots \geq 1.0$$

When radionuclides other than those in Table 16.11.6-3 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 from all radionuclides is equal to or greater than the calendar year limits of SLC 16.11.1 or SLC 16.11.2. 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 Operating Report required by Technical Specification 5.6.2. The methodology and parameters used to estimate the potential annual dose to a MEMBER OF THE PUBLIC shall be indicated in the 30-day Special Report.

The following requirement(s) were relocated from the CTS 6.4.4.f during the conversion to ITS.

The station shall have a program to monitor the radiation and radionuclides in the environs of the plant. The program shall provide (1) representative measurements of radioactivity in the highest potential exposure pathways, and (2) verification of the accuracy of the effluent monitoring program and modeling of environmental exposure pathways. The program shall (1) be contained in UFSAR Chapter 16, (2) conform to the guidance of Appendix I to 10 CFR Part 50, and (3) include the following:

1. Monitoring, sampling, analysis, and reporting of radiation and radionuclides in the environment in accordance with the methodology and parameters in the ODCM;
2. A Land Use Census to ensure that changes in the use of areas at and beyond the SITE BOUNDARY are identified and that modifications to the monitoring program are made if required by the results of this census; and,
3. Participation in an Interlaboratory Comparison Program to ensure that independent checks on the precision and accuracy of the measurements of radioactive materials in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring.

REFERENCES:

1. 10 CFR Part 50, Appendix I.
2. Offsite Dose Calculation Manual.

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.7 Dose Calculations

COMMITMENT The annual (calendar year) dose or dose commitment, to any Member of the Public due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to ≤ 25 mrems to the total body or to any organ, except the thyroid, which shall be limited to ≤ 75 mrems.

APPLICABILITY: At all times

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. Calculated doses from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of SLC 16.11.1.b, SLC 16.11.2.b.1, or SLC 16.11.2.b.2</p>	<p>A.1 Determine by calculation, including direct radiation contributions from the reactor units and from outside storage tanks, whether the limits of Commitment 16.11.7 have been exceeded.</p>	<p>None</p>

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>B. Calculated dose exceeds limits of Commitment 16.11.7.</p>	<p>-----NOTE----- This Special Report, as defined in 10 CFR Part 20.2203(a), shall include an analysis that estimates the radiation exposure (dose) to a Member of the Public from uranium fuel cycle sources, (including all effluent pathways and direct radiation), for the calendar year that includes the release(s) covered by this report. It shall also describe the levels of radiation and concentration of radioactive material involved, and the cause of the exposure levels or concentrations.</p> <p>-----</p> <p>B.1 Prepare and submit to the Commission a Special Report that defines the corrective action to be taken to reduce subsequent releases to prevent recurrence of exceeding the specified limits and includes the schedule for achieving conformance with the specified limits.</p>	<p>30 days</p>

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>C. Calculated dose exceeds limit of Commitment 16.11.7.</p> <p><u>AND</u></p> <p>Release condition resulting in violation of 40 CFR 190 not corrected at time of report submittal.</p>	<p>C.1</p> <p>-----NOTE----- Submittal of the report is considered a timely request, and a variance is granted until staff action on the request is complete. -----</p> <p>Include a request for a variance in accordance with the provisions of 40 CFR Part 190.</p>	<p>30 days from exceeding the limit</p>

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
<p>SR 16.11.7.1 Determine cumulative dose contributions from liquid effluents in accordance with Offsite Dose Calculation Manual.</p>	<p>31 days</p>
<p>SR 16.11.7.2 Determine cumulative dose contributions from gaseous effluents in accordance with Offsite Dose Calculation Manual.</p>	<p>31 days</p>

BASES

The dose commitment is provided to assure that the release of radioactive material in liquid and gaseous effluents will be kept "as low as is reasonably achievable." The dose calculations in the ODCM implement the requirements in Section III.A of Appendix I in that conformance with the guides of Appendix I is to be shown by calculations and procedures based on models and data such that the actual exposure of an individual through appropriate pathways is unlikely to be substantially underestimated.

REFERENCES:

1. 10 CFR Part 20.
2. 40 CFR Part 190.
3. Offsite Dose Calculation Manual.
4. 10 CFR Part 50, Appendix I.

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.8 Reports

COMMITMENT Special reports shall be submitted to the Regional Administrator, Region II, within the time period specified for each report. These reports shall be submitted covering the activities identified below pursuant to the requirements of the applicable SLC:

- a. Radioactive Liquid Effluents,
Dose, SLC 16.11.1.b
Liquid Waste Treatment, SLC 16.11.1.c
- b. Radioactive Gaseous Effluents,
Dose, SLC 16.11.2.b
Gaseous Radwaste Treatment, SLC 16.11.2.c
- c. Radiological Environmental Monitoring Program, SLC 16.11.6.a, b,
and c
- d. Land Use Census, SLC 16.11.6.d
- e. Dose Calculations, SLC 16.11.7

APPLICABILITY: At all times.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Individual milk samples show I-131 concentrations of 10 picocuries per liter or greater.	A.1 Submit plan advising the NRC of the proposed action to ensure the plant related annual doses will be within the design objective of 45 mrem/yr to the thyroid of any individual.	7 days

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. Milk samples collected over a calendar quarter show I-131 average concentrations of 4.8 picoCuries per liter or greater	B.1 Submit a plan advising the NRC of the proposed action to ensure the plant related annual doses will be within the design objective of 45 mrem/yr to the thyroid of any individual.	30 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 16.11.8.1 NA	NA

BASES

Reference applicable commitments.

REFERENCES:

1. 10 CFR Part 20.
2. 40 CFR Part 190.
3. Offsite Dose Calculation Manual.

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.9 Radioactive Effluent Release Report

COMMITMENT The Annual Radioactive Effluent Release Report covering the operation of the unit during the previous calendar year shall be submitted before May 1 of each year.

A single submittal may be made for a multiple unit station. The submittal shall combine those sections that are common to all units at the station; however, for units with separate radwaste systems, the submittal shall specify the release of radioactive material from each unit.

The Annual Radioactive Effluent Release Report shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the station during the reporting period.

The annual Radioactive Effluent Release Report shall include a summary of the meteorological conditions concurrent with the release of gaseous effluents during each quarter.

The Annual Radioactive Effluent Release Report shall include the following information for all unplanned releases to unrestricted areas of radioactive materials in gaseous and liquid effluents:

- a. A description of the event and equipment involved;
- b. Cause(s) for the unplanned release;
- c. Actions taken to prevent recurrence; and,
- d. Consequences of the unplanned release.

The Annual Radioactive Effluent Release Report shall include an assessment of radiation doses from the radioactive liquid and gaseous effluents released from the station during each calendar quarter. In addition, the unrestricted area boundary maximum noble gas gamma air and beta air doses shall be evaluated. The annual average meteorological conditions shall be used for determining the gaseous pathway doses. Approximate and conservative approximate methods are acceptable. The assessment of radiation doses shall be performed in accordance with the Offsite Dose Calculation Manual.

The Annual Radioactive Effluent Release Report shall include an explanation of why the inoperability of liquid or gaseous effluent monitoring instrumentation out of service for greater than 30 days was not corrected in a timely manner per SLC 16.11.3.

The Annual Radioactive Effluent Release Report shall include the following information for each type of solid waste shipped offsite during the report period:

- a. Total container volume (cubic meters);
- b. Total curie quantity (determined by measurement or estimate);
- c. Principal radionuclides (determined by measurement or estimate);
- d. Type of waste, (e.g., spent resin, compacted dry waste evaporator bottoms);
- e. Number of shipments; and,
- f. Solidification agent (e.g., cement, or other approved agents (media)).

The Annual Radioactive Effluent Release Report shall include a list and description of unplanned releases from the site to Unrestricted Areas of radioactive materials in gaseous and liquid effluents made during the reporting period.

The Annual Radioactive Effluent Release Report shall include any changes made during the reporting period to the Offsite Dose Calculation Manual (ODCM), as well as a listing of new locations for dose calculations and/or environmental monitoring identified by the land use census.

The Annual Radioactive Effluent Release Report shall also include an assessment of radiation doses to the likely most exposed Member of the Public from reactor releases and other nearby uranium fuel cycle sources (including doses from primary effluent pathways and direct radiation) for the previous calendar year to show conformance with 40 CFR 190, Environmental Radiation Protection Standards for Nuclear Power Operation. Methods for calculating the dose contribution from liquid and gaseous effluents are given in the ODCM.

APPLICABILITY: At all times.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. N/A	A.1 N/A	N/A

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 16.11.9.1 N/A	N/A

BASES

N/A

REFERENCES:

1. Oconee ITS.
2. Offsite Dose Calculation Manual.

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.10 Radiological Environmental Operating Report

COMMITMENT Routine Radiological Environmental Operating Reports covering the operation of the unit during the previous calendar year shall be submitted by May 15 of each year.

The Annual Radiological Environmental Operating Report shall include summaries, interpretations, and statistical evaluation of the results of the radiological environmental surveillance activities for the report period, including a comparison with preoperational studies, operational controls (as appropriate), and previous environmental surveillance reports and an assessment of the observed impacts of the plant operation on the environment. The reports shall also include the results of the land use censuses. If harmful effects are detected by the monitoring, the report shall provide an analysis of the problem and a planned course of action to alleviate the problem.

The Annual Radiological Environmental Operating Report shall include a summary of the results obtained as part of the required Interlaboratory Comparison Program. The Interlaboratory Comparison Program shall be described in the Annual Radiological Environmental Operating Report.

The Annual Radiological Environmental Operating Report shall include summarized and tabulated results of the radiological environmental samples required by SLCs taken during the report period. In the event that some results are not available for inclusion with the report, the report shall be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted as soon as practical in a supplementary report.

The initial report shall also include the following: a summary description of the radiological environmental monitoring program including sampling methods for each sample type, size and physical characteristics of each sample type, sample preparation methods, analytical methods, and measuring equipment used; a map of all sampling locations keyed to a table giving distances and directions from one reactor; and, the result of land use censuses. Subsequent reports shall describe all substantial changes in these aspects.

APPLICABILITY: At all times.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. NA	A.1 NA	NA

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 16.11.10.1 NA	NA

BASES

NA

REFERENCES:

1. Oconee ITS
2. Offsite Dose Calculation Manual

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.11 Iodine Radiation Monitoring Filters

COMMITMENT Assure that the iodine radiation monitoring filters perform their intended function.

APPLICABILITY: At all times.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. NA	A.1 NA	NA

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 16.11.11.1 Remove and replace iodine radiation monitoring filters in RIA-44.	30 days of operation
SR 16.11.11.2 Discard spare iodine radiation monitoring filters.	After manufacturer expiration date.

BASES

The purpose of this commitment is to assure the reliability of the iodine radiation monitoring charcoal filters. Plant procedures prevent the use of spare filters after the manufacturer expiration date.

REFERENCES:

1. Oconee CTS Amendment No. 3/3 SER date July, 1974.

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.12 Radioactive Material in Outside Temporary Tanks Exceeding Limit

COMMITMENT The quantity of radioactive material in outside temporary storage tanks shall not exceed the limit specified in ITS 5.5.13.c.

APPLICABILITY: At all times.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. The quantity of radioactive material in outside temporary storage tank not within limit.	A.1 Suspend addition of radioactive material to tank.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 16.11.12.1 Verify the quantity of radioactive material contained in each of the outside temporary tanks is within the limit by analyzing a representative sample of the tanks' contents. <u>OR</u> Verify the quantity of radioactive material in each of the outside temporary tanks does not result in exceeding the limit by analyzing a representative sample of radioactive material to be added.	Within 7 days after addition of radioactive materials to an outside temporary tank Prior to addition of radioactive materials to an outside temporary tank.

BASES

The requirement(s) of this SLC section were relocated from CTS 3.9.1.c during the conversion to ITS.

The tanks included in this specification are all those outdoor radwaste liquid storage tanks that are not surrounded by liners, dikes, or walls capable of holding the tank contents and that do not have tank overflows and surrounding area drains connected to the liquid radwaste treatment system. Restricting the quantity of radioactive material contained in the specified tanks provides assurance that in the event of an uncontrolled release of a tank's contents, the resulting concentrations would be less than the limits of 10CFR Part 20, Appendix B, Table II, Column 2, at the nearest potable water supply and the nearest surface water supply in an UNRESTRICTED AREA.

REFERENCES

N/A

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.13 Radioactive Material in Waste Gas Holdup Tank Exceeding Limit

COMMITMENT The quantity of radioactive material in the Waste Gas Holdup tanks shall not exceed the limit specified in ITS 5.5.13.b.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

Separate Condition Entry is allowed for each tank.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. The quantity of radioactive material in the Waste Gas Holdup tank not within limit.	A.1 Suspend addition of radioactive material to tank.	Immediately
	<u>AND</u>	
	A.2 Reduce tank contents to within limit.	48 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 16.11.13.1 Verify quantity of radioactive materials in each tank is within limit.	24 hours when tank is being filled

BASES

The requirement(s) of this SLC section were relocated from CTS 3.10.1.b and 3.10.1.c during the conversion to ITS.

Restricting the quantity of radioactivity contained in each waste gas holdup tank provides assurance that in the event of an uncontrolled release of the tank contents, the resulting total body exposure to an individual at the exclusion area boundary will not exceed 0.5 rem.

REFERENCE

UFSAR, Section 15.10

16.11 RADIOLOGICAL EFFLUENTS CONTROL

16.11.14 Explosive Gas Mixture

COMMITMENT The concentration of Hydrogen in the Waste Gas Holdup Tanks shall be \leq 3% by volume.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----
Separate Condition Entry is allowed for each tank.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Concentration of Hydrogen in Waste Gas Holdup tank is $>$ 3% and \leq 4% by volume.	A.1 Reduce Concentration of Hydrogen to within limit.	48 hours
B. Concentration of Hydrogen in Waste Gas Holdup tank is $>$ 4% by volume.	B.1 Suspend addition of waste gases to tank.	Immediately
	AND B.2 Reduce Concentration of Hydrogen to within limit.	24 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 16.11.14.1 Verify Hydrogen concentration in Waste Gas Holdup Tank is $\leq 3\%$ by volume.	5 times/week on each tank when in service <u>AND</u> once within 24 hours after isolation of the tank

BASES

The requirement(s) of this SLC section were relocated from CTS 3.10.2 and Table 4.1-3, Item 13 during the conversion to ITS.

This Commitment is provided to ensure that the concentration of potentially explosive gas mixtures contained in the Waste Gas Holdup Tanks is maintained below the flammability limits of hydrogen. (Administrative controls are used to prevent the hydrogen concentrations from reaching the flammability limit.) These controls include sampling each tank 5 times a week while in service, and/or once in 24 hours after isolation of the tank; injection of dilutants to reduce the concentration of hydrogen below its flammability limits provides assurance that the releases of radioactive material will be controlled in conformance with the requirements of GDC 60 of Appendix A to CFR Part 50.

REFERENCES

N/A

Attachment 10
Summary of Changes to the Process Control Program

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 10

Summary of Changes to the Process Control Program

This attachment includes a summary of changes to the PCP.

Attachment 10
Summary of Changes to the Process Control Program

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

The Oconee Nuclear Station PCP was not revised in 2019. The most recent revision was provided with the Oconee Nuclear Station 2018 ARERR.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 11

Summary of Major Modifications to the Radioactive Waste Treatment Systems

This attachment includes a description of major modifications to the radioactive waste treatment systems that are anticipated to affect effluent releases.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

No major modifications to Oconee Nuclear Station liquid, gaseous, solid, or mobile radioactive waste treatment systems occurred in 2019.

Attachment 12
Errata to a Previous Year's ARERR

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

ATTACHMENT 12

Errata to a Previous Year's ARERR

This attachment includes any amended pages from a previous year's ARERR.

Attachment 12
Errata to a Previous Year's ARERR

Oconee Nuclear Station Units 1, 2, & 3
Period 1/1/2019 - 12/31/2019

There are no changes to a previous year's ARERR.

Enclosure 6
RA-20-0078

ENCLOSURE 6: [RNP Annual Radioactive Effluent Release Report](#)



H.B. Robinson Steam Electric Plant Unit 2

Annual Radioactive Effluent Release Report

January 1, 2019 through December 31, 2019

Docket 50-261



Introduction

The Annual Radioactive Effluent Release Report is pursuant to H.B. Robinson Steam Electric Plant Technical Specification 5.6.3 and ODCM 9.1. The below listed attachments to this report provide the required information. In addition, the ODCM is included pursuant to H.B. Robinson Steam Electric Plant Technical Specification 5.5.1.

- Attachment 1 Summary of Gaseous and Liquid Effluents
- Attachment 2 Supplemental Information
- Attachment 3 Solid Radioactive Waste Disposal
- Attachment 4 Meteorological Data
- Attachment 5 Unplanned Offsite Releases
- Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public
- Attachment 7 Information to Support the NEI Ground Water Protection Initiative
- Attachment 8 Inoperable Equipment
- Attachment 9 Summary of Changes to the Offsite Dose Calculation Manual
- Attachment 10 Summary of Changes to the Process Control Program
- Attachment 11 Summary of Major Modifications to the Radioactive Waste Treatment Systems
- Attachment 12 Errata to a Previous Year's ARERR

Attachment 1
Summary of Gaseous and Liquid Effluents

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 1

Summary of Gaseous and Liquid Effluents

This attachment includes a summary of the quantities of radioactive liquid and gaseous effluents as outlined in Regulatory Guide 1.21, Appendix B.

Attachment 1
Summary of Gaseous and Liquid Effluents

H.B. Robinson Steam Electric Plant Unit 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
1. Total Release	Ci	3.50E-02	3.72E-02	5.64E-02	3.46E-02	1.63E-01
2. Avg. Release Rate	μCi/sec	4.50E-03	4.73E-03	7.10E-03	4.35E-02	1.50E-02
B. Iodine-131						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	μCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life ≥ 8 days						
1. Total Release	Ci	0.00E+00	0.00E+00	4.92E-08	0.00E+00	4.92E-08
2. Avg. Release Rate	μCi/sec	0.00E+00	0.00E+00	6.19E-09	0.00E+00	1.55E-09
D. Tritium						
1. Total Release	Ci	3.02E+00	3.24E+00	1.67E+01	3.10E+00	2.61E+01
2. Avg. Release Rate	μCi/sec	3.88E-01	4.12E-01	2.10E+00	3.91E-01	8.23E-01
E. Carbon-14						
1. Total Release	Ci	2.10E+00	2.12E+00	2.14E+00	2.14E+00	8.50E+00
2. Avg. Release Rate	μCi/sec	2.66E-01	2.69E-01	2.71E-01	2.71E-01	2.69E-01
F. Gross Alpha						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Release Rate	μCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Attachment 1
Summary of Gaseous and Liquid Effluents**

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Elevated Releases - Continuous Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life \geq 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* H.B. Robinson Steam Electric Plant Unit 2 does not have elevated releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

H.B. Robinson Steam Electric Plant Unit 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Elevated Releases - Batch Mode *

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
B. Iodines						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
C. Particulates Half-Life \geq 8 days						
N/A	Ci	-	-	-	-	-
Total for Period	Ci	-	-	-	-	-
D. Tritium						
N/A	Ci	-	-	-	-	-
E. Carbon-14						
N/A	Ci	-	-	-	-	-
F. Gross Alpha						
Total for Period	Ci	-	-	-	-	-

* H.B. Robinson Steam Electric Plant Unit 2 does not have elevated releases.

Attachment 1
Summary of Gaseous and Liquid Effluents

H.B. Robinson Steam Electric Plant Unit 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground & Mixed-Mode Releases - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
Xe-133	Ci	0.00E+00	0.00E+00	3.24E-02	0.00E+00	3.24E-02
Total for Period	Ci	0.00E+00	0.00E+00	3.24E-02	0.00E+00	3.24E-02
B. Iodines						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life \geq 8 days						
Co-58	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Tritium						
H-3	Ci	3.00E+00	3.15E+00	1.64E+00	3.03E+00	1.08E+01
E. Carbon-14						
C-14	Ci	1.29E+00	1.31E+00	1.32E+00	1.32E+00	5.24E+00
F. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

H.B. Robinson Steam Electric Plant Unit 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents - Ground & Mixed Mode Releases - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Gases						
Ar-41	Ci	3.50E-02	3.64E-02	2.36E-02	3.46E-02	1.30E-01
Xe-133	Ci	0.00E+00	7.55E-04	4.27E-04	0.00E+00	1.18E-03
Xe-135	Ci	0.00E+00	5.04E-06	0.00E+00	0.00E+00	5.04E-06
Total for Period	Ci	3.50E-02	3.72E-02	2.40E-02	3.46E-02	1.31E-01
B. -Iodines						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Particulates Half-Life ≥ 8 days						
Co-58	Ci	0.00E+00	0.00E+00	4.92E-08	0.00E+00	4.92E-08
Total for Period	Ci	0.00E+00	0.00E+00	4.92E-08	0.00E+00	4.92E-08
D. Tritium						
H-3	Ci	2.19E-02	9.16E-02	3.46E-01	7.75E-02	5.37E-01
E. Carbon-14						
C-14	Ci	8.04E-01	8.13E-01	8.22E-01	8.22E-01	3.26E+00
F. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Summation of All Releases

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products *						
1. Total Release	Ci	1.04E-03	1.30E-03	1.95E-03	8.67E-04	5.16E-03
2. Avg. Diluted Conc.	µCi/ml	4.31E-12	4.96E-12	7.05E-12	3.24E-12	4.89E-12
B. Tritium						
1. Total Release	Ci	5.54E+00	2.84E+00	1.75E+02	1.01E+02	2.84E+02
2. Avg. Diluted Conc.	µCi/ml	2.30E-08	1.08E-08	6.33E-08	3.77E-07	1.19E-07
C. Dissolved & Entrained Gases						
1. Total Release	Ci	5.93E-06	0.00E+00	1.56E-05	0.00E+00	2.15E-05
2. Avg. Diluted Conc.	µCi/ml	2.46E-14	0.00E+00	5.65E-14	0.00E+00	2.03E-14
D. Gross Alpha						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Avg. Diluted Conc.	µCi/ml	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E. Volume of Liquid Waste						
1. Total	liters	1.69E+05	4.35E+04	3.94E+05	2.05E+05	8.12E+05
F. Volume of Dilution Water						
1. Total	liters	2.41E+11	2.62E+11	2.77E+11	2.67E+11	1.05E+12

* Excludes tritium, dissolved and entrained noble gases, and gross alpha.

**Attachment 1
Summary of Gaseous and Liquid Effluents**

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Liquid Effluents - Continuous Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
B. Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C. Dissolved & Entrained Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
D. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Attachment 1
Summary of Gaseous and Liquid Effluents

H.B. Robinson Steam Electric Plant Unit 2
 Period 1/1/2019 - 12/31/2019

Liquid Effluents - Batch Mode

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Fission and Activation Products						
Fe-55	Ci	9.41E-05	4.96E-04	1.12E-03	6.21E-04	2.33E-03
Co-57	Ci	1.51E-06	9.91E-06	6.18E-06	0.00E+00	1.76E-05
Co-58	Ci	4.15E-04	4.93E-04	2.84E-04	1.74E-04	1.37E-03
Co-60	Ci	4.90E-05	1.26E-04	1.45E-04	2.01E-05	3.40E-04
Ni-63	Ci	1.70E-04	1.32E-04	3.40E-04	4.90E-05	6.91E-04
Sn-117m	Ci	1.34E-05	5.05E-07	1.64E-06	0.00E+00	1.55E-05
Sb-124	Ci	3.83E-05	0.00E+00	0.00E+00	0.00E+00	3.83E-05
Sb-125	Ci	2.45E-04	3.76E-05	4.52E-05	3.51E-06	3.31E-04
Te-123m	Ci	1.37E-05	5.18E-07	1.68E-06	0.00E+00	1.59E-05
Te-131m	Ci	0.00E+00	0.00E+00	2.81E-06	0.00E+00	2.81E-06
Total for Period	Ci	1.04E-03	1.30E-03	1.95E-03	8.68E-04	5.15E-03
B. Tritium						
H-3	Ci	5.54E+00	2.84E+00	1.75E+02	1.01E+02	2.84E+02
C. Dissolved & Entrained Gases						
Xe-133	Ci	5.93E-06	0.00E+00	1.56E-05	0.00E+00	2.15E-05
Total for Period	Ci	5.93E-06	0.00E+00	1.56E-05	0.00E+00	2.15E-05
D. Gross Alpha						
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Attachment 2
Supplemental Information**

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 2

Supplemental Information

This attachment includes supplemental information to the gaseous and liquid effluents report.

Attachment 2 Supplemental Information

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

I. Regulatory Limits - Per Unit

A. Noble Gases - Air Dose

1. Calendar Quarter Gamma Dose	= 5	mRAD
2. Calendar Quarter Beta Dose	= 10	mRAD
3. Calendar Year Gamma Dose	= 10	mRAD
4. Calendar Year Beta Dose	= 20	mRAD

B. Liquid Effluents – Dose

1. Calendar Quarter Total Body Dose	= 1.5	mREM
2. Calendar Quarter Organ Dose	= 5	mREM
3. Calendar Year Total Body Dose	= 3	mREM
4. Calendar Year Organ Dose	= 10	mREM

C. Gaseous Effluents - Iodine-131 & 133, Tritium, and Particulates with Half-lives > 8 days

1. Calendar Quarter Organ Dose	= 7.5	mREM
2. Calendar Year Organ Dose	= 15	mREM

II. Maximum Permissible Effluent Concentrations

A. Gaseous Effluents

- Information found in Offsite Dose Calculation Manual

B. Liquid Effluents

- Information found in 10 CFR Part 20, Appendix B, Table 2, Column 2

III. Average Energy

(not applicable)

IV. Measurements and Approximations of Total Radioactivity

Analyses of specific radionuclides in selected or composited samples as described in the ODCM are used to determine the radionuclide composition of the effluent. A summary description of the method used for estimating overall errors associated with radioactivity measurements is provided as part of this attachment.

V. Batch Releases

A. Liquid Effluents

		Jan - Jun	Jul - Dec
1. Total Number of Batch Releases	=	8	23
2. Total Time (min) for Batch Releases	=	1.51E+03	4.40E+03
3. Maximum Time (min) for a Batch Release	=	2.24E+02	2.46E+02
4. Average Time (min) for Batch Releases	=	1.89E+02	1.91E+02
5. Minimum Time (min) for a Batch Release	=	8.70E+01	9.60E+01
6. Average Dilution Water Flow During Release (gpm)	=	4.00E+05	3.93E+05

B. Gaseous Effluents

		Jan - Jun	Jul - Dec
1. Total Number of Batch Releases	=	47	44
2. Total Time (min) for Batch Releases	=	1.71E+04	2.69E+04
3. Maximum Time (min) for a Batch Release	=	1.36E+03	1.03E+04
4. Average Time (min) for Batch Releases	=	3.63E+02	6.12E+02
5. Minimum Time (min) for a Batch Release	=	3.40E+01	2.40E+01

VI. Abnormal Releases

See Attachment 5, Unplanned Offsite Releases.

Attachment 2 Supplemental Information

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Carbon-14

Carbon-14 (C-14), with a half-life of 5730 years, is a naturally occurring isotope of carbon produced by cosmic ray interactions in the atmosphere. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. C-14 is also produced in commercial nuclear reactors, but the amounts produced are much less than those produced naturally or from weapons testing.

In Regulatory Guide 1.21, Revision 2, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste", the NRC recommends U.S. nuclear power plants evaluate whether C-14 is a "principal radionuclide", and if so, report the amount of C-14 released. Improvements over the years in effluent management practices and fuel performance have resulted in a decrease in gaseous radionuclide (non-C-14) concentrations, and a change in the distribution of gaseous radionuclides released to the environment. As a result, many sites show C-14 has become a "principal radionuclide" for the gaseous effluent pathway, as defined in Regulatory Guide 1.21, Rev. 2. H.B. Robinson Steam Electric Plant 2019 ARERR contains estimates of C-14 radioactivity released in 2019, and estimates of public dose resulting from the C-14 effluent.

Because the dose contribution of C-14 from liquid radioactive waste is much less than that contributed by gaseous radioactive waste, evaluation of C-14 in liquid radioactive waste is not required (Ref. Reg. Guide 1.21, Rev. 2). The quantity of gaseous C-14 released to the environment can be estimated by use of a C-14 source term scaling factor based on power generation (Ref. Reg. Guide 1.21, Rev. 2). Many documents provide information related to the magnitude of C-14 in typical effluents from commercial nuclear power plants. Those documents suggest that nominal annual releases of C-14 in gaseous effluents are approximately 5 to 7.3 curies from PWRs (Ref. Reg. Guide 1.21, Rev. 2). A more recent study recommends a higher C-14 gaseous source term scaling factor of approximately 9.0 to 9.8 Ci/GWe-yr for a PWR (Westinghouse) (Ref. EPRI 1021106). The H.B. Robinson Steam Electric Plant ODCM states the expected C-14 generation to be 7.3 Curies assuming 292 effective full power days (EFPD) in a calendar year. 2.8 of the 7.3 Curies are released in batch mode from the Containment building and Waste Gas Decay Tanks. The remaining 4.5 Curies are released in continuous mode from the Auxiliary and Fuel Handling buildings. The total C-14 activity released compares favorably with more recent studies. For the H.B. Robinson Steam Electric Plant 2019 ARERR, a source term scaling factor using actual EFPD of 340.173 days is assumed. Using the source term scaling factor from H.B. Robinson Steam Electric Plant in 2019 results in a site total C-14 gaseous release estimate to the environment of 8.50 Curies, 3.26 Curies in batch mode and 5.24 Curies in continuous mode.

C-14 releases in PWRs occur primarily as a mix of organic carbon and carbon dioxide released from the waste gas system. Since the PWR operates with a reducing chemistry, most, if not all, of the C-14 species initially produced are organic (e.g., methane). As a general rule, C-14 in the primary coolant is essentially all organic with a large fraction as a gaseous species. Any time the RCS liquid or gas is exposed to an oxidizing environment (e.g. during shutdown or refueling), a slow transformation from an organic to an inorganic chemical form can occur. Various studies documenting measured C-14 releases from PWRs suggest a range of 70% to 95% organic with an average of 80% organic with the remainder being CO₂ (Ref. EPRI TR-105715). For the H.B. Robinson Steam Electric Plant 2019 ARERR a value of 70% organic C-14 is assumed.

Public dose estimates from airborne C-14 are performed using dose models in and Regulatory Guide 1.109. The dose models and assumptions used are documented in the H.B. Robinson Steam Electric Plant ODCM. The estimated C-14 dose impact on the maximum organ dose from airborne effluents released from H.B. Robinson Steam Electric Plant in 2019 is well below the 10CFR50, Appendix I, ALARA design objective (i.e., 15 mrem/yr per unit).

Attachment 2 Supplemental Information

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Dose from Evaporation of Lake Robinson

Evaporation of water containing tritium in Lake Robinson creates an exposure pathway to a member of the public. Murray and Trettle, Inc. was contracted to perform an evaluation of the dose to a member of the public from evaporation of tritium in Lake Robinson. Results of the evaluation are contained in report "*Impact of Tritium Release from Lake Robinson at the Robinson Nuclear Plant for 2019*". Using the methodology described in ODCM 2.5.3, the following is a summary of tritium activity released through evaporation and resulting dose for 2019.

	<u>Units</u>	<u>Year</u>
1. H-3 Activity Released	Ci	3.17E+01
2. H-3 Dose	mREM	2.04E-01

Receptor Location **6.38 km N**
Critical Age **CHILD**
Critical Organ **N/A ***

Tritium in Fish from Lake Robinson

Concentrations of radionuclides used in this specific fish consumption pathway are determined by averaging the monthly concentrations detected in environmental location (REMP) SW-40. In 2019, no plant related gamma emitting radionuclides were detected. Since tritium is consistently detected in Lake Robinson REMP samples, tritium concentration in the fish is assumed to be in equilibrium with Lake Robinson. Using the methodology and data described in NRC Regulatory Guide 1.109, Rev.1, October 1977, Equation A-1, Table E-5, and Table E-11, the following is a summary of average concentration consumed and resulting dose for 2019.

	<u>Units</u>	<u>Year</u>
1. Avg. H-3 Concentration	pCi/L	2.56E+03
2. H-3 Dose	mREM	5.64E-03

Critical Age **ADULT**
Critical Organ **N/A ***

* The dose factor for H-3 is the same for all organs and Total Body (with the exception of Bone, which is 0.00E+00).

**Attachment 2
Supplemental Information**

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Overall Estimate of Error for Effluent Radioactivity Release Reported

The estimated percentage of overall error for both Liquid and Gaseous effluent release data at H.B. Robinson Steam Electric Plant has been determined to be $\pm 30.3\%$. This value was derived by taking the square root of the sum of the squares of the following discrete individual estimates of error:

1. Flow Rate Determining Devices = $\pm 20\%$
2. Counting Statistical Error = $\pm 20\%$
3. Calibration Error = $\pm 10\%$
4. Calibration Source Error = $\pm 2.5\%$
5. Sample Preparation Error = $\pm 3\%$

Attachment 2 Supplemental Information

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Summary of Changes in Land Use Census Affecting Effluent Dose Calculations

The 2019 Land Use Census was performed July 17-18, 2019, and the results were certified and made available for use on August 18, 2019. The following are changes to residences, gardens, and milk animals from the previous year.

Residences

The residence in the NE sector (1.03 miles) at 1920 New Market Road from the 2018 census was replaced with a new residence (1.11 miles) at 1912 New Market Road. Nobody is living in 2018 residence at 1920 New Market Road.

Gardens

NOTE: There were no gardens within the 5-mile radius in any of the 16 meteorological sectors identified by the census as being irrigated from plant discharge water. Any of the irrigation sources identified by the census are from other sources; such as wells or public utilities.

The garden in the NNE sector (2.75 miles) was replaced with a new garden at 2.13 miles. This garden is in the second highest D/Q sector, and produces a greater than 20% dose difference from the 2018 RNP LUC.

The garden in the E sector (4.19 miles) was replaced with a new garden at 3.94 miles.

The garden in the SSE sector (2.61 miles) was replaced with a new garden at 2.56 miles.

The garden in the SSW sector (4.61 miles) was replaced with a new garden at 3.66 miles,

The garden in the SW sector (2.78 miles) was replaced with a new garden at 2.35 miles.

The garden in the NW sector (2.36 miles) was replaced with a new garden at 2.58 miles. This is a farm that sells fruits and vegetables, but the GPS reading was taken at the southernmost garden closest to the plant.

A new garden was found in the NNW sector at 2.85 miles. This is the same garden found in the NW sector, because it is present in both sectors,

Meat Animals

NOTE: Meat animals were only identified at the nearest garden or closer in each sector.

There were no meat animals found during the 2018 census in the E sector at or closer than the nearest garden; however, the 2019 census identified a meat animal in the E sector (3.02 miles).

The meat animal in the SE sector (1.96 miles) was no longer present and a replacement could not be found at or closer than the nearest garden in the SE sector.

Milk Animals

No milk animals (cows or goats) were identified in the 5-mile radius in any of the 16 meteorological sectors by the 2019 census.

Environmental Monitoring Locations

No changes to environmental monitoring locations in each sector.

Attachment 3
Solid Radioactive Waste Disposal

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 3

Solid Radioactive Waste Disposal

This attachment includes a summary of the solid waste shipped off-site for burial and/or disposal, including:

- Container volume
- Total Curie content (specify whether determined by measurement or estimate)
- Principal Radionuclides
- Source/Type of waste
- Solidification agent or absorbent
- Type of shipping container
- Number of shipments
- Other relevant information as necessary

Attachment 3 Solid Radioactive Waste Disposal

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Type of Waste Shipped	Number of Shipments	Number of Containers	Waste Class	Container Type	Solidification Agent	Burial Volume (m ³)	Total Activity (Curies)
1. <u>Waste from Liquid Systems</u>							
a. Dewatered Secondary Resins	N/A	N/A	N/A	N/A	N/A	N/A	N/A
b. Dewatered Primary Resins	2	2	(1) A-S (1) B	(1) 8-120 Poly HIC (1) 8-120 Poly HIC	N/A	4.27	44.9
c. Evaporator Concentrates	N/A	N/A	N/A	N/A	N/A	N/A	N/A
d. Dewatered Mechanical Filters	3	7	A-U C	(7) Metal Drums (1) 12-160 Poly HIC	N/A	4.265	34.8
e. Dewatered Demineralizers	N/A	N/A	N/A	N/A	N/A	N/A	N/A
f. Solidified (cement) Acids, Oils, Sludge	N/A	N/A	N/A	N/A	N/A	N/A	N/A
g. <i>Other (add as necessary)</i>	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2. <u>Dry Solid Waste</u>							
a. Dry Active Waste (compacted)	8	11	A-U	20' Sealand	N/A	310.0	0.451
b. Dry Active Waste (non-compacted)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
c. Dry Active Waste (brokered)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
d. Irradiated Components (brokered)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
e. Sources for Disposal (brokered)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3. <u>Total Solid Waste</u>	13	20	N/A	N/A	N/A	318.535	79.7451

Attachment 3 Solid Radioactive Waste Disposal

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Type of Waste Shipped	Radionuclide	% Abundance
1. <u>Waste from Liquid Systems</u>		
a. Dewatered Secondary Resins	N/A	N/A
b. Dewatered Primary Resins	Ni-63	56.43
	Co-60	30.65
	Fe-55	8.08
	Co-58	2.38
	Mn-54	0.63
	Cs-137	0.54
	C-14	0.42
	Co-57	0.34
	Ni-59	0.33
	Zn-65	0.059
	H-3	0.043
	Ce-144	0.030
	Cs-134	0.026
	Sr-90	0.019
	Sb-125	0.018
	Pu-241	0.004
	Nb-95	0.003
	Tc-99	0.003
	I-129	0.0003
	Pu-238	0.0003
c. Evaporator Concentrates	N/A	N/A
d. Dewatered Mechanical Filters	Ni-63	50.41
	Fe-55	32.06
	Co-58	6.29
	Co-60	6.10
	C-14	1.81
	Nb-95	1.16
	H-3	0.78
	Zr-95	0.52
	Ag-110m	0.20
	Co-57	0.16
	Mn-54	0.16
	Ce-144	0.13
	Tc-99	0.077
	Cs-137	0.065
	Sb-125	0.036
	Cr-51	0.012
	I-129	0.0086
	Zn-65	0.0072
	Sn-113	0.0041
	Sr-90	0.0041
	Sb-124	0.0024
	Fe-99	0.0022
e. Dewatered Demineralizers	N/A	N/A
f. Solidified (cement) Acids, Oils, Sludge	N/A	N/A
g. <i>Other (add as necessary)</i>	N/A	N/A

Attachment 3
Solid Radioactive Waste Disposal

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

2.

a. Dry Active Waste (compacted)	Fe-55	35.49
	Co-58	18.83
	Co-60	11.26
	Ni-63	9.31
	Nb-95	8.04
	Tc-99	6.22
	H-3	5.63
	Zr-95	3.75
	C-14	0.342
	Mn-54	0.282
	Ce-144	0.255
	Ag-110m	0.235
	Cs-137	0.215
	Co-57	0.130
	I-129	0.014
Ag-108m	0.0002	
b. Dry Active Waste (non-compacted)	N/A	N/A
c. Dry Active Waste (brokered)	N/A	N/A
d. Irradiated Components	N/A	N/A
e. Sources (for Disposal)	N/A	N/A

**Attachment 4
Meteorological Data**

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 4

Meteorological Data

This attachment includes a summary of meteorological joint frequency distributions of wind speed, wind direction, and atmospheric stability (hours of occurrence).

Attachment 4 Meteorological Data

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (mph)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
A	0.75-3.50	0	0	2	0	3	8	4	3	3	3	3	0	0	0	0	
	3.51-7.50	4	4	13	13	10	18	32	27	41	48	64	24	8	3	2	1
	7.51-12.50	1	0	0	0	0	0	0	7	24	28	33	10	4	20	4	1
	12.51-18.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	0.75-3.50	0	1	6	15	16	17	9	3	3	4	4	2	1	0	0	0
	3.51-7.50	23	23	29	21	11	9	21	12	18	32	35	19	3	16	6	3
	7.51-12.50	5	2	0	0	0	0	0	5	6	15	12	0	4	2	4	3
	12.51-18.50	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C	0.75-3.50	5	9	13	16	28	26	12	14	4	7	2	6	4	1	0	4
	3.51-7.50	55	39	26	15	3	6	12	11	15	19	33	12	8	9	6	11
	7.51-12.50	17	3	0	0	0	0	0	4	8	21	12	2	0	3	5	4
	12.51-18.50	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D	0.75-3.50	51	82	104	102	81	66	74	53	60	36	41	42	30	16	17	20
	3.51-7.50	286	310	139	83	32	22	66	191	180	112	75	40	33	48	55	84
	7.51-12.50	148	60	1	1	0	1	1	36	48	59	35	7	13	10	25	53
	12.51-18.50	4	1	0	0	0	0	0	2	10	5	0	0	0	2	2	9
	18.51-25.00	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Attachment 4 Meteorological Data

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

Stability Class	Wind Speed (mph)	Hours of Occurrence															
		Sector															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
E	0.75-3.50	56	56	70	51	38	31	45	131	201	121	75	68	47	39	40	50
	3.51-7.50	51	39	26	20	5	3	10	143	133	98	62	46	25	23	84	122
	7.51-12.50	10	8	0	0	0	1	1	10	17	29	17	16	6	6	16	28
	12.51-18.50	0	0	0	0	0	0	0	1	1	1	1	0	0	0	3	3
	18.51-25.00	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F	0.75-3.50	32	20	14	6	9	5	19	57	88	69	63	71	50	40	75	71
	3.51-7.50	7	5	0	0	1	0	0	18	18	11	17	16	5	16	34	49
	7.51-12.50	0	0	0	0	0	0	0	4	7	5	5	3	2	0	4	0
	12.51-18.50	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	0.75-3.50	38	15	3	4	3	9	8	33	57	68	31	27	26	46	89	93
	3.51-7.50	3	0	0	0	0	0	0	4	6	1	2	4	1	2	8	9
	7.51-12.50	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
	12.51-18.50	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	18.51-25.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Attachment 5
Unplanned Offsite Releases

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 5

Unplanned Offsite Releases

This attachment includes a summary of the unplanned offsite releases of gaseous and liquid radioactive effluents.

Attachment 5
Unplanned Offsite Releases

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

H.B. Robinson Steam Electric Plant had zero (0) unplanned liquid release in 2019.

H.B. Robinson Steam Electric Plant had zero (0) unplanned gaseous release in 2019.

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 6

Assessment of Radiation Dose from Radioactive Effluents to Members of the Public
(includes fuel cycle dose calculation results)

This attachment includes an assessment of radiation doses to the maximum exposed member of the public due to radioactive liquid and gaseous effluents released from the site for each calendar quarter for the calendar year of the report as well as the total dose for the calendar year.

This attachment also includes an assessment of radiation doses to the maximum exposed member of the public from all uranium fuel cycle sources within 8 km of the site for the calendar year of this report to show conformance with 40 CFR Part 190.

Methods for calculating the dose contribution from liquid and gaseous effluents are given in the Offsite Dose Calculation Manual (ODCM).

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

H.B. Robinson Steam Electric Plant Unit 2
 Period 1/1/2019 - 12/31/2019

Gaseous Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Noble Gases						
1. Maximum Gamma Air	mRAD	8.34E-04	8.68E-04	5.91E-04	8.24E-04	3.12E-03
(a) Limit	mRAD	5.00	5.00	5.00	5.00	10.00
(b) % of Limit		1.67E-02	1.74E-02	1.18E-02	1.65E-02	3.12E-02
2. Maximum Beta Air	mRAD	2.94E-04	3.08E-04	2.86E-04	2.91E-04	1.18E-03
(a) Limit	mRAD	10	10	10	10	20
(b) % of Limit		2.94E-03	3.08E-03	2.86E-03	2.91E-03	5.90E-03

Receptor Location **0.42 km SSE**

B. Iodine, H-3, & Particulates						
1. Maximum Organ Dose	mREM	1.43E-01	1.44E-01	1.46E-01	1.46E-01	5.79E-01
(a) Limit	mREM	7.50	7.50	7.50	7.50	15.00
(b) % of Limit		1.91E+00	1.93E+00	1.95E+00	1.95E+00	3.86E+00

Receptor Location **0.42 km SSE**

Critical Age **CHILD**

Critical Organ **BONE**

Attachment 6
Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

H.B. Robinson Steam Electric Plant Unit 2
 Period 1/1/2019 - 12/31/2019

Liquid Effluents Dose Summary

	<u>Units</u>	<u>Qtr 1</u>	<u>Qtr 2</u>	<u>Qtr 3</u>	<u>Qtr 4</u>	<u>Year</u>
A. Batch & Continuous Mode						
1. Maximum Organ Dose	mREM	6.89E-07	8.90E-08	1.19E-05	5.64E-04	1.83E-05
(a) Limit	mREM	5.00	5.00	5.00	5.00	10.00
(b) % of Limit		1.38E-05	1.78E-06	2.39E-04	1.13E-03	1.83E-04
2. Maximum Total Body Dose	mREM	3.13E-07	4.02E-08	1.16E-05	5.54E-06	1.75E-05
(a) Limit	mREM	1.50	1.50	1.50	1.50	3.00
(b) % of Limit		2.08E-05	2.68E-06	7.77E-04	3.69E-04	5.85E-04

Critical Age **ADULT**
Critical Organ **GI-LLI**

Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

40 CFR Part 190 Uranium Fuel Cycle Dose Calculation Results

In accordance with the requirements of 40 CFR Part 190, the annual dose commitment to any member of the general public shall be calculated to assure that doses are limited to 25 millirems to the total body or any organ with the exception of the thyroid which is limited to 75 millirems. The fuel cycle dose assessment for H.B. Robinson Steam Electric Plant includes liquid and gaseous effluent dose contributions from H.B. Robinson Steam Electric Plant and direct and air-scatter dose from the onsite ISFSI. No other direct or air-scatter source or uranium fuel cycle facility contributes significantly to the maximum exposed individual. Included in the gaseous effluent dose below is the estimated dose contributed by Carbon-14 (Ref. Attachment 2, Supplemental Information, of this report for further information). Also included is dose from evaporation of H-3 in Lake Robinson and H-3 in fish from Lake Robinson. The combined dose to a maximum exposed individual from effluent releases, combined with the additional dose pathways, is below 40 CFR Part 190 limits as shown by the following summary.

Note: The 40 CFR Part 190 effluent dose analysis to the maximum exposed individual from liquid and gas releases does not include the dose from noble gases (i.e., total body and skin) due to the low significance compared to other dose pathways.

40 CFR Part 190 Effluent Dose Summary

A. Gaseous Effluent Dose	
1. Location	0.42 km SSE
2. Critical Age	CHILD
3. Critical Organ	BONE
4. Organ Dose (mREM)	5.79E-01
5. Total Body Dose (mREM)	4.74E-01
B. Liquid Effluent Dose	
1. Location	6.76 km NE
2. Critical Age	ADULT
3. Critical Organ	GI-LLI
4. Organ Dose (mREM)	1.83E-05
5. Total Body Dose (mREM)	1.75E-05
C. Lake Robinson Evaporation H-3 Dose*	
1. Location	6.38 km N
2. Critical Age	CHILD
3. Critical Organ	N/A
4. Organ Dose (mREM)	2.04E-01
5. Total Body Dose (mREM)	2.04E-01
D. H-3 in Fish from Lake Robinson*	
1. Location	Lake
2. Critical Age	ADULT
3. Critical Organ	N/A
4. Organ Dose (mREM)	5.64E-03
5. Total Body Dose (mREM)	5.64E-03

* = Ref. Attachment 2, Supplemental Information, of this report.

Attachment 6 Assessment of Radiation Dose from Radioactive Effluents to Members of the Public

H.B. Robinson Steam Electric Plant Unit 2 Period 1/1/2019 - 12/31/2019

Dose contributions from Carbon-14 in gaseous effluents have been determined from ODCM 3.16, Methodology for Carbon-14 Dose. The maximum dose rate to the nearest real individual from the release of Carbon-14 in batch and continuous gaseous effluents is conservatively calculated to be less than 5.96E-01 mrem/yr based on 8.50 Curies released in 2019 (Ref. Attachment 2, Supplemental Information, of this report).

Direct and air-scatter radiation dose contributions from the onsite ISFSI at H.B. Robinson Steam Electric Plant have been calculated and documented in the ISFSI Safety Analysis Report, Chapter 7 Radiation Protection, Revision 22. The dose rate to the maximum exposed individual from the ISFSI is conservatively calculated to be less than 5 mrem/yr.

The below excerpt from the H.B. Robinson Steam Electric Plant ISFSI Safety Analysis Report is provided to document the conclusion that the H.B. Robinson Steam Electric Plant ISFSI contributes less than 5 mrem/year to the maximum exposed individual.

7.6.2 ANALYSIS OF MULTIPLE CONTRIBUTION

An analysis of multiple contribution was performed in order to determine the radiological impact the ISFSI will impose on the population surrounding the HBR plant. This impact added to contributions made by other uranium cycle facilities were compared to the natural background radiation and the regulatory requirements of 40 CFR 190.

The maximally exposed member of the public would receive approximately 1.6 mrem per year from an ISFSI made up of a three-unit HSM (reference Figure 7.6.1). An ISFSI consisting of an eight-unit HSM would contribute approximately 4.3 mrem per year. This is a result of external radiation only; there are no gaseous, particulate, or liquid effluents associated with the normal operation of the ISFSI. It can be concluded that the actual exposure contribution from the ISFSI along with the total of all other uranium fuel cycle activities is within the regulatory limits set forth in 40CFR190.

Assessment of the actual dose from direct radiation is performed as part of the H.B. Robinson Steam Electric Plant REMP and reported in the AREOR. During 2019, the assessment of dose from direct radiation, performed as part of the REMP, demonstrated no measurable contribution above background attributable to H.B. Robinson Steam Electric Plant operations.

Total dose from liquid and gaseous effluents from H.B. Robinson Steam Electric Plant and the additional pathways listed in table above is conservatively estimated to be less than 6 mrem/yr for total body and organ. It is recognized summing dose for different organs and age groups is not entirely accurate. However, the sum of the organ and age specific doses will always be less than the sum of the maximums of each. Therefore, summing the maximum values of each provides the most conservative value to ensure compliance with 40 CFR 190. The dose from all pathways related to operation of H.B. Robinson Steam Electric Plant meets the 40 CFR Part 190 requirements of an annual dose commitment to any member of the general public of less than 25 mrem total body or any organ and 75 mrem to the thyroid.

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 7

Information to Support the NEI Ground Water Protection Initiative

This attachment includes a summary of voluntary reports made in accordance with the NEI Ground Water Protection Initiative and a summary of ground water well sample data.

Attachment 7 Information to Support the NEI Ground Water Protection Initiative

H.B. Robinson Steam Electric Plant Unit 2 Period 1/1/2019 - 12/31/2019

H.B. Robinson Steam Electric Plant has implemented a Ground Water Protection program in accordance with NEI 07-07. This initiative was developed to ensure timely and effective management of situations involving inadvertent releases of licensed material to ground water. As part of this program, H.B. Robinson Steam Electric Plant monitored 42 wells in 2019. 41 wells not sampled as part of the ODCM REMP are reported below. The remaining 1 well is sampled in accordance with the ODCM REMP and reported in the AREOR.

Wells are sampled quarterly. Ground water samples are analyzed for tritium and gamma emitters. No gamma, other than naturally occurring radionuclides, were identified in well samples during 2019. There were no anomalous results identified in 2019.

Results from sampling during 2019 are shown in the table below.

No events meeting the criteria for voluntary notification per NEI 07-07, Industry Ground Water Protection Initiative, occurred at H.B. Robinson Steam Electric Plant in 2019. No special dose calculations were performed as part of the Ground Water Protection program.

Key to below table.

NS	-	Not scheduled to be sampled, not sampled due to insufficient volume in well, or well inaccessible during outage.
pCi/l	-	picocuries per liter.
< MDA	-	less than minimum detectable activity, typically 250 pCi/l.
20,000 pCi/l	-	the Environmental Protection Agency drinking water standard for tritium. This standard applies only to water used for drinking.
1,000,000 pCi/l	-	the 10 CFR Part 20, Appendix B, Table 2, Column 2, Effluent Concentration Limit for tritium.

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

H.B. Robinson Steam Electric Plant Unit 2
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Well Name	Location / Description	Tritium Concentration (pCi/l)				# of Samples
		1st Qtr	2nd Qtr	3rd Qtr	4 th Qtr	
R42	Unit 1 North Deep Wells	NS	<MDA	NS	<MDA	2
R64	Artesian Well - 0.6 miles SE	<MDA	<MDA	<MDA	<MDA	4
R68	Well A - Between Unit 1 Switchyard and breakroom	NS	3.64E+02	NS	<MDA	2
R69	Well B - Behind the Training Building	NS	<MDA	NS	<MDA	2
R70	Well C - Between the O&M Building & Fab Shop	NS	<MDA	NS	<MDA	2
R72	MW-06 - 0.10 miles E - U/1 North Deep Well Pump	NS	<MDA	NS	<MDA	2
R73	MW-13 - 0.11 miles ENE - Near Discharge Canal	8.97E+02	1.35E+03	1.06E+03	9.48E+02	4
R75	PSW-02 - 0.05 miles NE - By U/1 boundary fence	NS	<MDA	NS	<MDA	2
R76	PSW-03 - 0.49 miles N - Northeast corner of the MET Tower Station	NS	<MDA	NS	<MDA	2
R77	TS-01B - 0.25 miles SSE - By entrance road to Unit 1	<MDA	<MDA	<MDA	<MDA	4
R78	TS-02C - 0.17 miles SSE - Northeast corner by East Settling Pond	NS	<MDA	NS	<MDA	2
R79	TS-07C - 1.0 miles N - South corner by cove & Discharge Canal	3.82E+02	3.17E+02	3.99E+02	3.01E+02	4
R81	TS-17B - 0.19 miles SSE - West of West Settling Pond	<MDA	<MDA	<MDA	<MDA	4
R82	PDW-01 - 0.30 miles SSE - By entrance road to Unit 1	NS	<MDA	NS	<MDA	2
RDW6	Robinson Deep Well #6	5.06E+02	4.97E+02	5.04E+02	4.67E+02	4
RMW07	MW-07 - Robinson Monitoring Well	NS	<MDA	NS	<MDA	2
RMW09	MW-09 - Robinson Monitoring Well	NS	<MDA	NS	<MDA	2
RMW-101D	MW-101D - Robinson Monitoring Well	2.84E+02	4.37E+02	3.35E+02	3.35E+02	4
RMW-101S	MW-101S - Robinson Monitoring Well	<MDA	<MDA	<MDA	<MDA	4
RMW-102	MW-102 - Robinson Monitoring Well	1.06E+03	3.63E+02	<MDA	1.05E+03	4
RMW-103D	MW-103D - Robinson Monitoring Well	3.51E+02	3.99E+02	2.56E+02	3.70E+02	4
RMW-103S	MW-103S - Robinson Monitoring Well	<MDA	<MDA	<MDA	<MDA	4
RMW-104	MW-104 - Robinson Monitoring Well	<MDA	<MDA	<MDA	<MDA	4
RMW-105	MW-105 - Robinson Monitoring Well	<MDA	<MDA	<MDA	<MDA	4
RMW-106	MW-106 - Robinson Monitoring Well	4.30E+03	2.90E+03	4.66E+03	<MDA	4
RMW-107	MW-107 - Robinson Monitoring Well	<MDA	<MDA	<MDA	<MDA	4
RMW-108	MW-108 - Robinson Monitoring Well	1.17E+03	8.71E+02	4.67E+02	5.15E+02	4
RMW-110	MW-110 - Robinson Monitoring Well	NS	NS	<MDA	<MDA	2
RMW-112	MW-112 - Robinson Monitoring Well	NS	NS	<MDA	<MDA	2
RMW1RASH	MW-1R (NPDES) ASH - Robinson	<MDA	<MDA	<MDA	<MDA	4
RMW2RASH	MW-2R (NPDES) ASH - Robinson	<MDA	<MDA	3.89E+02	<MDA	4
RMW3RASH	MW-3R (NPDES) ASH - Robinson	7.12E+02	5.77E+02	<MDA	4.21E+02	4
RMW4RASH	MW-4R (NPDES) ASH - Robinson	NS	<MDA	NS	<MDA	2
RMW5ASH	MW-5 (NPDES) ASH- Robinson	<MDA	3.94E+02	<MDA	<MDA	4
RMW6ASH	MW-6 (NPDES) ASH - Robinson	<MDA	<MDA	<MDA	<MDA	4
RMW7ASH	MW-7 (NPDES) ASH - Robinson	<MDA	<MDA	<MDA	<MDA	4
RP1	P1 (North of discharge canal) - Robinson Monitoring	1.46E+03	3.05E+03	1.68E+03	4.13E+02	4
RP2	P2 (South of discharge canal) - Robinson Monitoring	<MDA	<MDA	<MDA	<MDA	4
RPSW04	PSW-04	<MDA	<MDA	<MDA	<MDA	4
RPSW05	SW of Plant in a grass area on Entrance Road (Background Well)	NS	<MDA	NS	<MDA	2
RTS04B	RTS04B	NS	<MDA	NS	<MDA	2
U1SDEEP	Unit 1 South Deep Well	<MDA	NS	<MDA	NS	2

**Attachment 8
Inoperable Equipment**

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 8

Inoperable Equipment

This attachment includes an explanation of inoperable instruments related to effluent monitoring in excess of allowed time defined by licensing bases and an explanation of permanent or temporary outside liquid storage tanks exceeding 10 Curies total activity (excluding tritium and dissolved or entrained noble gases).

Attachment 8 Inoperable Equipment

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

H.B. Robinson Steam Electric Plant experienced one (1) instances of inoperable equipment relevant to effluent monitoring in excess of ODCM/TRMS limits during 2019. Details are described below.

H.B. Robinson Steam Electric Plant did not experience permanent or temporary outside liquid storage tanks not surrounded by liners, dikes, or walls, capable of holding the tank's contents and that does not have tank overflows and surrounding area drains connected to the Liquid Waste Disposal System exceeding 10 Curies total activity (excluding tritium and dissolved or entrained noble gases) during 2019.

ODCM # or TRMS #	Title	Completion Time	Description
TRMS 3.11	Waste Gas Holdup System Explosive Gas Monitoring System	14 days	<p>NCR 02279133: The Gas Analyzer has been OOS since 0339 on 6/12/19 due to a low flow trip. Condition A was entered and required that: Obtain and analyze grab samples for oxygen once per 24 hours and once per 4 hours during degassing. AND Restore the Waste Gas Holdup System Explosive Gas Monitoring System Oxygen Monitor to OPERABLE status in 14 days. AT 0339 hrs on 6/26/19.</p> <p>TRM 3.11 Condition B requires that the reason for the function not being repaired within 14 days be documented in the next Radioactive Effluent Release Report. Chemistry has been notified of the need to include this in the ARERR. Declared back in service 6/28/19 at 2119. Time exceeded 14 days due to WO 20333341, investigating cause of trip and sample pump rebuild.</p>

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 9

Summary of Changes to the Offsite Dose Calculation Manual

This attachment includes a summary of changes to the ODCM and Radiological Effluent Controls.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

SUMMARY OF CHANGES

The H.B. Robinson Steam Electric Plant Unit 2 Offsite Dose Calculation Manual was not revised in 2019 . The most recent revision is Revision 36.

Attachment 10
Summary of Changes to the Process Control Program

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 10

Summary of Changes to the Process Control Program

The H.B. Robinson Steam Electric Plant Unit 2 Process Control Program was not revised in 2019 . The most recent revision is #6.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 11

Summary of Major Modifications to the Radioactive Waste Treatment Systems

This attachment includes a description of major modifications to the radioactive waste treatment systems that are anticipated to affect effluent releases.

Attachment 11
Summary of Major Modifications to the Radioactive Waste Treatment Systems

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

No major modifications to liquid, gaseous, solid, or mobile radioactive waste treatment systems occurred at H.B. Robinson Steam Electric Plant in 2019.

Attachment 12
Errata to a Previous Year's ARERR

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

ATTACHMENT 12

Errata to a Previous Year's ARERR

This attachment includes any amended pages from a previous year's ARERR.

Attachment 12
Errata to a Previous Year's ARERR

H.B. Robinson Steam Electric Plant Unit 2
Period 1/1/2019 - 12/31/2019

There were no changes to a previous year's ARERR.