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RA-19-0209

April 30, 2019

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

Subject: Duke Energy Carolinas, LLC
Catawba Nuclear Station, Units 1 and 2
Docket Nos. 50-413 and 50-414
2018 Annual Radioactive Effluent Release Report

Pursuant to Catawba Nuclear Station Technical Specification (TS) 5.6.3 and Selected Licensee Commitment 16.11-16, please find the enclosed Annual Radioactive Effluent Release Report for the period of January 1, 2018, through December 31, 2018. In accordance with Catawba TS 5.5.1, the Offsite Dose Calculation Manual (ODCM) is included in this submittal.

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 Groundwater 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

Any questions concerning this report should be directed to Sherry Andrews, Nuclear Support Services, at (803) 701-3424.

Sincerely,

Tom Simril

Tom Simril
Vice President, Catawba Nuclear Station

Enclosure:

1. Catawba Nuclear Station, Units 1 and 2, Annual Radioactive Effluent Release Report, January 1, 2018, through December 31, 2018

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Catawba Nuclear Station
Units 1 and 2

Annual Radioactive Effluent Release Report

January 1, 2018 through December 31, 2018

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
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Attachment 12	Errata to a Previous Year's ARERR

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 1/1/2018 - 12/31/2018

Gaseous Effluents - Summation of All Releases

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
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 1
Summary of Gaseous and Liquid Effluents

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

Gaseous Effluents - Elevated Releases - Continuous Mode *

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
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 1/1/2018 - 12/31/2018

Gaseous Effluents - Elevated Releases - Batch Mode *

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
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 1/1/2018 - 12/31/2018

Gaseous Effluents - Ground Releases - Continuous Mode

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
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	4.66E+01	4.88E+01	4.19E+01	5.80E+01	1.95E+02
E. Carbon-14 *						
C-14	Ci	1.48E+00	1.50E+00	1.64E+00	1.42E+00	6.03E+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 1/1/2018 - 12/31/2018

Gaseous Effluents - Ground Releases - Batch Mode

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
A. Fission and Activation Gases						
AR-41	Ci	1.23E+00	1.13E+00	1.53E+00	1.26E+00	5.15E+00
KR-85	Ci	0.00E+00	8.90E-02	0.00E+00	0.00E+00	8.90E-02
KR-85M	Ci	0.00E+00	0.00E+00	0.00E+00	3.40E-04	3.40E-04
XE-133	Ci	2.55E-02	2.29E-02	3.98E-02	3.95E-02	1.28E-01
XE-135	Ci	0.00E+00	0.00E+00	0.00E+00	7.74E-03	7.74E-03
Total for Period	Ci	1.25E+00	1.25E+00	1.57E+00	1.31E+00	5.37E+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	1.67E-01	1.16E-01	1.00E-01	1.54E-01	5.36E-01
E. Carbon-14 *						
C-14	Ci	3.46E+00	3.51E+00	3.83E+00	3.31E+00	1.41E+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 1/1/2018 - 12/31/2018

Gaseous Effluents - Mixed-Mode Releases - Continuous Mode *

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
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 1/1/2018 - 12/31/2018

Gaseous Effluents - Mixed-Mode Releases - Batch Mode *

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
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 1/1/2018 - 12/31/2018

Liquid Effluents - Summation of All Releases

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
A. Fission and Activation Products *						
1. Total Release	Ci	6.88E-03	1.53E-02	1.79E-02	1.94E-02	5.95E-02
2. Avg. Diluted Conc.	µCi/ml	2.84E-10	5.65E-10	4.35E-10	7.09E-10	4.96E-10
3. Batch Releases	µCi/ml	2.84E-10	5.65E-10	4.35E-10	7.09E-10	4.96E-10
B. Tritium						
1. Total Release	Ci	1.68E+02	1.85E+02	1.83E+02	3.62E+02	8.97E+02
2. Avg. Diluted Conc.	µCi/ml	6.92E-06	6.86E-06	4.44E-06	1.32E-05	7.49E-06
3. Batch Releases	µCi/ml	6.92E-06	6.86E-06	4.44E-06	1.32E-05	7.49E-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	4.42E-05	0.00E+00	0.00E+00	3.20E-05	7.62E-05
2. Avg. Diluted Conc.	µCi/ml	1.82E-12	0.00E+00	0.00E+00	1.17E-12	6.35E-13
3. Batch Releases	µCi/ml	1.82E-12	0.00E+00	0.00E+00	1.17E-12	6.35E-13
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	5.35E+05	5.95E+05	7.47E+05	1.51E+06	3.41E+06
F. Volume of Dilution Water						
1. Continuous Releases	liters	2.43E+09	2.70E+09	4.13E+09	2.74E+09	1.20E+10
2. Batch Releases	liters	2.43E+10	2.70E+10	4.13E+10	2.74E+10	1.20E+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 1/1/2018 - 12/31/2018

Liquid Effluents - Continuous Mode

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
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 1/1/2018 - 12/31/2018

Liquid Effluents - Batch Mode

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
A. Fission and Activation Products						
AG-110M	Ci	9.97E-06	0.00E+00	0.00E+00	6.47E-06	1.64E-05
BE-7	Ci	1.06E-05	6.06E-05	0.00E+00	0.00E+00	7.13E-05
BI-214	Ci	0.00E+00	0.00E+00	1.07E-05	0.00E+00	1.07E-05
CO-57	Ci	0.00E+00	0.00E+00	0.00E+00	7.01E-06	7.01E-06
CO-58	Ci	2.44E-04	8.20E-04	1.32E-03	1.83E-03	4.22E-03
CO-60	Ci	2.79E-03	2.49E-03	5.47E-03	5.14E-03	1.59E-02
CR-51	Ci	0.00E+00	0.00E+00	0.00E+00	2.00E-03	2.00E-03
CS-134	Ci	7.90E-06	0.00E+00	0.00E+00	0.00E+00	7.90E-06
CS-137	Ci	7.34E-06	9.65E-06	5.78E-06	6.89E-06	2.97E-05
FE-55	Ci	9.35E-04	1.37E-03	3.26E-03	6.23E-03	1.18E-02
MN-54	Ci	1.60E-04	1.40E-04	2.84E-04	1.78E-04	7.61E-04
NB-95	Ci	8.58E-07	7.33E-06	0.00E+00	2.64E-05	3.46E-05
NB-97	Ci	3.00E-05	0.00E+00	0.00E+00	7.30E-06	3.73E-05
NI-63	Ci	2.11E-03	1.02E-02	7.01E-03	3.61E-03	2.30E-02
PB-214	Ci	0.00E+00	0.00E+00	0.00E+00	6.53E-06	6.53E-06
SB-125	Ci	3.28E-04	1.37E-04	5.60E-04	3.38E-04	1.36E-03
ZN-65	Ci	9.49E-06	0.00E+00	1.21E-05	0.00E+00	2.16E-05
ZR-95	Ci	0.00E+00	0.00E+00	0.00E+00	1.01E-05	1.01E-05
ZR-97	Ci	2.38E-04	0.00E+00	0.00E+00	0.00E+00	2.38E-04
Total for Period	Ci	6.88E-03	1.53E-02	1.79E-02	1.94E-02	5.95E-02
B. Tritium						
H-3	Ci	1.68E+02	1.85E+02	1.83E+02	3.62E+02	8.97E+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	4.42E-05	0.00E+00	0.00E+00	3.20E-05	7.62E-05

<u>ATTACHMENT 2</u>

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 1/1/2018 - 12/31/2018

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	=	69
2. Total Time (min) for Batch Releases	=	4.57E+03
3. Maximum Time (min) for a Batch Release	=	1.47E+02
4. Average Time (min) for Batch Releases	=	6.63E+01
5. Minimum Time (min) for a Batch Release	=	2.00E+01
6. Average Dilution Water Flow During Release (gpm)	=	6.03E+04

B. Gaseous Effluents

1. Total Number of Batch Releases	=	60
2. Total Time (min) for Batch Releases	=	1.03E+06
3. Maximum Time (min) for a Batch Release	=	4.56E+04
4. Average Time (min) for Batch Releases	=	1.72E+04
5. Minimum Time (min) for a Batch Release	=	1.21E+02

VI. Abnormal Releases

See Attachment 5, Unplanned Offsite Releases.

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 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 Catawba 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 Catawba Nuclear Station in 2018 results in a site total C-14 gaseous release estimate to the environment of 2.01E+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 CO_2 (Ref. EPRI TR-105715). For the Catawba 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 Catawba ODCM. The estimated C-14 dose impact on the maximum organ dose from airborne effluents released from Catawba 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

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

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 ± 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 = ± 20%
2. Counting Statistical Error = ± 20%
3. Calibration Error = ± 10%
4. Calibration Source Error = ± 2.5%
5. Sample Preparation Error = ± 3%

Attachment 2
Supplemental Information

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

Summary of Changes in Land Use Census Affecting Effluent Dose Calculations

The 2018 Land Use Census was performed June 19-20, 2018, and the results were certified and made available for use on July 26, 2018. 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 N sector (1.74 miles) was replaced with a garden at 1.55 miles.
The garden in the NNE sector (0.69 miles) was replaced with a garden at 3.09 miles.
The garden in the ESE sector (1.29 miles) was replaced with a garden at 3.54 miles.
The garden in the SSE sector (1.64 miles) was replaced with a garden at 2.02 miles.
The garden in the S sector (1.25 miles) was replaced with a garden at 1.45 miles.
The garden in the SSW sector (1.33 miles) was replaced with a garden at 1.08 miles.
The garden in the SW sector (2.32 miles) was replaced with a garden at 2.88 miles.
The garden in the WNW sector (2.53 miles) was replaced with a garden at 1.27 miles.

Milk Animals

No changes to nearest milk animal in each sector.

Environmental Monitoring Locations

No changes to environmental monitoring locations in each sector.

<u>ATTACHMENT 3</u>

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

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

	Type of Waste Shipped	Number of Shipments	Number of Containers	Waste Class	Container Type	Solidification Agent	Burial Volume (m^3)	Total Activity (Curies)
1.	**Waste from Liquid Systems**							
	a. Dewatered Secondary Resins							
	b. Dewatered Primary Resins	2	2	A / B	HIC	NA	9.237	255
	c. Evaporator Concentrates							
	d. Dewatered Mechanical Filters	2	2	C	HIC	NA	6.814	45.3
	e. Dewatered Demineralizers							
	f. Solidified (cement) Acids, Oils, Sludge							
	g. ***Other (add as necessary)***							
2.	**Dry Solid Waste**							
	a. Dry Active Waste (compacted)							
	b. Dry Active Waste (non-compacted)							
	c. Dry Active Waste (brokered)	13	26	A	GDP	NA	429.7	1.27
	d. Irradiated Components							
	e. ***Other (add as necessary)***							
3.	**Total Solid Waste**	**17**	**30**				**445.7**	**302**

Attachment 3
Solid Radioactive Waste Disposal

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

	Type of Waste Shipped	Radionuclide	% Abundance
1.	**Waste from Liquid Systems**		
a.	Dewatered Secondary Resins	N/A	N/A
b.	Dewatered Primary Resins	H-3	0.01%
		Be-7	0.60%
		Mn-54	5.21%
		Co-57	0.20%
		Co-58	4.77%
		Co-60	16.81%
		Zn-65	0.63%
		Sb-125	0.09%
		Cs-134	0.24%
		Cs-137	0.32%
		Ce-144	0.01%
		C-14	0.04%
		Fe-55	11.82%
		Ni-59	0.41%
		Ni-63	58.83%
		Sr-90	0.00%
c.	Evaporator Concentrates	N/A	N/A
d.	Dewatered Mechanical Filters	H-3	2.28%
		Be-7	0.07%
		Cr-51	10.37%
		Mn-54	4.59%
		Co-57	0.20%
		Co-58	33.31%
		Fe-59	0.61%
		Co-60	17.70%
		Zn-65	0.72%
		Nb-95	10.45%
		Zr-95	5.09%
		Ag-110m	0.00%
		Sn-113	0.25%
		Sb-124	0.12%
		Sb-125	0.29%
		I-131	0.00%
		Cs-134	0.09%
		Cs-137	0.13%
		Hf-181	0.02%
		Ba/La-140	0.00%
		Ce-144	0.26%
		C-14	0.45%
		Fe-55	11.58%
		Ni-63	1.41%
		Sr-89	0.00%
		Sr-90	0.00%
		Tc-99	0.00%
		Sn-117m	0.00%
		I-129	0.00%
		Cm-242	0.00%
e.	Dewatered Demineralizers	N/A	N/A
f.	Solidified (cement) Acids, Oils, Sludge	N/A	N/A
g.	***Other (add as necessary)***	N/A	N/A
2.	**Dry Solid Waste**		
a.	Dry Active Waste (compacted)	N/A	N/A
b.	Dry Active Waste (non-compacted)	N/A	N/A

Attachment 3
Solid Radioactive Waste Disposal

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

c. Dry Active Waste (brokered)	H-3	0.16%
	Cr-51	15.87%
	Mn-54	2.97%
	Co-57	0.15%
	Co-58	25.15%
	Fe-59	0.95%
	Co-60	12.87%
	Zn-65	0.32%
	Nb-95	13.05%
	Zr-95	7.77%
	Sn-113	0.37%
	Sb-124	0.16%
	Sb-125	0.75%
	Cs-137	0.06%
	Ce-144	0.21%
	Pu-238	0.00%
	C-14	0.02%
	Fe-55	16.54%
	Ni-63	2.63%
d. Irradiated Components	N/A	N/A
e. ***Other (add as necessary)***	N/A	N/A

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 1/1/2018 - 12/31/2018

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	1	0	0	0	1	0	0	0
	0.76-1.00	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0
	1.01-1.25	1	0	0	0	0	0	0	0	1	2	0	0	0	0	0	1
	1.26-1.50	0	1	1	0	0	1	1	5	8	4	13	7	5	1	0	0
	1.51-2.00	2	1	0	1	1	2	9	21	19	54	77	41	30	4	5	3
	2.01-3.00	24	12	8	0	0	0	0	6	4	43	41	7	4	2	2	3
	3.01-4.00	19	19	11	0	0	0	0	0	5	5	15	1	1	2	5	4
	4.01-5.00	8	10	5	0	0	0	0	0	0	0	1	0	0	1	4	4
	5.01-6.00	4	3	1	0	0	0	0	0	0	0	0	0	0	0	4	8
	6.01-8.00	0	1	1	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	0	0	0	1	0	1	1	1	0	0
	1.26-1.50	1	0	0	0	1	1	2	4	4	20	16	12	8	3	0	1
	1.51-2.00	5	3	0	1	4	2	8	24	24	52	46	18	18	7	4	2
	2.01-3.00	32	5	2	1	1	0	5	1	8	14	10	3	6	11	9	8
	3.01-4.00	15	8	6	0	0	0	0	0	0	3	1	1	0	2	3	4
	4.01-5.00	5	7	1	0	0	0	0	0	0	1	0	0	0	0	6	5
	5.01-6.00	1	4	4	0	0	0	0	0	0	0	0	0	0	0	3	8
	6.01-8.00	3	3	1	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 1/1/2018 - 12/31/2018

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	1	0	2	0	1	1	0	0	0	0	0
	1.01-1.25	0	0	0	0	0	1	1	0	1	1	1	0	1	1	1	0
	1.26-1.50	2	0	1	0	0	3	14	16	16	22	24	15	9	2	1	1
	1.51-2.00	20	6	2	4	1	2	9	27	26	35	27	10	20	11	9	10
	2.01-3.00	26	22	7	1	1	1	4	3	3	8	13	2	4	4	8	4
	3.01-4.00	17	17	13	3	0	0	0	0	1	2	3	0	0	2	4	5
	4.01-5.00	6	6	0	0	0	0	0	0	0	0	0	0	0	0	4	6
	5.01-6.00	2	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	6.01-8.00	4	2	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	2	1	0	2	2	2	1	0	0	0	0
D	0.46-0.75	2	1	0	1	0	2	2	9	6	14	10	11	5	5	3	9
	0.76-1.00	1	2	2	3	2	2	4	11	24	26	32	31	13	15	9	8
	1.01-1.25	15	5	2	1	4	6	17	15	66	50	41	27	29	19	12	10
	1.26-1.50	42	11	3	10	11	10	37	66	118	105	84	32	50	37	29	52
	1.51-2.00	154	56	23	15	8	9	37	67	140	96	69	21	30	30	31	93
	2.01-3.00	183	122	73	15	5	2	21	12	38	34	23	3	1	15	21	38
	3.01-4.00	92	108	72	8	2	1	6	5	9	7	5	1	1	7	10	37
	4.01-5.00	37	18	24	7	0	0	0	3	0	1	1	0	0	1	5	12
	5.01-6.00	16	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	6.01-8.00	12	8	0	1	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	1
	10.01-max	0	0	0	0	0	0	1	2	2	2	3	3	2	3	1	0

Attachment 4
Meteorological Data

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

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	4	2	1	2	3	0	1	16	14	28	39	24	21	12	14	3
	0.76-1.00	1	1	0	0	1	1	5	13	53	64	52	31	23	10	15	8
	1.01-1.25	3	1	2	1	1	2	7	24	98	95	35	29	30	26	29	11
	1.26-1.50	17	2	4	3	1	4	17	41	131	73	36	29	32	26	62	47
	1.51-2.00	69	6	3	6	3	7	32	33	121	51	22	15	8	43	66	104
	2.01-3.00	50	11	7	8	3	10	9	16	28	20	7	4	1	4	23	32
	3.01-4.00	12	7	7	4	3	6	15	2	5	2	1	0	0	2	1	2
	4.01-5.00	3	2	4	4	3	1	0	0	0	0	0	0	0	0	2	0
	5.01-6.00	0	0	3	4	1	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	1	1	2	7	7	6	2	0	0
F	0.46-0.75	0	0	0	0	0	0	1	2	20	33	23	14	16	11	14	2
	0.76-1.00	2	0	0	0	0	0	4	3	27	34	30	11	9	17	15	9
	1.01-1.25	2	1	1	1	0	0	0	10	29	24	18	19	19	13	13	12
	1.26-1.50	5	0	1	0	0	1	2	10	15	9	8	12	25	13	14	34
	1.51-2.00	23	1	1	1	0	4	3	4	2	0	1	0	12	13	7	26
	2.01-3.00	2	0	0	1	0	2	5	3	0	0	0	0	0	0	0	1
	3.01-4.00	0	2	2	0	0	0	2	0	0	0	0	0	0	0	0	0
	4.01-5.00	0	0	2	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	3	3	6	7	12	8	4	3	1

Attachment 4
Meteorological Data

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

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	2	1	0	0	0	0	0	21	14	20	25	18	13	19	8
	0.76-1.00	0	0	1	0	0	0	0	0	22	20	28	17	13	10	17	8
	1.01-1.25	1	0	0	0	0	0	0	2	13	17	20	18	10	8	16	22
	1.26-1.50	4	0	0	0	0	0	0	7	10	5	8	7	6	6	11	20
	1.51-2.00	4	0	0	0	0	0	0	0	0	0	0	1	9	0	2	13
	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

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 1/1/2018 - 12/31/2018

Catawba Nuclear Station had no unplanned liquid releases in 2018.

Catawba Nuclear Station had no unplanned gaseous releases in 2018.

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 1/1/2018 - 12/31/2018

Gaseous Effluents Dose Summary

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
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						
Receptor Location	***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						
Receptor Location	***0.5*** miles	***NE***	***NE***	***NE***	***NE***	***NE***
Critical Age		***CHILD***	***CHILD***	***CHILD***	***CHILD***	***CHILD***
Critical Organ		***BONE***	***BONE***	***BONE***	***BONE***	***BONE***
Critical Pathway		***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 1/1/2018 - 12/31/2018

Liquid Effluents Dose Summary

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
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						
Critical Age		***CHILD***	***CHILD***	***CHILD***	***CHILD***	***CHILD***
Critical Organ		***LIVER***	***BONE***	***BONE***	***GILLI***	***LIVER***
Critical Pathway		***POTABLE WATER***	***FRESH WATER***	***FRESH 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	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						
Critical Age		***N/A***	***N/A***	***N/A***	***N/A***	***N/A***
Critical Organ		***N/A***	***N/A***	***N/A***	***N/A***	***N/A***
Critical Pathway		***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 1/1/2018 - 12/31/2018

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)	4.808E+00 mREM
1. Location	0.5 miles NE
2. Critical Age	CHILD
3. Critical Organ	BONE
4. Gas Contribution %	98.331%
5. Liquid Contribution %	1.669%
B. Maximum Total Body Dose	2.004E+00 mREM
1. Location	0.5 miles NE
2. Critical Age	CHILD
3. Gas non-NG Contribution %	93.269%
4. Gas NG Contribution %	2.110%
5. Liquid Contribution %	4.621%

Direct and air-scatter radiation dose contributions from the onsite ISFSI have been determined from the 10 CFR 72.212 Evaluation Report, MAGNASTOR®, Revision 1. 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 1 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 21 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.

10 CFR 72.212 Evaluation Report, MAGNASTOR®, Revision 1

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.

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

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 1/1/2018 - 12/31/2018

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 2018.

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 2018. Results from sampling during 2018 confirmed existing knowledge of tritium concentrations in site ground water.

Results from sampling during 2018 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 2018.

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 ρCi/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 1/1/2018 - 12/31/2018

Well Name	Location / Description	Tritium Concentration (pCi/l) 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	# of Samples
C-100DR	CNS GWPI/ C-100DR /U-1 SFP	2.17E+02	2.88E+02	<MDA	2.35E+02	4
C-101DR	CNS GWPI/ C-101DR/ U-1 SFP	3.80E+02	3.25E+02	2.77E+02	3.28E+02	4
C-101R	CNS GWPI/ C-101R/ U-1 SFP	8.23E+02	7.02E+02	4.77E+02	4.62E+02	4
C-102	CNS GWPI/ C-102/ E of U1 SFP O/S protected area	3.63E+02	NS	2.09E+02	NS	2
C-103	CNS GWPI/ C-103/ E of U1 SFP @ Cooling Towers	3.40E+02	NS	2.38E+02	NS	2
C-104	CNS GWPI/ C-104/ U-1 RMWST	7.52E+02	5.00E+02	3.05E+02	6.32E+02	4
C-105	CNS GWPI/ C-105/ Engr. Bldg.	1.50E+03	3.55E+02	4.32E+02	1.96E+02	4
C-105R	CNS GWPI/ C-105R/ Engr. Bldg.	7.12E+02	6.08E+02	5.92E+02	5.80E+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	2.17E+02	NS	<MDA	NS	2
C-107	CNS GWPI/ C-107/ MET Tower Hill	6.41E+02	6.47E+02	5.11E+02	6.86E+02	4
C-108	CNS GWPI/ C-108/	2.15E+02	NS	6.18E+02	NS	2
C-109	CNS GWPI/ C-109/	6.15E+02	NS	5.68E+02	NS	2
C-110	CNS GWPI/ C-110/	1.45E+03	1.29E+03	1.03E+03	9.77E+02	4
C-200DR	CNS GWPI/ C-200DR/ U-2 SFP	2.68E+02	3.73E+02	3.27E+02	3.61E+02	4
C-200R	CNS GWPI/ C-200R/ U-2 SFP	5.77E+02	5.00E+02	5.14E+02	5.95E+02	4
C-201DR	CNS GWPI/ C-201DR/ U-2 SFP	4.18E+02	4.77E+02	3.10E+02	3.82E+02	4
C-201R	CNS GWPI/ C-201R/ U-S SFP	1.25E+03	6.45E+02	1.51E+03	1.01E+03	4
C-202	CNS GWPI/ C-202/ S of RMC Tent	6.57E+02	NS	4.84E+02	NS	2
C-203	CNS GWPI / C-203/ E of RMC Tent @ Cooling Towers	3.60E+02	NS	2.30E+02	NS	2
C-204	CNS GWPI/ C-204/ S of RMC Tent	2.36E+02	NS	3.57E+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	3.05E+02	2.46E+02	2.64E+02	3.27E+02	4
C-207R	CNS GWPI/ C-207R/ Mon. Tank B	3.08E+02	<MDA	<MDA	<MDA	4
C-208	CNS GWPI/ C-208/ N of MTB	2.89E+02	NS	<MDA	NS	2
C-209	CNS GWPI/ C-209/ MTUville S of light pole 23A	3.10E+02	<MDA	<MDA	<MDA	4
C-210	CNS GWPI/ C-210/ N of U2 Mech Equip Bldg	4.11E+02	NS	<MDA	NS	2
C-211	CNS GWPI/ C-211/ W of RL Intake O/S Protected Area	8.39E+02	NS	5.64E+02	NS	2
C-212	CNS GWPI/ C-212/ Behind Aquatic Center	2.42E+02	<MDA	<MDA	<MDA	4
C-213	CNS GWPI/ C-213/ Mon. Tank B	4.44E+03	4.37E+03	4.65E+03	6.37E+03	4
C-213R	CNS GWPI/ C-213R/ Mon. Tank B	<MDA	<MDA	<MDA	<MDA	4
C-214	CNS GWPI/ C-214/ N of U2 TB	6.35E+02	6.67E+02	7.01E+02	7.71E+02	4
C-215	CNS GWPI/ C-215/ N of U2 TB	2.15E+02	5.19E+02	6.30E+02	7.48E+02	4
C-217	CNS GWPI/ C-217/ N of U2 TB	5.72E+02	4.16E+02	5.45E+02	5.54E+02	4
C-218	CNS GWPI/ C-218/ N of U2 TB	4.79E+02	2.88E+02	3.94E+02	4.90E+02	4
C-220	CNS GWPI/ C-220/ N of U2 TB	1.81E+03	1.70E+03	1.43E+03	1.77E+03	4
C-221	CNS GWPI/ C-221/ N of U2 TB	4.48E+02	3.48E+02	2.52E+02	3.87E+02	4

Attachment 7
Information to Support the NEI Ground Water Protection Initiative

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

Well Name	Location / Description	Tritium Concentration (pCi/l) 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	# of Samples
LMW-1B	CNS Landfill/ LMW-1B/ Landfill	NS	<MDA	NS	NS	1
LMW-2A	CNS Landfill/ LMW-2A/ Landfill	NS	<MDA	NS	NS	1
LMW-3A	CNS Landfill/ LMW-3A/ Landfill	NS	<MDA	NS	NS	1
LMW-4	CNS Landfill/ LMW-4/ Landfill	NS	<MDA	NS	NS	1
LMW-5D	CNS Landfill/ LMW-5D/ Landfill	NS	<MDA	NS	NS	1
LMW-5S	CNS Landfill/ LMW-5S/ Landfill	NS	<MDA	NS	NS	1
OUTFALL017	CNS WC Ponds/ OUTFALL-017/ WC Ponds	1.23E+03	6.74E+02	6.72E+02	9.27E+02	4
WCMW-2	CNS WC Ponds/ WCMW-2/ WC Ponds	2.89E+03	2.55E+03	2.44E+03	2.46E+03	4
WCMW-3	CNS WC Ponds/ WCMW-3/ WC Ponds	1.13E+03	1.17E+03	9.29E+02	8.93E+02	4
WCMW-4	CNS WC Ponds/ WCMW-4/ WC Ponds	4.28E+02	5.19E+02	4.13E+02	3.44E+02	4
WCMW-5	CNS WC Ponds/ WCMW-5/ WC Ponds	<MDA	<MDA	<MDA	<MDA	4

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 1/1/2018 - 12/31/2018

Catawba Nuclear Station did not experience any inoperable equipment relevant to effluent monitoring in excess of SLC 16.11 limits during 2018.

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 2018.

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 1/1/2018 - 12/31/2018

ODCM Revision 62

ODCM Revision 62 is provided in entirety in this section.

Summary of ODCM Revision 62 Changes

ODCM Revision 62 was approved by the Radiation Protection Manager on 9/12/2018. 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 4 - Page 1
Reworded 4.0.1 from:
"There are two liquid 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). 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…"
to:
"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…"

Reworded for clarification and formatting only. No technical changes.

Section 4- Page 7
Added 'Grass/Goat/Meat' Pathway and set Factor Used as 'D/Q (m^{-2})' to W parameter in table for $Dose_{oa}$ formula per DRR 02209371.

Section 4 – Page 21 to 23
Added R_{oapi} equations and parameters for newly added Grass/Goat/Meat pathway per DRR 02209371.

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-mrem/yr per µCi/sec). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/µCi (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 (5.73×10^{-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 µCi/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 gm/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 $\mu Ci/m^3$). (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.

Attachment 9
Summary of Changes to the Offsite Dose Calculation Manual

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

Appendix C, D, E, and F
Added dose factors for Se-75, Ag-108m, Sn-113, Sn-117m, Sb-124, Sb-125, Sb-126, Te-123m, Ba-133, and Eu-152 to Appendix C, D, E, and F for all age groups and applicable pathways per DRR 02195639. Assessment of Oconee Count Room determined not all radionuclides listed on liquid waste release permits have dose factors in the ODCM. Dose factors developed using method described in CSD-RP-ALL-0028.

Appendix G, H, and I
Added tables for Adult, Teen, and Child Grass/Goat/Meat pathway dose factors to Appendix G, H, and I respectively per DRR 02209371. Dose factors developed using method described in CSD-RP-ALL-0029.

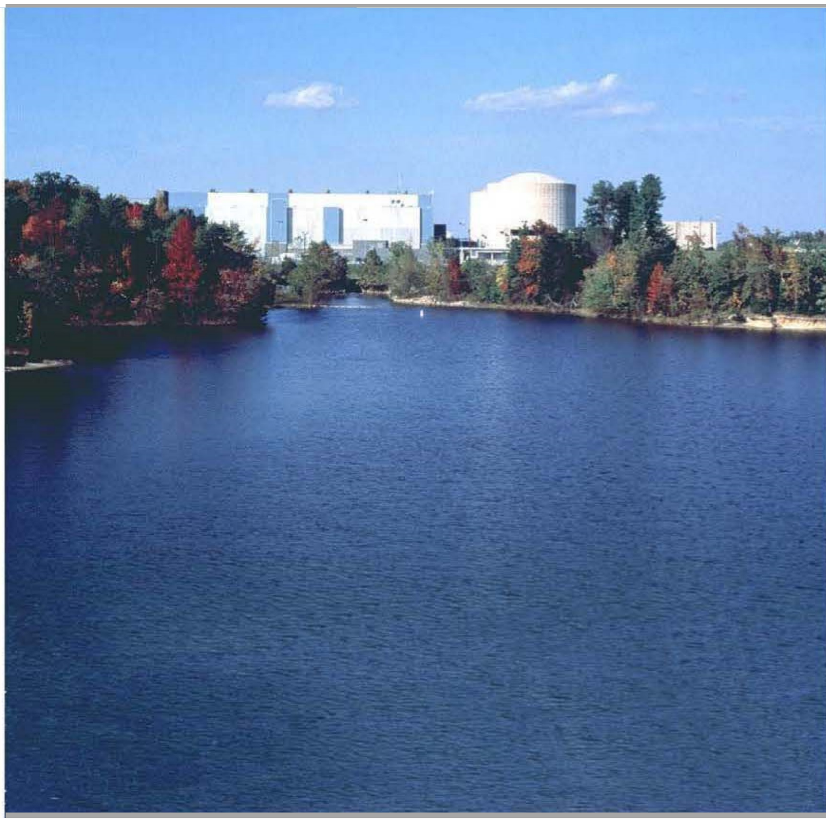
Radiological Effluent Controls (SLC 16.11)

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

There were no revisions made to the Catawba Nuclear Station Updated Final Safety Analysis Report, Section 16.11, Radiological Controls, in 2018.

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

DUKE ENERGY

Catawba Nuclear Station
Units 1 and 2

OFFSITE DOSE CALCULATION MANUAL (ODCM)

Revision 62

Prepared By: Christopher C. Courtenay Fleet Scientific Services RP	**Signature**	8/6/2018 **Date**
Reviewed By: Jonathan B. Hanni CNS Radiation Protection	**Signature**	9-12-2018 **Date**
Approved By: Joe W. Smith CNS Radiation Protection Manager	**Signature**	9-12-2018 **Date**

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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:

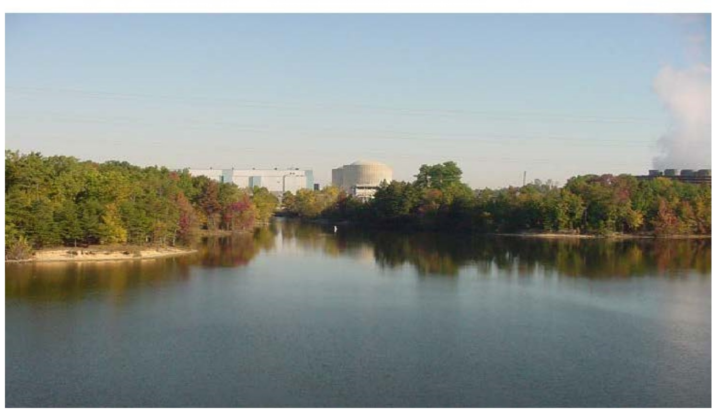
(1) the concentration of radioactive liquid effluents released from the site to the unrestricted area will be limited to 10 times the effluent concentration (EC) levels of 10CFR20, Appendix B, Table 2, and 2.0E-04 μCi/ml for dissolved and entrained noble gases (TS 5.5.5(a)(2), SLC 16.11-1);

(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 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.

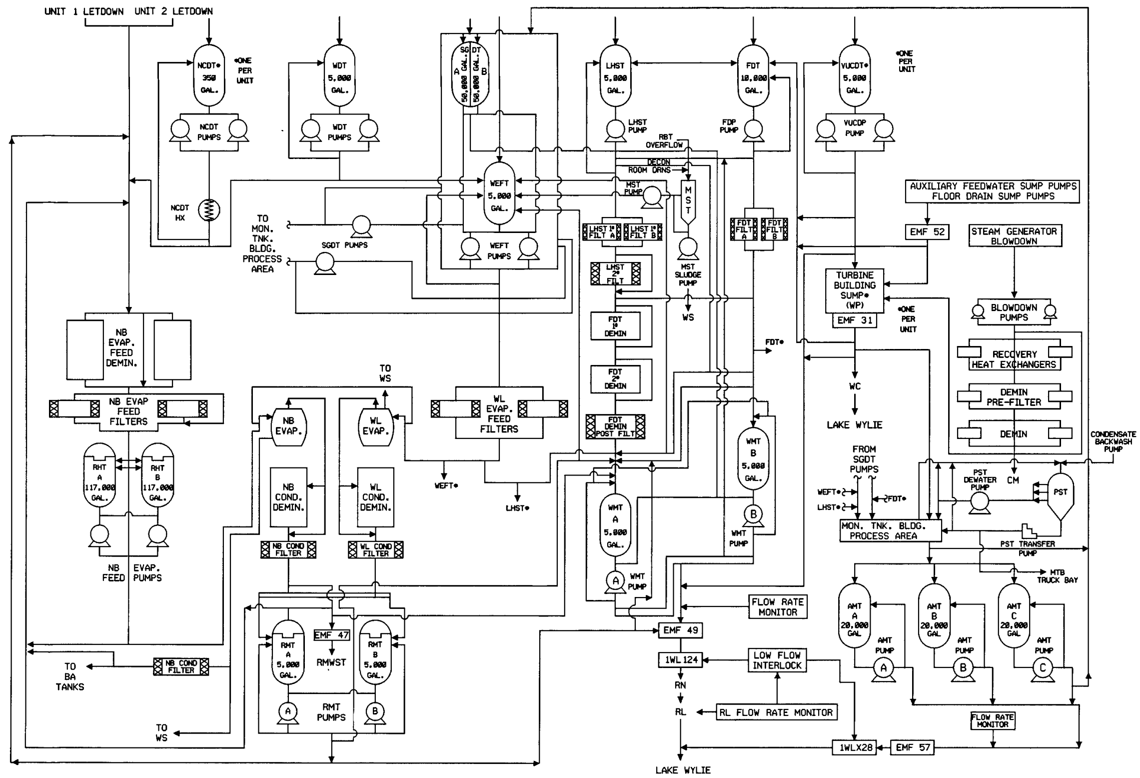
(D) Gas Stripping - Removal of gaseous radioactive fission products is accomplished in recycled water by the NB Evaporator.

(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.

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

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.

Figure 1.0-2 Catawba Nuclear Station Gaseous Radwaste System
Page 1 of 2

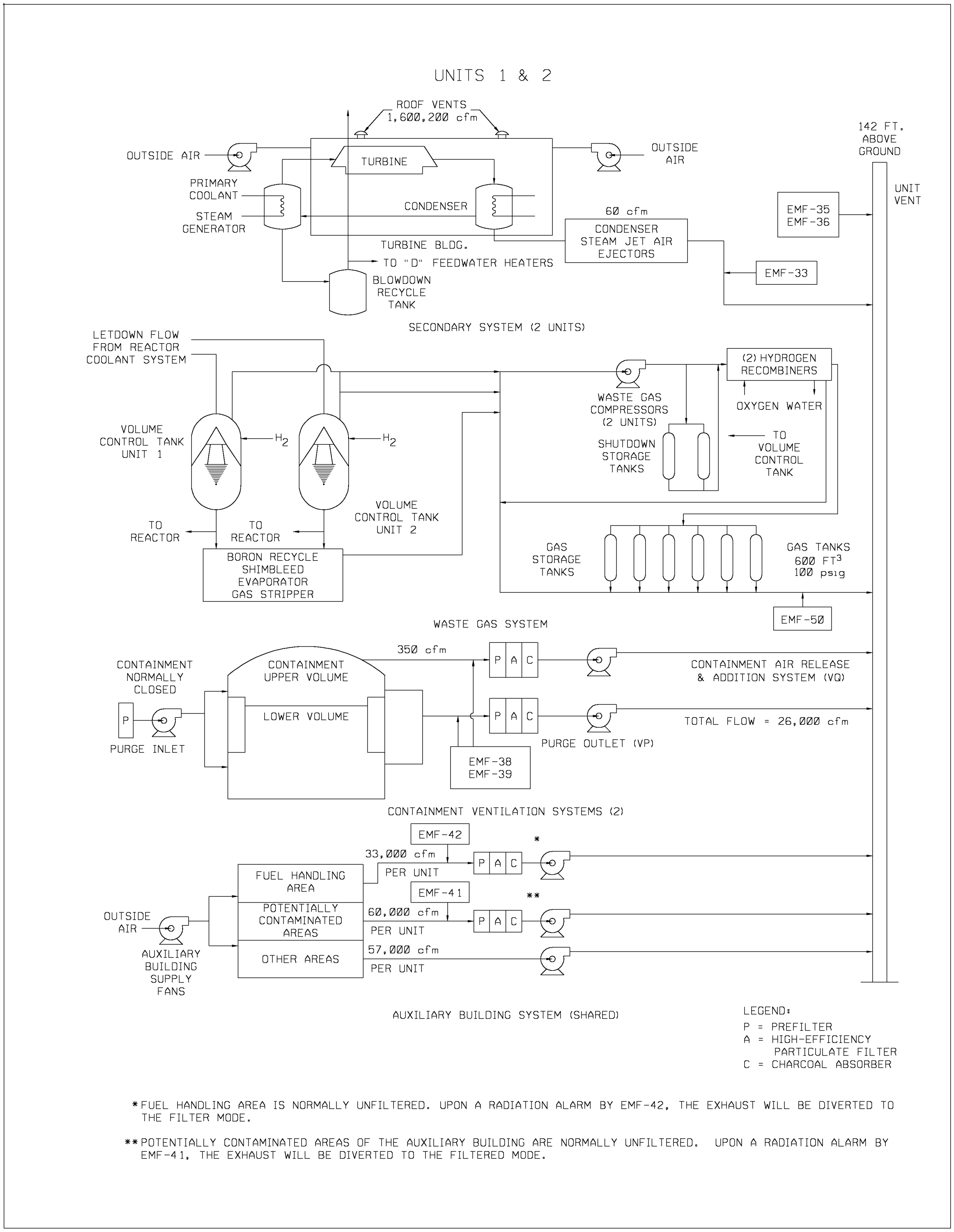
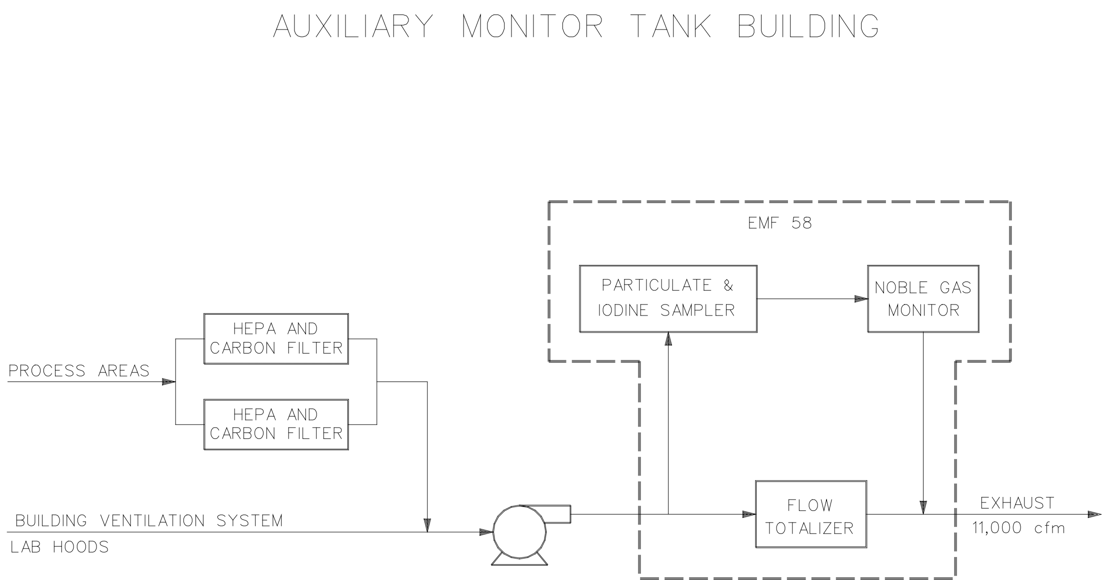


Figure 1.0-2 Catawba Nuclear Station Gaseous Radwaste System
Page 2 of 2



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 μCi/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:

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

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.

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

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 µCi/ml.

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

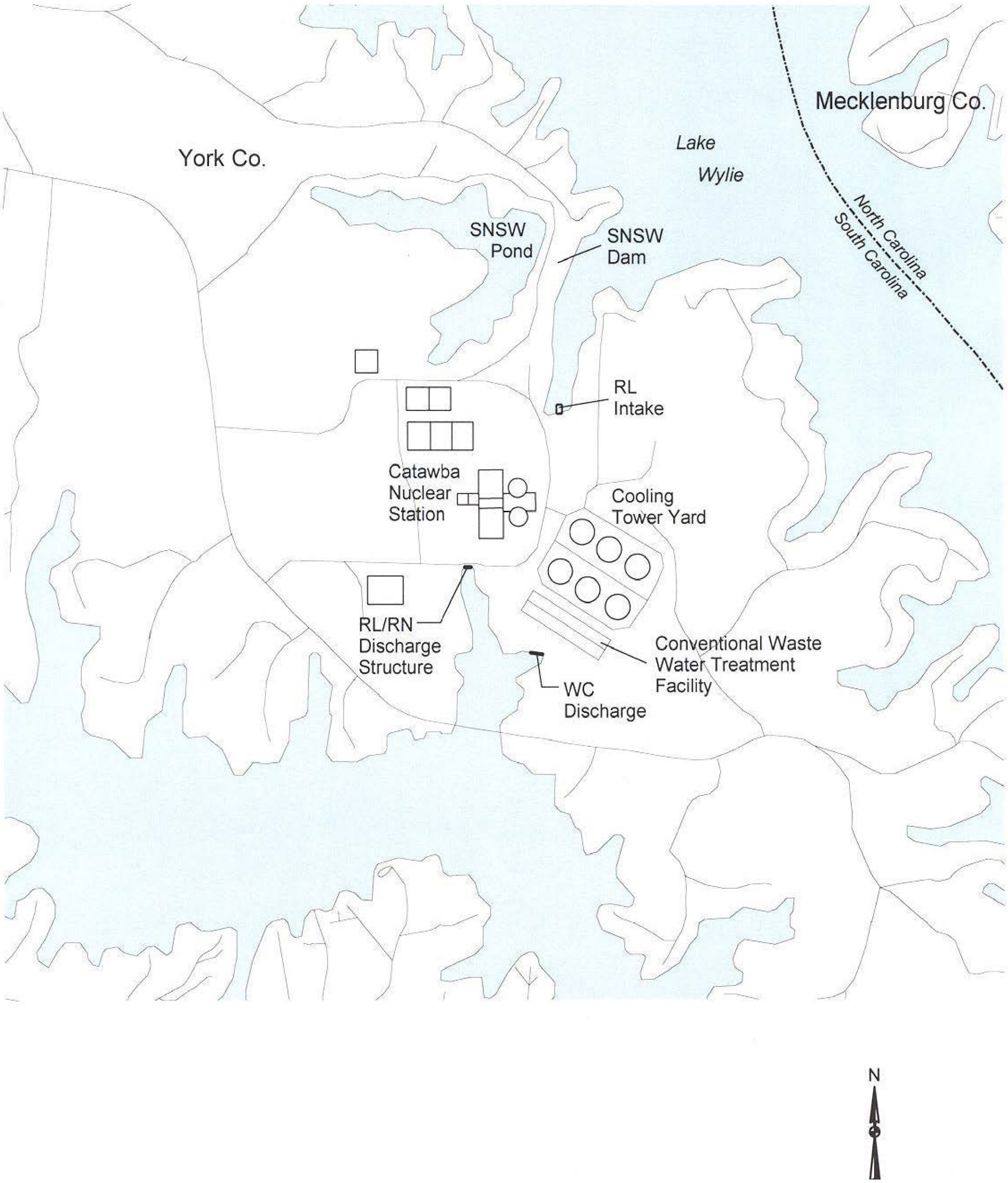
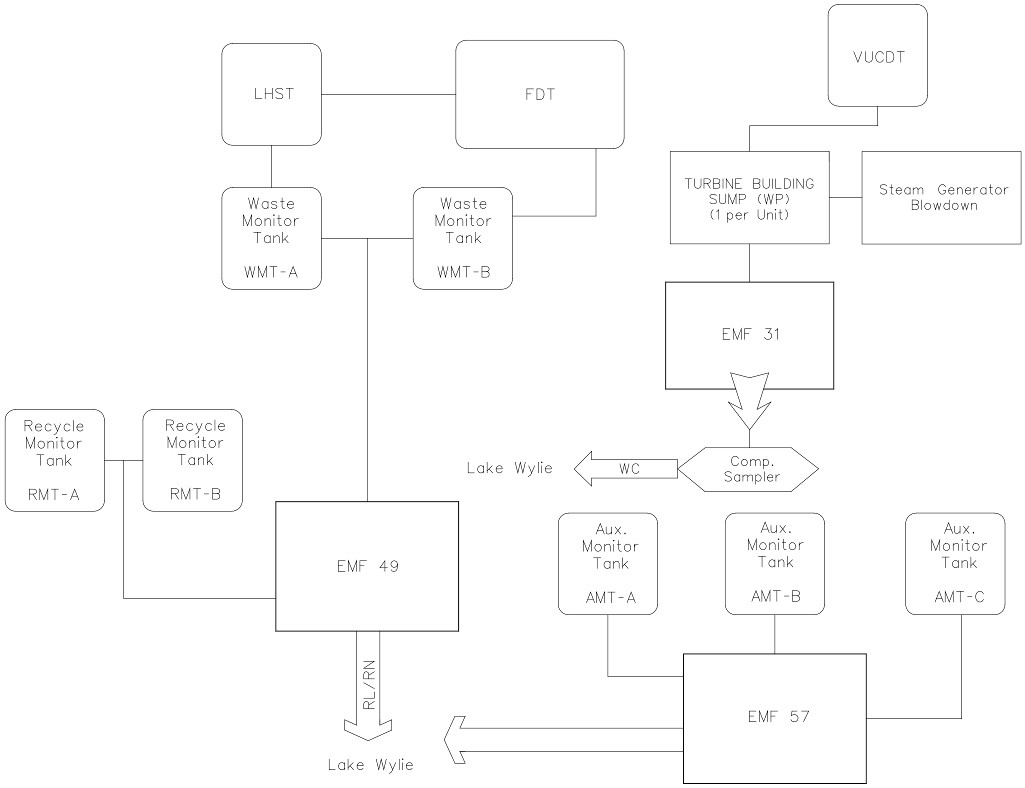


Figure 2.0-2 Liquid Radwaste Discharge to Lake Wylie



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. <u>Noble Gases</u>

Total Body:

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

Skin:

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

b. Radioiodines, Particulates, and Others

Inhalation, Ingestion and Ground Organ Pathways:

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

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

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

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 $\mu Ci/m^3$ (See Appendix A).

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

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide, ‘i’, in mrad/yr per $\mu Ci/m^3$ (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 $\mu Ci/m^3$ and for the food and ground plane pathways in ($m^2 \times$ (mrem/yr per μCi/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 3.510E-5 sec/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:

$W_{\chi/Q}$ = 3.510E-5 sec/m^3, 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 m^{-2}, 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 μCi/sec.

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

where:

C_i = the concentration of radionuclide, 'i', in undiluted gaseous effluent, in μCi/ml.

f = the undiluted effluent flow, in ft^3/min.

k_1 = conversion factor, 2.83E+04 cc/ft^3.

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:

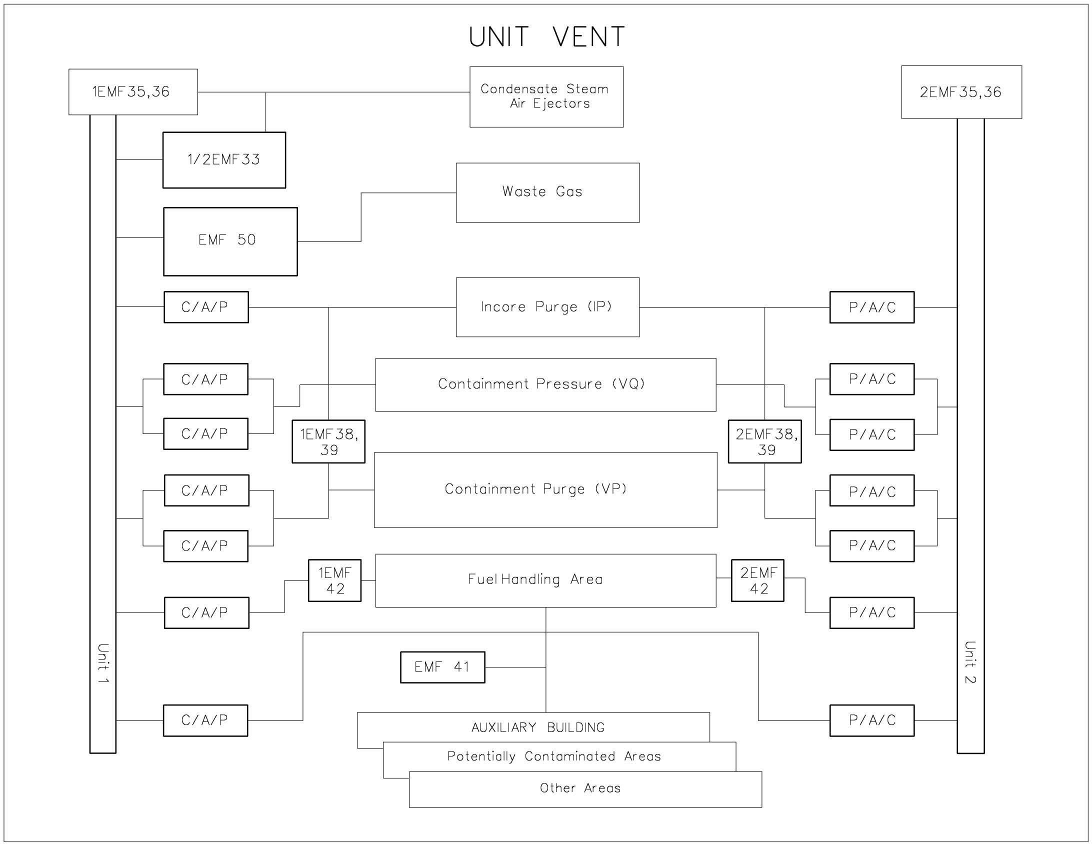
$$f_{sk} < \frac{3000}{472 \times \chi/Q \times \sum_i [(L_i + 1.1M_i) \times C_i]}$$

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

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

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.

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 µCi/m^3). (See Appendix B for the pathway specific dose commitment factors).
K'	Units conversion factor pCi/µCi (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 μCi/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:

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

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

where:

C_i = the maximum allowable concentration of radionuclide, ‘i’, in the undiluted liquid effluent, in μCi/ml.

SP = radiation monitor setpoint, in cpm.

CF_i = radiation monitor correlation factor for radionuclide, ‘i’, in cpm/μCi/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:

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

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

where:

$C_{Cs\text{-}137}$ = Cs-137 equivalent concentration, in µCi/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:

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

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

Maximum EMF 49 Trip 2 setpoint based on discharge concentration limits

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

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

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

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

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

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 (μCi/ml).

1.0 = The recirculation value for Catawba (unitless).

3.49E+08 = The radiation monitor correlation value for EMF 49 (cpm/μCi/ml).

<u>EMF 49 Trip 2 setpoint based on sample concentration</u>

When $Cs-137$ equivalent concentration $\leq$ 4.58E-05 μCi/ml:

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

When $Cs-137$ equivalent concentration $>$ 4.58E-05 μCi/ml:

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

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

where:

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

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

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

If the Cs-137 equivalent concentration is ≤ 4.58E-05 μCi/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:

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

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

Maximum EMF 57 Trip 2 setpoint based on discharge concentration limits

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

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

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

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

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

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 (μCi/ml).

1.0 = The recirculation value for Catawba (unitless).

9.60E+07 = The radiation monitor correlation value for EMF 57 (cpm/μCi/ml).

EMF 57 Trip 2 setpoint based on sample concentration

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

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

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

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

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

where:

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

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

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

If the Cs-137 equivalent concentration is ≤ 1.66E-04 μCi/ml, then 1.66E-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)

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

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

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

where:

1.0E-06 = Minimum practical detectable Cs-137 equivalent concentration, in μCi/ml.

3.49E+08 = EMF 31 Cs-137 correlation factor, in cpm/μCi/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.

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

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

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

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

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 gpm - 50 gpm (TBS) = 221 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 (μCi/ml).

1.0 = The recirculation value for Catawba (unitless).

3.49E+08 = The radiation monitor correlation value for EMF 31 (cpm/μCi/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.

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

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

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

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

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.

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 (μCi/ml).

1.0 = The recirculation value for Catawba (unitless).

3.49E+08 = The radiation monitor correlation value for EMF 31 (cpm/μCi/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 $Q_{Xe\text{-}133}$:

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

From Equation 2.6:

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

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 $C_{Xe\text{-}133}$:

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

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

where:

$K_{Xe\text{-}133}$ = 2.94E+02, the total body dose factor due to gamma emissions for Xe-133, in mrem/year per μCi/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.

$Q_{Xe\text{-}133}$ = Xe-133 equivalent release rate limit for the noble gas total body dose pathway, in μCi/sec.

472 = conversion factor, (cc/ft^3)/(sec/min).

$C_{Xe\text{-}133}$ = the maximum allowable Xe-133 equivalent concentration in the gaseous effluent, in μCi/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 cpm/μCi/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:

<u>1 and 2 EMF 36 - Maximum Setpoint</u>

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.

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

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

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

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

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, cpm/μCi/ml

0.49 = apportioned 49% to each unit vent.

EMF 58 - Maximum Setpoint

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

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

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

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

where:

1.10E+04 = AMTB Vent flow in cfm.

1.41E+07 = EMF58 Xe-133 Correlation Factor, cpm/μCi/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:

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

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

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

where:

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

$$Trip\,1\ =\ \text{Trip 2} \times 0.7\ =\ 2.10E+06\ \text{cpm}$$

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/μCi/cc.

EMF 39 Trip 2 Setpoint Based on Sample Concentration

For EMF 39 if the containment Xe-133 equivalent is ≤ 2.0E-05 μCi/ml, then 2.0E-05 μCi/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 μCi/ml:

$$\text{Trip 2 setpoint} = (C_{Xe-133} \times CF_{Xe-133} \times 2.0) + \text{bkg}\ \ \textbf{or}\ \ 3 \times \text{bkg}, \text{ whichever is higher.}$$

When $Xe-133$ equivalent concentration $> 2.0E-05$ µCi/ml:

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

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

where:

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

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

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

bkg = EMF 39 background.

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

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:

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

where:

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

$CF_{Xe\text{-}133}$ = EMF 36 Xe-133 correlation factor, 2.66E+07 cpm/µCi/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 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 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 ≤ 1.07E-03 μCi/ml, then 1.07E-03 μCi/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 μCi/ml:

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

whichever is higher.

When $Xe-133$ equivalent concentration $>$ 1.07E-03 μCi/ml:

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

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

where:

350 cfm = VQ flow rate.

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

CF_{Xe-133} = EMF 36 Xe-133 correlation factor, 2.66E+07 cpm/μCi/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

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

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

$$Trip\,1 = \text{Trip 2} \times 0.7 = 3.50E+04 \text{ cpm}$$

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/μCi/cc.

EMF 39 Trip 2 Setpoint Based on Sample Concentration

For EMF 39 if the containment Xe-133 equivalent is ≤ 2.0E-05 μCi/ml, then 2.0E-05 μCi/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 $\le$ 2.0E-05 μCi/ml:

$$\text{Trip 2 setpoint} = (\text{C}_{\text{Xe-133}} \times \text{CF}_{\text{Xe-133}} \times 2.0) + \text{bkg} \ \ \textbf{or} \ \ 3 \times \text{bkg}\text{, whichever is higher.}$$

When $Xe-133$ equivalent concentration $>$ 2.0E-05 μCi/ml:

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

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

where:

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

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

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

bkg = EMF 39 background.

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

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:

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

where:

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

$CF_{Xe\text{-}133}$ = EMF 36 Xe-133 correlation factor, 2.66E+07 cpm/µCi/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 < 7.50E+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 ≥ 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 ≤ 1.45E-05 μCi/ml, then 1.45E-05 μCi/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 μCi/ml:

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

whichever is higher.

When $Xe-133$ equivalent concentration $>$ 1.45E-05 μCi/ml:

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

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

where:

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

CF_{Xe-133} = EMF 36 Xe-133 correlation factor, 2.66E+07 cpm/μCi/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

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

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

$$Trip\,1 = \text{Trip } 2 \times 0.7 = 7.70E+05 \text{ cpm}$$

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 µCi/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 µCi/ml:

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

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

where:

Maximum EMF 50 Trip 2 Setpoint = 1.10E +06 cpm

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

$CF_{Xe\text{-}133}$ = EMF 50 Xe-133 pressure corrected correlation factor, 1.39E+06 cpm/µCi/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 ≤ 1.00E -04 µCi/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:

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

where:

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

$CF_{Xe\text{-}133}$ = EMF 50 Xe-133 pressure corrected correlation factor, 1.39E+06 cpm/µCi/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:

$$Expected\ cpm = \frac{50\,\text{cfm} \times \text{C}_{\text{Xe - 133}} \times \text{CF}_{\text{Xe - 133}}}{\text{F}_{\text{UV}}} + \text{bkg}$$

where:

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

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

<u>Maximum EMF 36 Trip 2 Setpoint</u>

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.

<u>EMF 36 Trip 2 Setpoint Based on Sample Concentration</u>

For EMF 36 if the WG Tank Xe-133 equivalent is ≤ 7.50E-03 µCi/ml, then 7.50E-03 µCi/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 µCi/ml:

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

whichever is higher.

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

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

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

where:

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

$CF_{Xe\text{-}133}$ = EMF 36 Xe-133 correlation factor, 2.66E+07 cpm/μCi/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:

$$Dose_{oa} = \sum_{p} \sum_{i} \left(A_{oapi} \times C_i \right) \times \Delta t \times F_n \times \frac{1}{D_w}$$

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

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 µCi/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)/(µCi-hr-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 = 4.32E+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 µCi/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)/(µCi-hr-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 = 8.64E+04 sec (1 day). From Regulatory Guide 1.109, Table E-15.

Shoreline Sediment

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

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 µCi/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)/(µCi-hr-l).
100	Proportionality constant used in the sediment radioactivity model, (liters/(m^2-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
$T_i^{½}$	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

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

Formula: adapted from NUREG-0133, page 28.	
Where:	
$Dose_{\gamma}$	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 $\mu Ci/m^3$). (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

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

Formula: adapted from NUREG-0133, page 28.	
Where:	
$Dose_{\beta}$	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 $\mu Ci/m^3$). (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

$$Dose_{oa} = 3.17 \times 10^{-8} \times W \times \sum_{p} \sum_{i} \left(R_{oapi} \times Q_i \right)$$

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 $\mu Ci/m^3$. When a D/Q is used the units are ($m^2 \cdot$ mrem/yr) per μCi/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.	
	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})
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·mrem/yr per µCi/sec). (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 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 µCi/m^3). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/µCi (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·mrem/yr per µCi/sec). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/µCi (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 (5.73×10^{-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^L_a	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^S_a	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

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

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 μCi/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^L_a	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^S_a	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 gm/m^3, from Regulatory Guide 1.109).

Vegetation – Carbon-14

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

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 µCi/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).
$U^L{}_a$	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).
$U^S{}_a$	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·mrem/yr per µCi/sec). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/µCi (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 (5.73×10^{-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-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

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

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 µCi/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 gm/m^3, from Regulatory Guide 1.109).

Grass/Cow/Milk – Carbon-14

$$R_{oapi} = \mathrm{K'K'''}\,\mathrm{F}_{mi}\,\mathrm{Q}_{F}\,\mathrm{U}_{ap}\,(DFL_{oi})_a \left[0.11/0.16\right](p)(f_I)$$

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 µCi/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 μCi/sec). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/μCi (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 (5.73×10^{-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

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

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 µCi/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 gm/m^3, from Regulatory Guide 1.109).

Grass/Goat/Milk – Carbon-14

$$R_{oapi} = \mathrm{K'K'''}\,\mathrm{F}_{mi}\,\mathrm{Q}_{F}\,\mathrm{U}_{ap}\,(DFL_{oi})_a \left[0.11/0.16\right](p)(f_I)$$

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 μCi/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 µCi/sec). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/µCi (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 (5.73×10^{-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

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

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 µCi/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 gm/m^3, from Regulatory Guide 1.109).

Grass/Cow/Meat – Carbon-14

$$R_{oapi} = \mathrm{K'K'''}\, \mathrm{F}_{fi}\, \mathrm{Q}_{F}\, \mathrm{U}_{ap}\, (DFL_{oi})_a \left[0.11/0.16\right](p)(f_I)$$

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 µCi/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 μCi/sec). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/μCi (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 (5.73×10^{-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

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

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 μCi/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 gm/m^3, from Regulatory Guide 1.109).

Grass/Goat/Meat – Carbon-14

$$R_{oapi} = \mathrm{K'K'''}\,\mathrm{F}_{fi}\,\mathrm{Q}_F\,\mathrm{U}_{ap}\,(DFL_{oi})_a\left[0.11/0.16\right](p)(f_I)$$

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 μCi/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

Fish Sampling

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 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						
215 C	River Pointe - Hwy 49 (4.21 mi NNE)		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	T-Bones Restaurant / Lake Wylie Marina - Hwy 49 (4.19 mi NNE)				SA					

(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.

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.

Figure 6.0-1 Sampling Locations Map (Site Boundary)

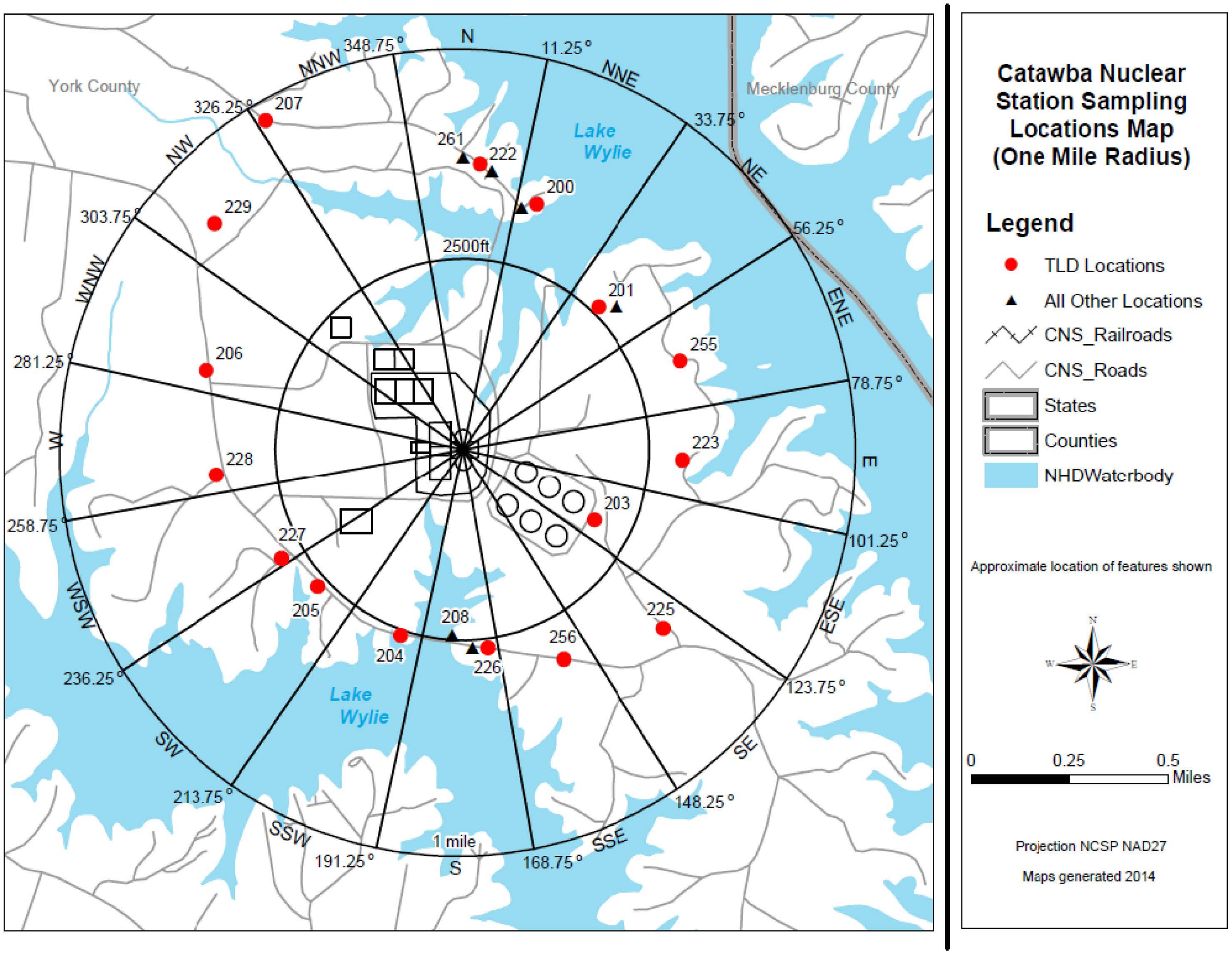


Figure 6.0-2 Sampling Locations Map (Ten Mile Radius)

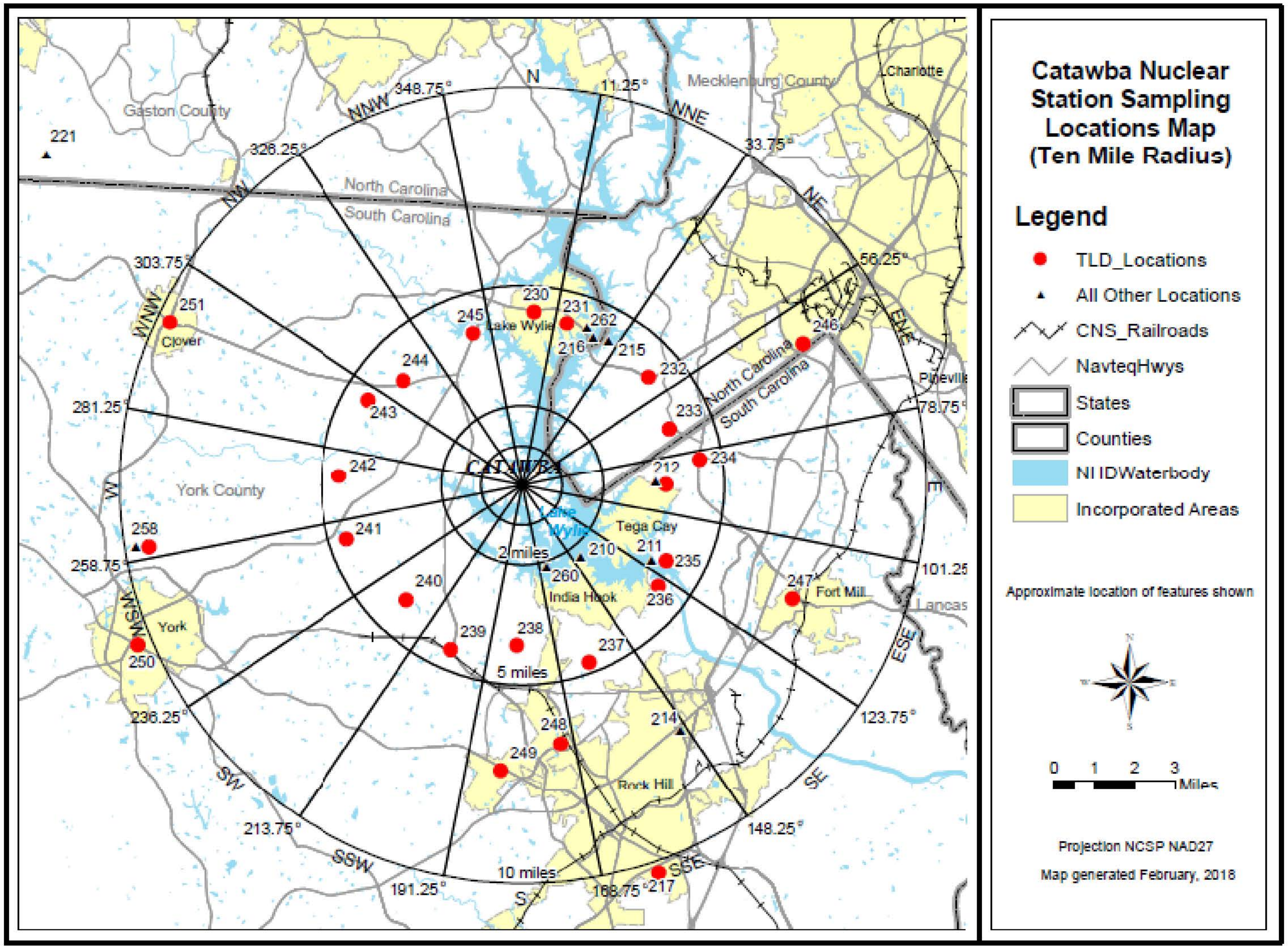


Figure 6.0-3 Land Use Census Map

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 m^2), 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)

	(χ/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/m^3)

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/m^3 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.

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 62
ODCM Revision 62 was approved by the Radiation Protection Manager on 9/12/2018. 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 4 - Page 1
Reworded 4.0.1 from:
"There are two liquid 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). 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…"
to:
"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…"

Reworded for clarification and formatting only. No technical changes.

Section 4 - Page 7
Added 'Grass/Goat/Meat' Pathway and set Factor Used as 'D/Q (m^{-2})' to W parameter in table for $Dose_{oa}$ formula per DRR 02209371.

Section 4 - Page 21 to 23
Added R_{oapi} equations and parameters for newly added Grass/Goat/Meat pathway per DRR 02209371.

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 µCi/sec). (See Appendices G through J for age group and pathway specific dose commitment factors).
K'	Units conversion factor pCi/µCi (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 (5.73×10^{-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

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

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 μCi/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 gm/m^3, from Regulatory Guide 1.109).

Grass/Goat/Meat – Carbon-14

$$R_{oapi} = \mathrm{K'K'''}\,\mathrm{F}_{fi}\,\mathrm{Q}_{F}\,\mathrm{U}_{ap}\,(DFL_{oi})_a\left[0.11/0.16\right](p)(f_I)$$

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 μCi/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.

Appendix C, D, E, and F

Added dose factors for Se-75, Ag-108m, Sn-113, Sn-117m, Sb-124, Sb-125, Sb-126, Te-123m, Ba-133, and Eu-152 to Appendix C, D, E, and F for all age groups and applicable pathways per DRR 02195639. Assessment of Oconee Count Room determined not all radionuclides listed on liquid waste release permits have dose factors in the ODCM. Dose factors developed using method described in CSD-RP-ALL-0028.

Appendix G, H, and I

Added tables for Adult, Teen, and Child Grass/Goat/Meat pathway dose factors to Appendix G, H, and I respectively per DRR 02209371. Dose factors developed using method described in CSD-RP-ALL-0029.

APPENDIX A

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

Nuclide	K_i Total Body mrem/yr/ µCi/m^3	L_i Skin mrem/yr/ µCi/m^3	M_i Gamma Air mrad/yr/ µCi/m^3	N_i Beta Air mrad/yr/ 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
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 / µCi/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 / µCi/m³	
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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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

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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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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 / µCi/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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	m²·mrem/yr / µCi/sec; mrem/yr / µCi/m³ (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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2\cdot$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:	$m^2 \cdot mrem/yr$ / $\mu Ci/sec$; $mrem/yr$ / $\mu Ci/m^3$ (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 / $\mu Ci/m^3$	
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 / µCi/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 / µCi/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:	$m^2 \cdot$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:	$m^2 \cdot mrem/yr$ / 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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	m²·mrem/yr / µCi/sec; mrem/yr / µCi/m³ (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:	m²·mrem/yr / µCi/sec; mrem/yr / µCi/m³ (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:	m²·mrem/yr / μCi/sec; mrem/yr / μCi/m³ (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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot mrem/yr$ / $\mu Ci/sec$; $mrem/yr$ / $\mu Ci/m^3$ (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:	$m^2 \cdot$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:	$m^2 \cdot mrem/yr$ / µCi/sec; mrem/yr / $\mu Ci/m^3$ (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 / µCi/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 / µCi/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 / µCi/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:	$m^2 \cdot mrem/yr$ / $\mu Ci/sec$	
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:	$m^2 \cdot mrem/yr$ / $\mu Ci/sec$	
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:	$m^2 \cdot mrem/yr$ / 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:	$m^2 \cdot$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:	$m^2\cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	m²·mrem/yr / µCi/sec; mrem/yr / µCi/m³ (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:	$m^2 \cdot$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:	$m^2\cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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 / µCi/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 / µCi/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 / µCi/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:	$m^2 \cdot mrem/yr$ / 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:	$m^2 \cdot mrem/yr$ / $\mu Ci/sec$	
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:	$m^2 \cdot$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:	$m^2 \cdot$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:	$m^2 \cdot$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:	m²·mrem/yr / µCi/sec; mrem/yr / µCi/m³ (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

Catawba Nuclear Station
Offsite Dose Calculation Manual (ODCM)

APPENDIX J

R_i Infant Dose Factors for use in the Gaseous Dose Calculations

Agegroup:	INFANT	Pathway:	Grs/Goat/Milk (GMILK)			Units:	$m^2 \cdot$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:	$m^2 \cdot$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 / µCi/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 / µCi/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 / µCi/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:	$m^2 \cdot mrem/yr$ / $\mu Ci/sec$	
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:**	**$m^2 \cdot mrem/yr$ / $\mu Ci/sec$**	
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:	$m^2 \cdot$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

SECTION	REVISION NUMBER	REVISION DATE
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	4	09/15/16
16.5-2	Deleted	
16.5-3	1	02/20/04
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	2	12/22/08
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	1	08/21/09
16.6-5	2	01/09/13
16.7-1	1	08/21/09
16.7-2	4	02/03/11
16.7-3	4	07/27/13
16.7-4	2	08/21/09
16.7-5	2	08/21/09

LIST OF EFFECTIVE SECTIONS

SECTION	REVISION NUMBER	REVISION DATE
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	7	03/28/16
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	2	02/20/12
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	10	07/12/18
16.9-6	12	07/03/18

LIST OF EFFECTIVE SECTIONS

SECTION	REVISION NUMBER	REVISION DATE
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	0	10/09/02
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

SECTION	REVISION NUMBER	REVISION DATE
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	2	03/28/16
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

SECTION	REVISION NUMBER	REVISION DATE
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
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

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)	5x10^{-7}
			I-131	1x10^{-6}
	Prior to each release One Batch/31 days	31 days	Dissolved and Entrained Gases (Gamma Emitters)	1x10^{-5}
	Prior to each release Each Batch	31 days Composite(4)	H-3	1x10^{-5}
			Gross Alpha	1x10^{-7}
	Prior to each release Each Batch	92 days Composite(4)	Sr-89, Sr-90	5x10^{-8}
2. Continuous Releases(5) Conventional Waste Water Treatment Line	Continuous(6)	7 days Composite(6)	Principal Gamma Emitters(3)	5x10^{-7}
			I-131	1x10^{-6}
	31 days Grab Sample	31 days	Dissolved and Entrained Gases (Gamma Emitters)	1x10^{-5}
	Continuous(6)	31 days Composite(6)	H-3	1x10^{-5}
			Gross Alpha	1x10^{-7}
	Continuous(6)	92 days Composite(6)	Sr-89, Sr-90	5x10^{-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:

$$LLD = \frac{(2.71/T) + 4.65 s_b}{E \cdot V \cdot 2.22 \; x \; 10^6 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

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 x 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 $5x10^{-6}$ µCi/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
		OR		
		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.	Prior to initiating a release
	<u>AND</u>	
	C.1.2 Perform independent verification of the discharge line valving.	Prior to initiating a release
	<u>AND</u>	
	C.1.3.1 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.1.3.2 Perform independent verification of entire calculations for release rate calculations performed manually.	Prior to initiating a release
	<u>AND</u>	
	C.1.4 Restore channel to FUNCTIONAL status.	14 days
	<u>OR</u>	
	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> Once per 24 hours during releases when secondary specific activity is $\leq$ 0.01 microCurie/gm DOSE EQUIVALENT I-131
	<u>AND</u>	
	E.2 Restore channel to FUNCTIONAL status.	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
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.	18 months

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 $\leq$ 1.5 mrem to the whole body and to $\leq$ 5 mrem to any organ, and

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

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Calculated dose from release of radioactive materials in liquid effluents exceeding above limits.	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.	30 days

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
A. Radioactive liquid waste being discharged without treatment and in excess of above limits. <u>AND</u> Any portion of Liquid Radwaste Treatment System not in operation.	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.	30 days

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:

$$\frac{264}{V} \cdot \sum_{j} \frac{A_j}{(C_j \; x\,10)} < 1.0$$

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
A. Quantity of radioactive material in any CTP exceeding above limit.	A.1 Suspend all additions of radioactive material to the CTP.	Immediately
	<u>AND</u>	
	A.2 Initiate corrective action to reduce the CTP contents to within limits.	Immediately

TESTING REQUIREMENTS

	TEST	FREQUENCY
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: $\sum_{j} \frac{c_j}{(C_j \; x \, 10)} < 0.006$, where: c_j = radioactive resin/water slurry concentration for radionuclide "j" entering the UNRESTRICTED AREA CTPs, in microCuries/milliliter; and C_j = 10 CFR 20, Appendix B, Table 2, Column 2, concentration for single radionuclide "j", in microCuries/milliliter.	Prior to each transfer

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:

$$\sum_{j} \frac{c_j}{(C_j \text{ x } 10)} < \frac{3 \text{ mrem/yr}}{500 \text{ mrem/yr}} = 0.006 ,$$

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: $\leq$ 500 mrem/yr to the whole body and $\leq$ 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: $\leq$ 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)	$1x10^{-4}$
		31 days	H-3 (oxide)	$1x10^{-6}$
3. Unit Vent	7 days(3)(4) Grab Sample	7 days(3)	Principal Gamma Emitters(2)	$1x10^{-4}$
			H-3 (oxide)	$1x10^{-6}$
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	$1x10^{-12}$
			I-133	$1x10^{-10}$
	Continuous(6)	7 days(7) Particulate Sample	Principal Gamma Emitters(2)	$1x10^{-11}$
	Continuous(6)	31 days Composite Particulate Sample	Gross Alpha(8)	$1x10^{-11}$
	Continuous(6)	92 days Composite Particulate Sample	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)	$1x10^{-4}$
			H-3 (oxide)	$1x10^{-6}$
	Continuous(6)	7 days(9) Charcoal Sample	I-131	$1x10^{-12}$
			I-133	$1x10^{-10}$
	Continuous(6)	7 days(9) Particulate Sample	Principal Gamma Emitters(2)	$1x10^{-11}$
	Continuous(6)	31 days Composite Particulate Sample	Gross Alpha	$1x10^{-11}$
	Continuous(6)	92 days Composite Particulate Sample	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:

$$\text{LLD} = \frac{(2.71/T) + 4.65\, s_b}{E \cdot V \cdot 2.22\ x\ 10^6 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

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 <u>a</u> <u>priori</u> (before the fact) limit representing the capability of a measurement system and not as an <u>a</u> <u>posteriori</u> (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} μCi/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} μCi/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 mrems. 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 mrems for isotopes for which inhalation or ingestion is limiting or 100 mrems for isotopes for which submersion (noble gases) is limiting. Since release concentrations corresponding to limiting dose rates less than or equal to 500 mrems/year to the whole body, 3000 mrems/year to the skin from noble gases, and 1500 mrems/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 mrems/year) or the dose rate associated with the EC value for isotopes based on submersion (100 mrems/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 mrems in a year. When applied on an instantaneous basis, this corresponds to a dose rate of 50 or 100 mrems/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 mrems/year to the whole body and 3000 mrems/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 $1x10^{-4}$ µCi/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 $5x10^{-9}$ µCi/ml, which has historically been applied and achieved for analytical results, and I-133, LLD of $1x10^{-10}$ µCi/ml, which again has been historically listed, as $1x10^{-9}$ µCi/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.

16.11 RADIOLOGICAL EFFLUENTS 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 their Alarm/Trip Setpoints set to ensure that the limits of SLC 16.11-6 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 16.11-7-1.

REMEDIAL ACTIONS

---NOTE---
Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more Radioactive Gaseous Effluent Monitoring Instrumentation channel(s) Alarm/Trip Setpoint less conservative than required.	A.1 Suspend the release of radioactive gaseous effluents monitored by the affected channel(s).	Immediately
	OR	
	A.2 Declare the channel(s) non-functional.	Immediately
B. One or more Radioactive Gaseous Effluent Monitoring Instrumentation channel(s) non-functional.	B.1 Enter the applicable Conditions and Required Actions specified in Table 16.11-7-1 for the channel(s).	Immediately

(continued)

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
	OR	
	C.2.1 Analyze two independent samples of the tank's contents.	Prior to initiating a release
	AND	
	C.2.2 Perform independent verification of the discharge line valving.	Prior to initiating a release
	AND	
	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
	OR	
	C.2.3.2 Perform independent verification of entire calculations for release rate calculations performed manually.	Prior to initiating a release
	AND	
	C.2.4 Restore channel to FUNCTIONAL status.	14 days
	OR	
	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
F. Noble Gas Activity Monitor (EMF-39 – Low Range) providing automatic termination of release via the Containment Purge Exhaust System (CPES) non-functional.	F.1 -------------NOTE-------------- In order to utilize Required Action F.1, the following conditions must be satisfied: 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. ----------------------------------- Restore the non-functional channel to FUNCTIONAL status.	 12 hours
G. Required Action and associated Completion Time of Condition F not met. <u>OR</u> Required Action F.1 not utilized.	G.1 Suspend PURGING of radioactive effluents via this pathway.	Immediately

(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
	AND	
	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
	AND	
	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
	AND	
		(continued)

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
I. (continued)	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.	Once per 12 hours during releases when secondary specific activity is > 0.01 microCurie/gm DOSE EQUIVALENT I-131 <u>AND</u> Once per 24 hours during releases when secondary specific activity is $\leq$ 0.01 microCurie/gm DOSE EQUIVALENT I-131
	<u>AND</u>	
	I.4 Restore channel to FUNCTIONAL status.	30 days
J. Noble Gas Activity Monitor (EMF-39 – Low Range) providing automatic termination of release via the Containment Air Release and Addition System non-functional.	J.1 Verify that EMF-36 is FUNCTIONAL.	Prior to initiating a release
	<u>OR</u>	
	J.2.1 Analyze two independent samples of the containment atmosphere. <u>AND</u>	Prior to initiating a release
		(continued)

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
J. (continued)	J.2.2 Perform independent verification of the discharge line valving. AND	Prior to initiating a release
	J.2.3.1 Perform independent verification of manual portion of the computer input for release rate calculations performed by computer. OR	Prior to initiating a release
	J.2.3.2 Perform independent verification of entire calculations for release rate calculations performed manually. AND	Prior to initiating a release
	J.2.4 --------------NOTE------------- If channel remains or is anticipated to remain non-functional for $\geq$ 90 days, re-evaluate the configuration of the affected unit in accordance with the applicable portions of 10 CFR 50.59 and 10 CFR 50.65(a)(4) prior to expiration of the 90-day period. ------------------------------------ Restore channel to FUNCTIONAL status.	30 days

(continued)

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
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.	31 days
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: a. Instrument indicates measured levels above the Alarm/Trip Setpoint, or b. Circuit failure/instrument downscale failure (alarm only) -- Perform COT.	9 months
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: a. Instrument indicates measured levels above the Alarm/Trip Setpoint, or b. Circuit failure/instrument downscale failure (alarm only) -- Perform COT.	18 months

(continued)

TESTING REQUIREMENTS (continued)

	TEST	FREQUENCY
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.	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} μCi/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: $\leq$ 5 mrad for gamma radiation and $\leq$ 10 mrad for beta radiation, and

b. During any calendar year: $\leq$ 10 mrad for gamma radiation and $\leq$ 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: $\leq$ 7.5 mrem to any organ, and

b. During any calendar year: $\leq$ 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.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-11 Solid Radioactive Wastes

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 the PROCESS CONTROL PROGRAM 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 Part 61 licensed disposal site. Wastes shipped for offsite processing in accordance with the processor's specifications and transportation requirements are not required to be solidified or dewatered to meet disposal requirements.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Applicable regulatory requirements for solidified or dewatered wastes not satisfied.	A.1 Suspend shipment of inadequately processed waste.	Immediately
	AND	
	A.2 Take action to correct the PROCESS CONTROL PROGRAM, procedures, or solid waste equipment as necessary to prevent recurrence.	Prior to next shipment for disposal of solidified or dewatered wastes

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. Solidification test as described in the PROCESS CONTROL PROGRAM fails to verify solidification.	B.1 Suspend solidification of the batch under test and follow PROCESS CONTROL PROGRAM guidance for test failures.	Immediately
	AND	
	B.2 --------------NOTE------------- Once a subsequent test verifies solidification, solidification of the batch may be resumed as directed by the PROCESS CONTROL PROGRAM. ------------------------------------ Modify the PROCESS CONTROL PROGRAM as required to assure solidification of subsequent batches of waste.	Prior to next solidification for shipment of waste for disposal at a 10 CFR Part 61 disposal site
C. Solidification or dewatering for disposal not performed in accordance with the PROCESS CONTROL PROGRAM.	C.1 Reprocess the waste in accordance with PROCESS CONTROL PROGRAM requirements.	Prior to shipment for disposal of the inadequately processed waste that requires solidification or dewatering
	OR	
	C.2 Follow PROCESS CONTROL PROGRAM 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

(continued)

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.	In a time frame supporting COMMITMENT
	<u>OR</u>	
	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

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."

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-12 Total Dose

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 mrem to the whole body or any organ, except the thyroid, which shall be limited to ≤ 75 mrem.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Calculated doses from releases exceeding twice the specified limits of SLC 16.11-3, SLC 16.11-8, or SLC 16.11-9.	A.1 Verify, by calculation, that the cumulative dose from direct radiation contributions and outside storage tanks and radioactivity releases are within the total dose limit.	Immediately
	AND	
	A.2 --------------NOTE------------- Only required to be performed if the total dose limit is exceeded. ------------------------------------	
	Prepare and submit a Special Report to the NRC which identifies corrective actions to be taken to reduce subsequent releases to prevent recurrence and schedule for achieving conformance with specified limits.	30 days

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
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.	In the next scheduled Annual Radiological Environmental Operating Report pursuant to Technical Specification 5.6.2
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.	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.	30 days

(continued)

REMEDIAL ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
C. Milk or fresh leafy vegetation samples unavailable from one or more sample location(s) required by Table 16.11-13-1.	C.1 --------------NOTE------------- Specific location(s) from which samples were unavailable may be deleted from the program. ------------------------------------	
	Revise the Radiological Environmental Monitoring Program to identify location(s) for obtaining replacement samples.	30 days
	<u>AND</u>	
	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).	In the next scheduled Annual Radioactive Effluent Release Report pursuant to Technical Specification 5.5.1

TESTING REQUIREMENTS

TEST	FREQUENCY
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. ---	
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.	In accordance with Table 16.11-13-1

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]	Forty routine monitoring stations either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, placed as follows: An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY; An outer ring of stations, one in each meteorological sector in the 6- to 8-km range from the site; and 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.	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
2. Airborne Radioiodine and Particulates	Samples from five locations. Three samples from close to the three SITE BOUNDARY locations, in different sectors, of the highest calculated annual average ground-level D/Q; One sample from the vicinity of a community having the highest calculated annual average ground-level D/Q; and One sample from a control location, as for example 15 to 30 km distant and in the least prevalent wind direction.	Continuous sampler operation with sample collection weekly, or more frequently if required by dust loading.	<u>Radioiodine Canister</u>: I-131 analysis weekly. <u>Particulate Sampler</u>: Gross beta radioactivity analysis following filter change; [3] and gamma isotopic analysis [4] of composite (by location) quarterly.

(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
3. Waterborne			
a. Surface(5)	One sample upstream. One sample downstream.	Composite sample over 1-month period (6).	Gamma isotopic analysis (4) monthly. Composite for tritium analysis quarterly.
b. Ground	Samples from one or two sources only if likely to be affected(7).	Quarterly	Gamma isotopic (4) and tritium analysis quarterly.
c. Drinking	One sample of each of one to three of the nearest water supplies that could be affected by its discharge. One sample from a control location.	Composite sample over 2-week period (6) when I-131 analysis is performed; monthly composite otherwise.	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 (4) monthly. Composite for tritium analysis quarterly.
d. Sediment from Shoreline	One sample from downstream area with existing or potential recreational value.	Semiannually	Gamma isotopic analysis (4) semiannually.

(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
4. Ingestion			
a. Milk	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[8]. One sample from milking animals at a control location 15 to 30 km distant and in the least prevalent wind direction.	Semimonthly when animals are on pasture; monthly at other times.	Gamma isotopic[4] and I-131 analysis semi-monthly when animals are on pasture; monthly at other times.
b. Fish and Invertebrates	One sample each of a predatory species, a bottom feeder and a forage species in vicinity of plant discharge area. One sample each of a predatory species, a bottom feeder and a forage 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.

(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
4. Ingestion (Continued)			
c. Food Products	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.	At time of harvest [9].	Gamma isotopic analyses [4] on edible portion.
	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.	Monthly, when available.	Gamma isotopic [4] and I-131 analysis.
	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, when available.	Gamma isotopic [4] and I-131 analysis.

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:

$$LLD = \frac{(2.71/T) + 4.65 s_b}{E \cdot V \cdot 2.22 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

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:

$$\frac{\text{concentration (1)}}{\text{reporting level (1)}} + \frac{\text{concentration (2)}}{\text{reporting level (2)}} + \ldots \geq 1.0$$

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.

16.11 RADIOLOGICAL EFFLUENTS CONTROLS

16.11-14 Land Use Census

COMMITMENT

---NOTE---
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. Requirements for broad leaf vegetation sampling in Table 16.11-13-1 (Item 4c) shall be followed, including analysis of control samples.

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 > 50 m^2 (500 ft^2) producing broad leaf vegetation.

APPLICABILITY: At all times.

REMEDIAL ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Location(s) identified which yield a calculated dose or dose commitment greater than values currently calculated in SLC 16.11-9.	A.1 Identify the new location(s) in the Annual Radioactive Effluent Release Report.	In the next scheduled Annual Radioactive Effluent Release Report pursuant to Technical Specification 5.6.3
B. Location(s) identified which yield a calculated dose or dose commitment (via same exposure pathway) 20% greater than at a location from which samples are currently being obtained in accordance with SLC 16.11-13.	B.1 Add the new location(s) to the Radiological Environmental Monitoring Program. <u>AND</u>	30 days

(continued)

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
TR 16.11-14-1 --------------------------------NOTE-------------------------------- The results of the Land Use Census shall be included in the Annual Radiological Environmental Operating Report pursuant to Technical Specification 5.6.2. -- 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.	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 m^2 provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored since a garden of this size is the minimum required to produce the quantify (26 kg/year) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were made: (1) 20% of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage), and (2) a vegetation yield of 2 kg/m^2.

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

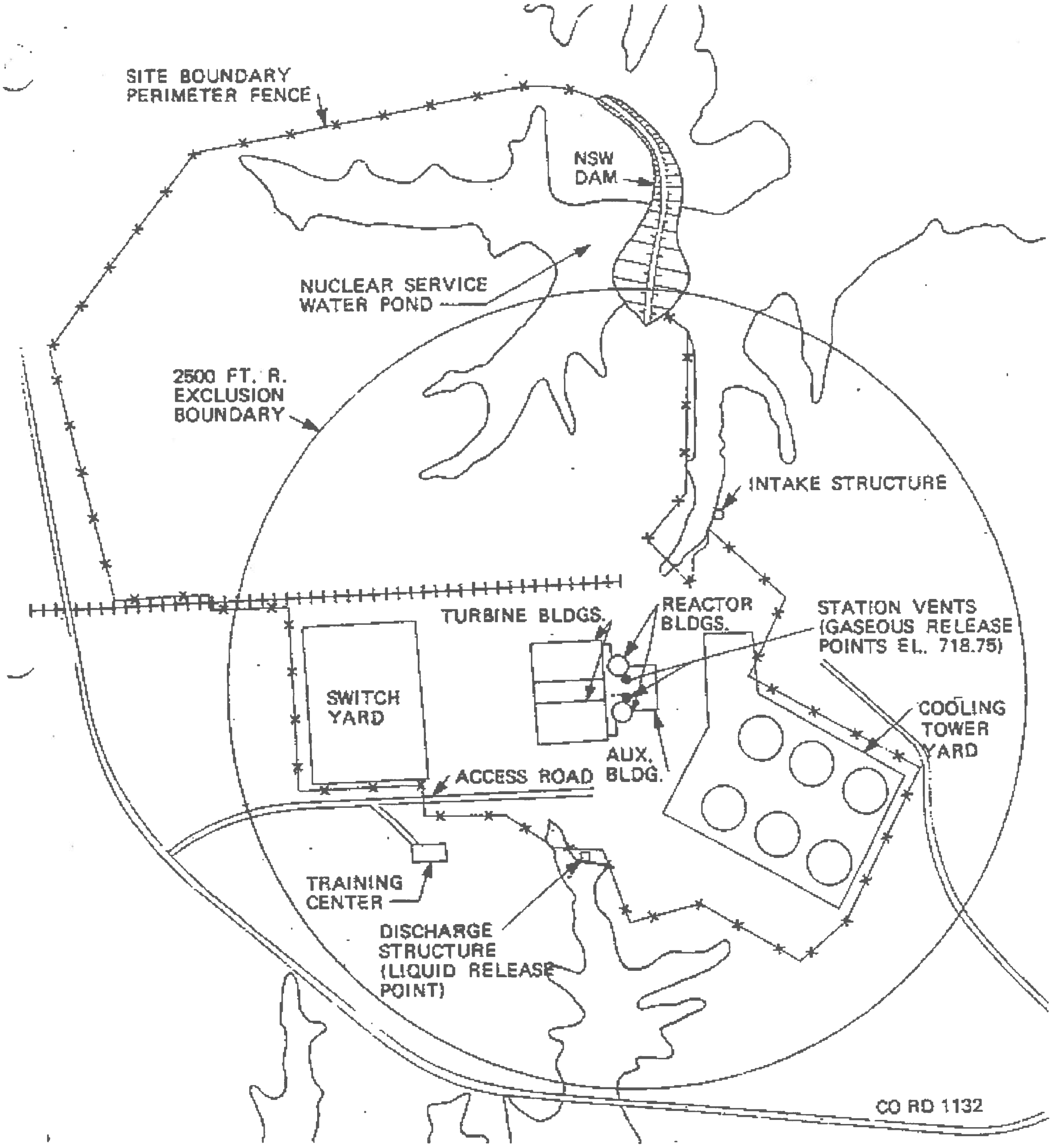

Figure 16.11-16-1

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 $\leq$ 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
	AND	
	A.2 Reduce tank(s) contents to within limit.	48 hours
	AND	
	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 ≤ 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 ≤ 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 ≤ 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 ≤ 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
	AND	
	A.2 Reduce tank(s) contents to within limit.	48 hours
	AND	
	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
	AND	
	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
	AND	
	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
TR 16.11-20-3 --------------------------------NOTE-------------------------------- 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) and four volume percent oxygen (for the oxygen monitors), with the balance nitrogen, shall be used in the calibration to check linearity of the analyzer. --- Perform CHANNEL CALIBRATION.	92 days

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/inservice train per station	TR 16.11-20-1 TR 16.11-20-2 TR 16.11-20-3
2.	Oxygen Monitors	2/inservice 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.

0WGMT6540 and 0WGMT6560 provide both an alarm and a trip function. 0WGMT6160 and 0WGMT6161 provide an alarm-only function.

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

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 1/1/2018 - 12/31/2018

The Catawba Nuclear Station PCP was revised in 2018.

The PCP consists of two parts:

- Duke Energy Carolinas (DEC) Corporate PCP, Rev. 016, approved 12/17/2018
- CNS Process Control Program, Rev. 014, approved 11/6/2018

Both documents were substantial revisions, so the entire documents are included in this report with change bars noted. Revision summaries for the individual documents are given in Section 11 of the DEC Corporate PCP document and Section 5 of the CNS PCP document.

DUKE ENERGY

Facility Code :	NGD
Applicable Facilities :	CN;MC;ON
Document Number :	DEC Corporate PCP
Document Revision Number :	016
Document EC Number :	
Change Reason :	DRR 02212730
Document Title :	DEC Corporate Process Control Program

Vaught, David L	Preparer	11/26/2018
Hammel, Lee A	PCP SME Reviewer	11/26/2018
Bowser, Ricky A.	PCP SME ONS RP	11/28/2018
Wald, Johnny D	PCP SME ONS Operations	11/26/2018
Reid, Orlando M	PCP SME MNS Operations	11/27/2018
Litaker, Jeffrey R	PCP SME MNS RP	11/26/2018
Williams, Doug	PCP SME CNS Operations	11/30/2018
Campbell, Darcy L.	PCP SME CNS RP	11/26/2018
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Notes :

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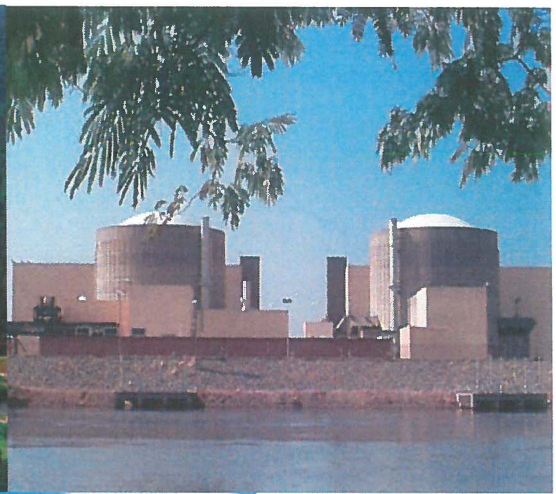
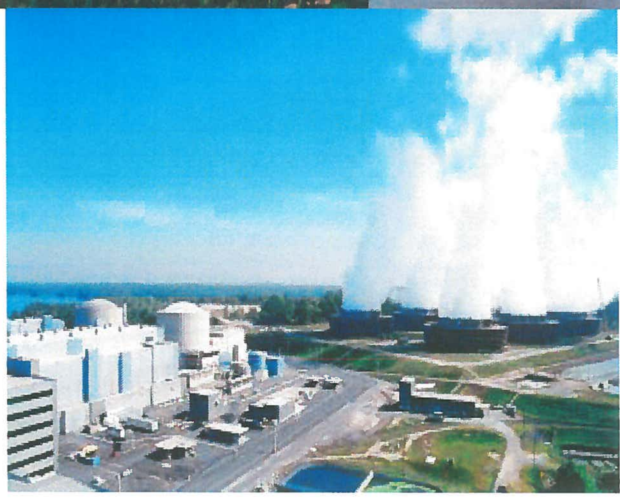
Revision 16 (DRR 02212730)

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1. INTRODUCTION

1.1 Purpose

The Duke Energy Carolinas (DEC) Radioactive Waste Process Control Program (PCP) addresses the requirements for solid radioactive waste referenced in Selected Licensing Commitments and Technical Specifications for DEC nuclear stations.

1.1.1 A Process Control Program (PCP) describes the administrative and operational controls used for the solidification of liquid or wet radioactive wastes and the dewatering of wet radioactive wastes. Its purpose is to assure that the final disposal waste product meets applicable Federal, State and Disposal Site waste form requirements for burial at a 10CFR61 licensed Low-Level Waste (LLW) disposal site.

1.1.2 Waste processing (solidification or dewatering) equipment and services may be provided by Duke Energy or approved vendors. Vendor services may be performed onsite or offsite. Any process used shall meet all applicable requirements of the Process Control Program.

1.1.3 For waste processed onsite for direct disposal it is the responsibility of the LLW generator/ shipper to ensure that PCP requirements are met and that the condition of the waste is acceptable upon arrival at the disposal site.

1.1.4 For waste packaged and shipped to an approved off-site processor contracted to meet the requirements for direct disposal at a 10CFR61 licensed Low-Level Waste (LLW) disposal site, the final waste form requirements are not applicable prior to shipment to the processor for final processing and disposition.

1.2 Description of Duke Energy PCP Documents

1.2.1 [ONS, MNS, CNS] The DEC PCP guidance is contained in the following documents published in the EDMS

- DEC Corporate PCP: Program requirements
- DEC Site PCP Documents: PCP Implementing documents

1.2.2 [BNP, HNP, RNP] The Duke Energy Progress (DEP) PCP documents are site specific licensing documents maintained by the DEP site PCP SMEs

1.3 Radioactive Waste Process Control Program Document Location

The Duke Radioactive Waste PCP documents satisfy NRC requirements for a Process Control Program. They are published electronically as controlled copy files of the documents maintained in the Duke EDMS.

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2. APPLICABILITY

2.1 Liquid and Wet Radioactive Waste Disposal

2.1.1 Licensing documents, e.g., Final Safety Analysis Reports (FSAR), tech Specs and SLCs, require that the Solid Radwaste System be operated in a manner to assure compliance with requirements for the transportation and disposal of LLW. They refer to the NRC requirement to follow a process control program for 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 such that the final product meets all applicable disposal site requirements.

2.1.2 These "Process Control Program" requirements are applicable to all liquid or wet radioactive wastes that are being prepared for direct disposal at a 10CFR61 LLW disposal facility.

2.1.3 Radioactive 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 prior to shipment to an offsite processor. They are not subject to the final waste form solidification or dewatering requirements of this PCP as specified in 10CFR61 when an offsite processor is contracted to perform the PCP processing for disposal.

2.2 Mixed Waste

2.2.1 AD-EN-ALL-0700 "WASTE MANAGEMENT AND RECYCLING" (Superseded DEC EWP 2.9 "Mixed Waste") describes handling of mixed waste at Duke Energy nuclear stations.

2.2.2 Disposal of Mixed Waste at a Low Level Radioactive Waste disposal site is prohibited unless it is approved by the disposal site, meets federal, state and disposal site requirements. (E.g., 40CFR, 10CFR61, site WAC)

2.2.3 All vendors supplying services for Mixed Waste using solidification shall meet the applicable requirements of the PCP and be a DEC Approved Supplier of PCP Services.

2.2.4 PCP Subject Matter Experts (SMEs) and disposal site regulators shall approve the use of solidification for disposal of Mixed Waste.

2.2.5 If Mixed Waste is to be rendered non-hazardous for disposal at a 10CFR61 disposal site using solidification the final product and packaging must meet all the LLW disposal site requirements.

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2.3 Radioactive Waste Oil

2.3.1 Radioactively contaminated oil is to be managed as described in ENV-20-40 - "Managing Used Oil" (superseded EWP 2.8 “Used Oil”). This procedure is part of the Environmental Compliance Manual.

2.3.2 Offsite processors are available for waste oil treatment, (e.g., incineration) reducing the regulatory burden on the generating site. Nuclear site programs address the specific waste oil management processes available at the site.

2.3.3 Each LLW disposal site defines the acceptable threshold for incidental levels of waste petroleum-based oil (e.g., less than 1% by volume). Solidified waste containing oil shipped to a 10CFR61 disposal site shall meet the applicable requirements of the PCP and all applicable disposal site acceptance criteria.

2.3.4 If a LLW site accepts greater than incidental concentrations of oil to be solidified for disposal, an oil-specific procedure must meet the requirements of the PCP and the acceptance criteria of that disposal site.

2.4 Radioactive Waste Interim Storage

Sites that have LLW requiring interim storage shall ensure that all of the following requirements that are applicable are met.

2.4.1 Any radioactive waste that is stored for an interim period in a shipping/ disposal container shall be packaged such that there is no detrimental interaction between the waste and its container.

2.4.2 If applicable, Certificates of Compliance shall be maintained at each station for all waste shipping/ disposal containers used for interim storage.

2.4.3 Vendor supplied containers used for storage shall be handled and stored according to applicable guidance in vendor documents, including chemical compatibility requirements.

3. REFERENCES

3.1 Regulatory Requirements

The use of and content of the PCP addresses requirements found in the following regulations:

3.1.1 10CFR20, “Standards for Protection Against Radiation”

3.1.2 10CFR50, “Domestic Licensing of Production and Utilization Facilities”

3.1.3 10CFR61, “Licensing Requirements for Land Disposal of Radioactive Waste”

3.1.4 I0CFR7I, “Packaging and Transportation of Radioactive Materials”

3.1.5 40CFR, “Protection of Environment”

3.1.6 40 CFR Part 266 “Storage, Treatment, Transportation, and Disposal of Mixed Waste”

3.1.7 Licensed radioactive waste burial site criteria

3.1.8 State hazardous waste regulations

3.2 Regulatory Guidance and Industry Standards

Technical guidance is provided in the following documents to standardize compliance with the applicable regulations:

3.2.1 NUREG-0133, “Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants”

3.2.2 NUREG-0452, “Standard Technical Specifications for Westinghouse PWR's” (Superseded by NUREG 1431)

3.2.3 NUREG-1431 “Standard Technical Specifications Westinghouse Plants”

3.2.4 NUREG-1430 “Standard Technical Specifications Babcock and Wilcox Plants”

3.2.5 NUREG-800 “Standard Review Plan”, Section 11.4 “Solid Waste Management Systems”

3.2.6 NUREG 800, Section 11.4, Appendix -A, “Design Guidance for Temporary Onsite Storage of Low Level Radioactive Waste”

3.2.7 Branch Technical Position - ETSB 11-3, “Design Guidance of Solid Radioactive Waste Management Systems”

3.2.8 NRC Review Criteria for Solid Waste Management Systems

3.2.9 Regulatory Guide 1.143, “Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Plants”

3.2.10 NRC "TECHNICAL POSITION ON WASTE FORM" Revision 1 (January 1991)

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3.2.11 NRC "Concentration Averaging and Encapsulation Branch Technical Position", Rev 1 (2015)

3.2.12 ANSI/ANS-40.37-2009 “mobile radioactive waste processing systems”

3.3 DEC License Documents Referencing the PCP

3.3.1 ONS Technical Specifications 5

3.3.2 CNS SLC 16

3.3.3 MNS SLC 16

3.3.4 ONS SLC 16

3.3.5 ONS UFSAR Chapter 11

3.3.6 CNS UFSAR Chapter 11

3.3.7 MNS UFSAR Chapter 16

3.3.8 Duke Energy Corporation Topical Report: Quality Assurance Program Description Operating Fleet (DUKE-QAPD-001 -A)

3.4 DEC PCP Interfaces With Other Programs

3.4.1 AD-RP-ALL-5000, Preparation and Shipment of Radioactive Material and Radioactive Waste

3.4.2 AD-RP-ALL-5002, 10 CFR 61 Radioactive Waste Classification

3.4.3 Duke Energy Information Retention Policy

Ref: (Legal 109, 10CFR20 Appendix G (III.A.3), 10CFR61.80)

3.4.4 AD-DC-ALL-0002 Records Management

3.4.5 AD-DC-ALL-0201 Development and Maintenance of Controlled Procedure Manual Procedures

3.4.6 ENV-20-40 "Managing Used Oil"

3.4.7 AD-EN-ALL-0700 "WASTE MANAGEMENT AND RECYCLING"

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4. DEFINITIONS

4.1 Safety Analysis Report (SAR)

The station's Technical Specifications (Tech Specs) updated final safety analysis report, licensee commitments, safety evaluation reports and the facility operating license.

4.2 Selected Licensee Commitments (SLCs)

Commitments to control important plant equipment and operating conditions not controlled elsewhere. Operational commitments which are to be removed from existing station Tech Specs may be included in the SLC program. Also included in this program can be selected NRC commitments contained in licensing documents such as the station's SERs, LERs, violation responses, generic letter and bulletin responses, submittal documents and other Duke letters to the NRC.

4.3 10CFR Part 61 "Licensing Requirements for Land Disposal of Radioactive Waste"

This NRC regulation requires that low-level radioactive waste (LLW) meet certain waste form acceptance criteria to be received for disposal at NRC and Agreement State licensed radioactive waste disposal sites.

4.4 Free Standing Liquid (FSL)

FSL is liquid that is in a disposal container but is not bound by the waste in the container. FSL is the liquid available for release if disposal container integrity is lost (e.g., punctured). The amount of FSL in a radioactive waste disposal container shall be less than a specified threshold to meet 10CFR61, state and disposal site requirements for disposal.

4.5 Liquid Radioactive Wastes

Radioactive wastes comprised primarily of water containing a combination of dissolved and suspended solids (e.g., evaporator concentrates, lab wastes, floor and equipment drain water, laundry, wet waste decant or drainage, etc.).

4.6 Wet Radioactive Wastes

Wet radioactive wastes are solid radioactive wastes containing loosely bound liquid that can collect in the disposal container as FSL (e.g., slurry wastes are comprised primarily of solid particles suspended in loosely bound interstitial water, spent mechanical filters are solid materials that are adsorbent or porous and retain liquid).

4.7 Solidification

The meaning of the term Solidification during the original implementation of 10CFR61 was a process that converted radioactive waste into a product meeting 10CFR61, State and

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disposal site requirements for waste-form stability and FSL. Solidification was accomplished by mixing measured amounts of liquid or wet radioactive waste, binder and required additives that, after sufficient curing time, produce a solid homogeneous, freestanding monolith. At the end of the curing period, the absence of excessive FSL was verified either by confirmation that the PCP boundary conditions were met or by physical verification/testing. Under current practices, generally the solidified waste does not meet waste form stability requirements since few of the processes tested during the early implementation were able to do so. The waste container or barriers in site design or process used at the disposal site meet the stability requirements. The process requirements described in the solidification section do not apply to encapsulation of discrete LLW items as described in the BTP for waste form.

4.8 High Integrity Container (HIC)

Disposal containers that have been approved by the NRC for disposal of Class A unstable, Class B or Class C LLW and meet the long term disposal requirements of 10CFR61 and the disposal site.

4.9 Dewatering

Dewatering as used in this document is the removal of liquid using a process that is required to meet the requirements of this PCP. Dewatering removes the loosely bound liquid from a wet radioactive waste such that accumulation of Free Standing Liquid in the disposal container is unlikely to approach the disposal limit threshold values as defined by applicable regulations and disposal site criteria. NRC regulations require that the process used to dewater radioactive wastes to meet disposal criteria shall be governed by a PCP.

4.9.1 10CFR61 FSL criteria requires less than 0.5% FSL by waste volume per container or less than 1.0% FSL if a high integrity container (HIC) is used.

4.9.2 Typically, liquid and wet wastes are pre-staged in vented tanks or containers and are therefore degassed prior to the dewatering process. However, all vendor-required venting practices should be adhered to.

4.10 Unwatering ("Gross Dewatering", "dewatering to loss of vacuum")

Unwatering as used in this document is the removal of water using a process that is not required to meet the requirements for direct disposal at a 10CFR61 disposal site. Unwatering removes loosely bound excess or freeboard water from wet radioactive wastes such that only the requirements for transportation set forth in 49CFR are satisfied (e.g., unwatering may be to complete the first dewatering cycle for a specific container and waste stream to loss of vacuum to prepare waste for shipment to an approved offsite processor who will perform additional processing that will meet the final disposal requirements).

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4.11 Mixed Waste

Defined in Resource Conservation Recovery Act (RCRA) as amended by the Federal Facility Compliance Act of 1992, a Mixed Waste contains both RCRA hazardous waste and source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954, as amended. The use of solidification to render Mixed Wastes non-hazardous shall ensure that the final product meets all waste form requirements applicable to radioactive waste disposal at a 10CFR61 disposal site (Ref: 3.1.6. “40 CFR Part 266”).

4.12 QA Approved Supplier List

Radwaste vendors approved to provide PCP processing are included on the Duke QA Approved Supplier List and are subject to the requirements and audits of that program.

4.13 Waste Batch

A "batch" shall be defined as an isolated quantity of waste to be processed having essentially consistent physical and chemical characteristics.

4.14 Waste Batch Mixing

A Waste Batch shall be adequately mixed using a proceduralized process such as agitation via mixers, air sparging or recirculating flow which meets a specified minimum rate that has been determined to provide a representative sample for the vessel.

4.15 Process Parameters

Those conditions measured or observed during a solidification or dewatering process to ensure an acceptable product. These are determined for each waste type and are specific to the process method used.

4.16 Boundary Conditions/ Acceptance Criteria

4.16.1 Solidification Boundary Conditions or Acceptance Criteria are defined as, the bounding numerical values for solidification process parameters that produce an acceptable product when shipped for direct disposal at a 10CFR61 disposal site.

4.16.2 Dewatering Boundary Conditions or Acceptance Criteria are defined as the bounding numerical values for process parameters that ensure free standing liquid requirements are met when shipped for direct disposal at a 10CFR61 disposal site.

4.16.2.1 Media: Acceptance Criteria for dewatering process media in disposal containers (e.g., HICs) have been determined by vendor tests using real or simulated waste to demonstrate the adequacy of the dewatering process for each combination of waste type and container. These tests are documented in dewatering Topical Reports, or equivalent, that shall be approved by the NRC or other appropriate authority before the containers are certified for use. The Acceptance Criteria are then incorporated into the dewatering procedures for each combination of waste type and container.

4.16.2.2 Filters: Acceptance criteria for mechanical filters (e.g., cartridge, bag, membranes, etc.) may be derived from tests performed on the various types of filters in use. Tests performed by Duke Energy should be documented in a retrievable manner. Acceptance criteria are then incorporated into the applicable procedure for each filter type (e.g., drainage time, drainage conditions, etc.).

4.16.2.3 Filters may also be packaged in disposal containers designed to allow the removal of free standing liquid from the container prior to shipment for direct disposal based on the disposal site's waste acceptance criteria (WAC).

4.17 PCP Topical Report (PIPs O-03-0624, M-03-2515, C-03-3385)

A Topical Report provides the basis for a PCP technology & process. It documents test results that demonstrate regulatory requirements were met during the regulatory required testing for solidification or dewatering technologies and processes. For a time period after implementation of 10CFR61 the NRC approved processes developed to dewater or solidify waste based their review of the Topical Report for that process. The NRC no longer performs the approval of Topical Reports so this approval is typically the responsibility of the disposal site host agreement state regulatory authorities. Topical report testing was designed to envelope the worst-case dewatering scenarios given the industry's then current practices. As with any topical based program, the critical conditions and parameters identified during testing are incorporated into the implementing process with enough conservative margin to ensure success if you operate within the enveloping conditions and assumptions of the tests performed. When actual conditions vary from the conditions in the specific tests performed for the Topical Report, the correlation with the Topical testing is diminished and degree of processing conservatism may need to increase to compensate.

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5. DEC RESPONSIBILITIES

5.1 Process Control Program Content and Implementation

5.1.1 The PCP is owned, sponsored, and administrated by individuals designated by management pursuant to the requirements of site licensing documents. These individuals may be designated as PCP subject matter experts (SME) or program owners. Their responsibilities may include:

5.1.1.1 Revise and publish the DEC PCP.

5.1.1.2 Technical contact for PCP issues.

5.1.1.3 Ensure corporate programs comply with applicable PCP requirements.

5.1.1.4 Support nuclear site programs in complying with applicable PCP requirements.

5.1.1.5 Provide review and approval of PCP service providers.

5.1.1.6 Provide review and approval of radioactive waste processors and manage vendor service and disposal contracts for the fleet

5.1.1.7 Review PCP revisions.

5.2 Oversight and Audits

Audits of the Process Control Program and implementing procedures for processing of radioactive wastes shall be performed per Duke QADP-001-A

5.3 DEC PCP Responsibilities

The PCP applies to liquid or wet radioactive waste generated at the nuclear site when it is solidified or dewatered for direct disposal at a 10CFR61 disposal site. Any group that has responsibility for activities that generate or manage these wastes shall ensure their programs and processes comply with and support compliance with the applicable portions of the PCP. The following responsibilities are currently identified at the nuclear sites, and will be applicable to any group that has the responsibility. Any changes in these responsibilities and the groups to whom they are assigned should be evaluated for impact and potential incorporation into applicable PCP documents.

5.3.1 DEC management approves PCP revisions as defined in licensing documents.

5.3.2 Line Management responsible for programs impacting the PCP ensures those programs are consistent with the applicable PCP documents.

5.3.3 Staff and Line Supervisors ensure applicable area-specific procedures and activities comply with the PCP.

5.3.4 PCP related document reviewers

5.3.4.1 Ensure site PCP documents and processes comply with the Corporate PCP (e.g., site dewatering or solidification procedures).

5.3.4.2 Review applicable PCP revisions.

5.3.4.3 PCP document sponsors and users ensure current documents are used to implement PCP-related activities

5.3.4.4 Support incorporation of the PCP revision summary report into the site Annual Radiological Effluent Release Report (ARERR).

6. ADMINISTRATION OF THE DEC PCP AND SUPPORT DOCUMENTS

6.1 PCP Changes: Revisions and Minor Changes

PCP document revisions and minor changes are initiated, reviewed and approved following the applicable guidance in licensing documents and administrative procedures. The EDMS document management processes should be used to document and issue the new versions. Where appropriate CAS DRR documentation may be used to document the bases for the changes and identify other DRRS being incorporated. The guidance for and descriptions of what constitutes a minor change and revision are:

6.1.1 The Duke Energy QADP implementation guidance is in procedure AD-LS-ALL-0019, On-Site Review Committee. This procedure describes when an ORC should be notified of changes to site documents. E.g., where NRC notification of the change is required prior to implementation.

6.1.2 Table 1 REVISIONS: Technical or significant changes to PCP documents shall be implemented as a Revision to the affected documents and include the reviews and approvals described in Table 1 below. Revisions will be documented in EDMS using EDMS processes and the changes summarized in the document revision summary section.

6.1.3 Table 2 DEC PCP MINOR CHANGES: If a change meets the following criteria it does not require a revision. Minor Changes will be documented in EDMS using EDMS processes and the changes summarized in the document revision summary section. Reviews and approvals are in Table 2 below:

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6.1.3.1 The change is editorial in nature; e.g., spelling, grammar, format, numbering, procedure name change, adding, deleting or changing a reference, only includes administration of the documents affecting only the preparer.

6.1.3.2 The change does not alter the scope, results, requirements, or methods by which the dewatering or solidification process is performed from requirements described in the applicable PCP document.

6.1.3.3 The change does not alter the responsibilities of site personnel in meeting the PCP requirements.

6.1.3.4 The change does not alter a PCP QA approved provider dewatering or solidification process, responsibilities for fulfilling PCP requirements or the vendor interface with the station personnel or work processes described in the PCP documents.

TABLE 1: DEC PCP Revision Review and Approval

PCP Document Title	**Technical Roles** **Author & Review**	**Approvals**
DEC Corporate Process Control Program	Preparer PCP SMEs	Corporate Management DEC Station Management
ONS PCP	Preparer PCP SMEs	Corporate Management ONS Management
MNS PCP	Preparer PCP SMEs	Corporate Management MNS Management
CNS PCP	Preparer PCP SMEs	Corporate Management CNS Management

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TABLE 2: DEC PCP Minor Change Review and Approval		
PCP Document Title	**Technical Roles** **Author & Review**	**Approvals**
DEC Corporate Process Control Program	Preparer PCP SMEs	Preparer Management
ONS PCP	Preparer PCP SMEs	Preparer Management
MNS PCP	Preparer PCP SMEs	Preparer Management
CNS PCP	Preparer PCP SMEs	Preparer Management

6.2 PCP Revision Reports to the NRC

Revisions to the DEC PCP shall be reported to the NRC each year as described in each site's licensing documents. The required documentation for the NRC ARERR shall be provided using the process and procedures for preparation of the ARERR.

6.3 PCP Document Revision Record Retention Requirements

See Duke Energy Record Retention Requirements.

6.4 PCP Implementing Procedure Requirements

6.4.1 DEC Station procedures that implement PCP requirements shall ensure that all requirements for solidification or dewatering are met when performed by Duke Energy workers per DEC PCP documents.

6.4.2 The DEC PCP implementing procedures are listed in the DEC site specific PCP published in the Duke EDMS.

6.4.2.1 Completed procedures documenting the onsite solidification verification records shall be retained by the site on each vessel of solidified waste.

6.4.2.2 Documentation of the onsite dewatering verification records shall be retained on each vessel of dewatered waste.

6.4.3 The technical PCP implementing procedures shall identify the fact that they are PCP related to ensure technical reviews consider the PCP requirements.

6.4.4 All revisions to technical PCP implementing procedures listed in the site PCPs shall be reviewed to determine if they alter or inhibit the procedure's performance of the Corporate PCP requirements.

6.4.5 QA Approved Suppliers' procedures may be used for onsite PCP activities using non-installed equipment as described in applicable administrative procedures. (e.g., AD-DC-ALL-0201 Development and Maintenance of Controlled Procedure Manual Procedures)

7. APPROVAL PROCESS FOR QA APPROVED SUPPLIERS

Any PCP service supplier shall be approved and incorporated into the QA Approved Supplier Program prior to being used as contracted for process services that use a dewatering or solidification PCP to meet final waste form requirements at a 10CFR61 disposal site.

7.1 Technical Review and Approval

Before vendors can provide PCP related services, they shall be evaluated against the applicable Duke PCP documents and approved by the appropriate designees.

7.1.1 If the vendor provides PCP related services, the vendor PCP and other related program documents are evaluated to ensure they meet the applicable requirements of the Duke PCP documents.

7.1.2 The results of these reviews should be documented appropriately for future reference.

8. PCP REQUIREMENTS FOR VENDOR PROCESSES AND SERVICES

8.1 Topical Report (or equivalent)

Any vendor service or vendor supplied processes utilized for solidification or dewatering by Duke Energy shall have a Topical Report or other form of certification documenting appropriate regulatory approval of the process and associated containers, or shall supply to Duke Energy sufficient documentation of the process and test results to demonstrate that an acceptable product will be produced using the described solidification or dewatering process.

8.2 10CFR61 Waste Form Compliance

8.2.1 The vendor(s) approved for solidification or dewatering services shall have regulatory certification documenting compliance with waste form requirements in the final product, or shall supply Duke Energy sufficient documentation to demonstrate waste form compliance.

8.2.2 Any vendor providing High Integrity Containers (HIC's) to Duke Energy shall provide proof of regulatory approval documenting compliance with waste form requirements, or shall supply Duke Energy sufficient documentation to demonstrate waste form compliance.

8.2.3 All vendor Topical Reports or equivalent shall certify that the final product conforms to the applicable waste form for Class A, B, or C waste.

8.2.4 Vendor PCP Service Quality Requirements

QA Approved PCP Service Suppliers shall meet the applicable quality requirements set forth in their contract or specific Purchase Order.

8.3 10CFR61Waste Classification Compliance

Each container of processed (i.e., solidified or dewatered) waste shall meet the requirements in AD-RP-ALL-5002, 10 CFR 61 Radioactive Waste Classification prior to disposal.

8.4 Minimum Requirements for Onsite Process Vendors

8.4.1 Vendors providing PCP services onsite shall be approved QA Suppliers.

8.4.2 PCP Vendors shall fulfill all the applicable requirements in the vendor Radioactive Waste PCP and the applicable quality requirements set forth in the contract prior to shipment of the solidified or dewatered waste for direct disposal.

8.4.3 Onsite Vendor System/Equipment Interface Requirements:

8.4.3.1 The vendor documentation, drawings or diagrams supplied to Duke Energy shall include adequate system or process description including all vendor interfaces with installed plant equipment and potential release pathways.

8.4.3.2 Solidification system radioactive effluents are treated or routed to the appropriate plant system to meet effluent discharge requirements.

8.4.3.3 Decanted radioactive liquid is processed as required or routed to the station liquid radwaste systems.

8.4.4 Onsite Vendor Supplied System Design Requirements

8.4.4.1 The vendor proposal and contract shall verify that the design, construction, operation and quality assurance provisions are in accordance with applicable portions of NRC ETSB Branch Technical Position 11-3 and Regulatory Guide 1.143.

8.4.4.2 Permanent or portable solidification and dewatering systems used at nuclear sites shall meet the applicable design, construction, operation and quality assurance provisions of NRC ETSB Branch Technical Position 11-3 and Regulatory Guide 1.143.

8.5 Minimum Requirements for Offsite PCP Process Vendors

QA Approved Supplier Vendors providing PCP services offsite shall meet the requirements of their PCP process and the applicable quality requirements set forth in the contract and/or purchase order prior to disposal of the final product.

9. PCP DEWATERING PROCESS DESCRIPTION

The methods used for removal of liquid from wet wastes for final disposal shall comply with the specific requirements of the disposal site at which the waste is being disposed. Dewatering of wet wastes shall be performed in accordance with the applicable PCP requirements equivalent to the process described below. PCP workers shall use approved procedures in a controlled and quality fashion which ensures that all applicable license documents and disposal site criteria are met. Procedures used to direct dewatering shall include enough detail to ensure requirements are met.

9.1 Dewatering Mechanical Filters (e.g., cartridge, bag, membrane)

The guidance below addresses dewatering methods and PCP issues unique to removal of FSL for direct disposal of mechanical filters at a 10CFR61 disposal site.

9.1.1 The dewatering process must ensure subsequent accumulation of free standing liquid in the disposal container is not likely to approach disposal site limits.

9.1.2 The FSL requirements for direct disposal may be met using a container and procedure designed to remove any subsequent FSL accumulation in the container prior to disposal.

9.1.3 Wet spent mechanical filters can be dewatered by several methods including allowing liquid to gravity drain from the filter, blowing the filter down with air, compacting the filter, etc.

9.1.4 The method of dewatering shall be in accordance with a defined, evaluated, and documented process.

9.1.5 The parameters of the process, referred to as boundary conditions, shall be defined and used to ensure quality in the process, which in turn serves to ensure an acceptable characteristic of the waste. An example of a boundary condition is the specified period of time for which a mechanical filter shall be allowed to drain freely to ensure FSL will be less than disposal requirements.

9.1.6 Filters placed in a filter disposal container designed for removal of FSL shall meet the PCP boundary conditions for dewatering the container.

9.1.6.1 If PCP boundary conditions are met after placing the filter in the disposal container, the container shall be dewatered to ensure the container FSL meets disposal requirements.

9.1.6.2 If the PCP boundary conditions have been met prior to placing the filters in the disposal container, dewatering the container to remove incidental FSL is at site discretion.

9.1.6.3 Case-by case circumstances, such as the following, should be considered in determining the appropriateness of performing additional filter disposal container dewatering:

- The time interval between removal of the filters from wet service and placement into the disposal container
- Size of the disposal container relative to the moisture content in the filters
- The number of filters
- The variety of filter types in a single container
- The environmental conditions of filter staging and interim storage

9.1.7 Use of absorbent package material in mechanical filter disposal containers is subject to the requirements of the disposal site acceptance criteria.

9.2 Dewatering Slurries

The guidance below addresses dewatering issues associated with slurry wastes.

9.2.1 Dewatering of “slurried” wet wastes (e.g., resin, carbon, Zeolite, filter precoat, filter backwash solids) removes the loosely bound interstitial liquid from solids such that the disposal container meets applicable regulatory and burial site FSL criteria for disposal.

9.2.2 Wet spent process media dewatering shall be performed using processes, containers and procedures that have met the Duke PCP approval requirements.

9.2.3 Typical container dewatering processes use a vacuum pump that takes suction from the container through a filter system in the container. The water is returned to a station liquid radwaste system and the waste solids are retained in the vessel by the container filter(s).

9.3 Additional Conservatism in Slurry Dewatering Procedures to Address Variation from the Topical Report (PIP O-03-0624, M-03-2515, C-03-3385)

This section only applies to dewatering for direct disposal at a 10CFR61 disposal site performed by Duke Energy Carolinas (DEC) workers using Duke Energy dewatering procedures. This section does not apply to QA Approved Suppliers performing PCP activities.

Dewatering processes based on approved and documented testing (e.g., Topical Reports) are applied to actual conditions that can vary from the conditions of the original testing. The results of a Root Cause investigation at ONS (PIP O-03-0624) identified several issues and resolutions that should be incorporated into applicable Duke dewatering implementing procedures. Vendor procedures applicable to the technologies and processes used by Duke Energy in implementing the PCP provide the basis for minimal requirements in PCP implementing procedures. In addition, the guidance below was added based on the Root Cause findings at ONS:

9.3.1 All Duke Energy Carolinas (DEC) PCP dewatering procedures shall include flexibility/ guidance for the worker to add conservatism to the dewatering process if waste content and/ or process conditions are atypical in a non-conservative manner relative to the testing performed for the Topical report. (e.g., presence of greater than normal non- media solids, dewatering boundary parameters are not easily met, higher than normal volume of FSL is collected during the final dewatering cycle, etc.)

9.3.1.1 Additional conservatism can include but is not limited to the following examples:

A. Additional dewatering cycles

B. Additional settling time between pumping periods

C. Additional processing by an approved offsite vendor to verify FSL prior to disposal

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9.3.2 Guidance for dewatering all liners using the DEC PCP and procedures for direct disposal at Barnwell (PIP O-03-0624 CAPR)

9.3.2.1 Require liner functional testing prior to filling liner with waste to ensure there are no leaks in the liner dewatering system. This testing should include:

A. filling the liner with water

B. testing each level of the liner dewatering laterals using the dewatering procedure to unwater the liner

C. verifying that vacuum is not broken prior to exposing the filters for each set of laterals as described in the procedure

9.3.2.2 Ensure ambient temperature guidance for dewatering will preclude localized freezing conditions during the dewatering sequence. After most of the water is removed during the first dewatering cycle, subsequent cycles pull air through the interstitial spaces of the media and the loss of heat due to evaporation can depress the temperature on surface of the media and dewatering filters below ambient temperature.

A. Follow guidance in the vendor documentation for the process in use

B. If no other guidance is provided, dewatering should not be performed unless ambient temperature of air entering the liner is 40 degrees Fahrenheit or higher (ref. EnergySolutions procedure FO-OP-022)

9.3.2.3 Ensure final water collection sample point is representative (e.g., as close as possible to the pump discharge)

9.3.3 Mixed Media: Additional guidance for dewatering liners containing Mixed Media with significant non- media solids using a PCP for direct disposal at a 10CFR61 disposal site. (PIP O-03-0624 CAPR)

The guidance below applies to liners containing combinations of different media with significant quantities of non-media solids (e.g., layered spent zeolite, carbon, resin, etc. containing a large amount of non-media particulate)

9.3.3.1 Require dewatering filters with maximized surface area (e.g., Ecodex filter or equivalent) in all liners that contain mixed media with significant non-media solids

9.3.3.2 Clearly specify media loading sequence if media is not homogeneously mixed to minimize potential blinding of the lowest level of filters. (e.g., for layered media, use the media with the fewest non-media solids and most consistent and largest diameter beads in the bottom of the liner)

9.3.3.3 Require additional dewatering Cycles (e.g. 3 additional cycles after the acceptance criteria in the vendor procedure have been met)

9.3.3.4 Require longer settling periods during the additional dewatering cycles (e.g., 24 hours instead of the 16 hours required in the vendor procedure)

9.3.3.5 The PCP implementing procedures must comply with the vendor PCP guidance and procedures applicable to the dewatering system and disposal containers in use. e.g., If the vendor process control program and procedures applicable to the current system and process require dewatering through the bottom 2 laterals during liner filling this must be reflected in the Duke procedures.

9.4 Dewatering Process Requirements

The procedures directing dewatering processes shall address all the following activities that apply to the specific waste type being dewatered.

9.4.1 Waste Characterization

Dewatering procedures shall describe how each type of waste is characterized. The characterization information determines what disposal and container requirements apply and may also be utilized to determine shipment packaging requirements (e.g., shielding). Much of the required information for slurry waste is obtained using a representative sample of the waste media. Characterization requires the following types of information:

9.4.1.1 Radioactivity content

A. To determine 10CFR61 waste class, form and container requirements

B. To provide waste radiological characteristics for packaging, transportation and disposal requirements

9.4.1.2 Waste compatibility with disposal container and process method

A. Chemical Compatibility: Process knowledge can be applied to determine chemical compatibility with the container.

B. Hazardous Characteristics: Process knowledge can be applied to determine if the waste is a Mixed Waste.

C. If process knowledge is uncertain due to a potential input of incompatible or hazardous materials, then chemical analysis using an approved method shall be performed to determine chemical compatibility or hazardous characteristics.

9.4.2 PCP process parameters shall be identified in implementing procedures. Typical parameters are based on:

9.4.2.1 Waste form (e.g., physical, chemical and radiological characteristics)

9.4.2.2 Settling time

9.4.2.3 Drain (or pump) time

9.4.2.4 Temperature

9.4.2.5 Drying time

9.4.3 PCP boundary conditions shall be established for applicable process parameters to verify FSL threshold limits are met.

9.4.4 Sample analysis results and boundary conditions shall be reviewed by the appropriate knowledgeable individual responsible for the dewatering process.

9.4.5 Actual dewatering shall be performed using approved procedures that ensure the process is performed within the established boundary conditions.

9.5 Product Verification

The amount of free-standing liquid shall be verified to be within disposal site criteria for each container of dewatered waste prior to disposal (e.g., 10CFR61 requires that each container shall have less than 0.5% free-standing liquids by waste volume or less than 1.0% free-standing liquid if a High Integrity Container (HIC) is used). Procedures should include guidance for problems during container loading or processing that preclude or fail to meet PCP requirements as required in SLC Remedial Action Requirements.

9.5.1 PCP Verification may be accomplished by documenting that the Process Control Program was followed.

9.5.2 A disposal site may define a product verification testing method approved for use for specific waste disposal categories in lieu of a process control method.

9.5.2.1 That approved product verification process may be used for that category of disposal on a case-by-case basis, (e.g., bulk waste non-containerized disposal).

9.5.2.2 Documentation of the method used for product verification and the results shall be included in the dewatering record as described in the Dewatering Documentation Retention section below.

9.5.2.3 Make programmatic changes as necessary to address any problems identified.

9.5.3 The PCP and site procedures must address the Commitments in the "The Solid Radioactive Wastes" sections of SLC 16 "RADIOLOGICAL EFFLUENTS CONTROLS" for CNS, MNS, and ONS. These Commitments include a description of the PCP purpose, and requirements for the use of the PCP to process LLW for direct disposal.

9.5.3.1 Remedial Actions address the following conditions:

A. Requirements not met by process or packaging conditions

B. Solidification verification failures

C. Processing not performed per PCP

D. Inoperable Equipment

9.5.3.2 Solidification processes must meet Testing or Surveillance requirements and frequencies

9.6 Dewatering Document Retention

Documentation of dewatering or solidification completed onsite for direct disposal at a 10CFR61 disposal site shall be retained as part of the radiological shipping and disposal records as described in the applicable procedures and documents. (e.g., PCP implementing procedures, AD-RP-ALL-5000, vendor documents)

10. PCP SOLIDIFICATION PROCESS DESCRIPTION

This section historically described a solidification process for liquid or media LLW in which a radioactive liquid or slurry waste was uniformly mixed into a binding matrix to create a physically uniform final waste form that is a homogeneous, free standing monolith and meets10CFR61 waste form stability and FSL disposal requirements.

No installed solidification systems are operational at the DEC sites because they were not able to meet all the 10CFR61 disposal requirements and or were not cost effective. The solidification of liquids and slurry media if required is now performed via contracts with PCP QA approved suppliers under their PCP in controlled and quality fashion which ensures that all applicable regulatory, licensing and disposal site criteria are met. e.g. the applicable Commitments in the “The Solid Radioactive Wastes” sections of SLC 16 “RADIOLOGICAL EFFLUENTS CONTROLS”

Only the FSL disposal requirements apply to solidification for encapsulation of discrete LLW items as described in the BTP for waste form. Encapsulation is also performed via contracts with PCP QA approved suppliers.

Documentation of onsite solidification for direct disposal at a 10CFR61 disposal site shall be retained as part of the radiological shipping and disposal records as described in the applicable procedures and documents. (e.g., PCP implementing procedures, AD-RP-ALL-5000, vendor documents).

11. REVISION SUMMARY

This section describes the changes in the current revision of the DEC Corporate PCP.

This revision 16 is essentially a rewrite of the entire document, retaining the general structure with changes in every section. Ref: (DRR 02212730)

The previous PCP documents for the DEC fleet [ONS, MNS, CNS] included the Corporate PCP and Appendices A-H for the remaining documents. The revision of the Corporate PCP, the site PCPs, Appendix A: ONS PCP, Appendix B: MNS PCP and Appendix C: CNS PCP are being completed concurrently. The convention of using Appendices for the site PCPs has been removed and the document numbers in Fusion for the revised documents are ONS PCP, MNS PCP and CNS PCP. The document titles in Fusion are ONS Process Control Program, MNS Process Control Program and CNS Process Control Program. The remainder of the Appendices D-H are being superseded by the DEC Corporate PCP through incorporation of the still applicable guidance and administrative processes or replaced using other fleet governing Document Control programs and the document administrative processes in our electronic resources. e.g., EDMS, CAS.

The Corporate PCP document title was changed to reflect applicability of the document to DEC sites only. [ONS, MNS, CNS]

The cover page and approvals will be generated using the Fusion E-Signature process.

Below is a summary by section of the types of changes made.

1. Introduction:

    - Purpose: Edited to simplify wording, clarify focus, reduce redundant information addressed elsewhere in the document, and to distinguish between the use of in-house employees and programs and the use of contracted service providers

Radioactive Waste Process Control Program

Duke Energy Carolinas (DEC) Corporate PCP

- Deleted details and specificity from references that is not needed
- Updated the description and location of DEC PCP guidance documents

2. Applicability:
    - Made references more generic rather than specific to reduce future changes
    - Edited wording to clarify differences in how the requirements differ for LLW being placed in final waste form onsite and shipped for direct disposal and LLW being shipped to an off-site processor
    - Updated wording for mixed waste, waste oil and packaging for interim storage
3. References
    - Updated References and reorganized to consolidate lists
    - Added new post-merger documents
4. Definitions
    - Updated “Solidification” wording to clarify the current practices in meeting 10CFR61 waste form stability requirements
    - Clarified the definition of “Unwatering” to include synonyms that may be used interchangeably, “gross dewatering”, “dewatering to loss of vacuum”
    - Boundary Conditions/ Acceptance Criteria: removed unnecessary details for current solidification practices, added filter packaging in disposal containers designed to remove water from the container
    - Updated Topical report wording since the NRC no longer approves them
5. Responsibilities
    - Changed specific references to position and group names to program roles where feasible to mitigate impact of continuous changes in nuclear organization and program ownership.
    - Removed references to groups that no longer have PCP involvement throughout thedocument. (e.g., Chemistry, Nuclear Supply Chain)
6. Administration of PCP and support documents

- Removed references to Appendix F that is being deleted and incorporated guidance that is still applicable and needed
- Incorporated updated revision and minor change guidance from Appendix F
- Incorporated updated approval guidance for DEC PCP documents
- Updated PCP ARERR guidance
- Updated record retention guidance
- Deleted PCP section “Periodic cross checks & comparisons” created by PIP O-03-0624 (ONS FSL Failure). The CAPR change is described in NTM 02125727 (ONS PIOC meeting minutes & approval) and CR#: 01740840-29. ONS PIOC approved this change based on changes since the 2003 event, including ONS improvements in equipment, and procedures, the addition of formal processes in the PCP documents and consistency of current equipment and processes at the DEC sites.
- Updated PCP implementing procedure requirements

7. Updated approval process for QA Approved Suppliers
8. PCP Requirements for Vendor Processes and Services
   - Editorial changes to reflect current administrative programs and processes.
   - Updated document references
   - Editorial changes to simplify wording and make more generic.
   - Clarified use of QA Approved Suppliers
9. PCP Dewatering Process Description
   - Updated use of filter packaging in disposal containers designed to remove water from the container to clarify process
   - Clarified wording for guidance from 2003 ONS root cause CAPRs

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Duke Energy Carolinas (DEC) Corporate PCP

- Changed wording (See step 9.3.3.5) to reflect ONS PIOC approved revision of PIP O-03-0624 CAPR, CR# 01740840-04. Changed a constraint that is not applicable to the enhanced Self Engaging Dewatering System (SEDS) technology now being used. (see NTM 02125727) The vendor procedure for the SEDS does not include the requirement to use the bottom dewatering laterals to compact the media. This is only applicable to the Universal Fill Head technology that was the original type of equipment used in the 1985 liner dewatering Topical Report testing performed by EnergySolutions (then Chem-Nuclear Topical Report CNSI-DW-11118-01-P-A)

- Reduced inclusion of SLC Remedial Action Requirements details

10. PCP Solidification Process Description

    - Rewrote entire section deleting the detailed content that was required in the original implementation of 10CFR61

    - Updated references to current requirements

Facility Code :	CN
Applicable Facilities :	
Document Number :	CNS PCP
Document Revision Number :	014
Document EC Number :	
Change Reason :	
Document Title :	CNS Process Control Program

Vaught, David L	Preparer	10/31/2018
Hammel, Lee A	PCP SME Reviewer	10/31/2018
Campbell, Darcy L.	PCP SME CNS RP	10/31/2018
Williams, Doug	PCP SME CNS Operations	10/31/2018
Eurey, Chad M	Approver Mgmt CNS Operations	11/6/2018
Curry, Clark E	Approver Plant Manager CNS	10/31/2018
Haynes, Larry E	Approver Mgmt Fleet Scientific Services	11/1/2018

Notes :

DUKE ENERGY

RADIOACTIVE WASTE PROCESS CONTROL PROGRAM

Catawba Nuclear Station Process Control Program

Revision 14 (DRR 02229141)

Reviews/ Approvals	Name
Prepared: PCP SME/ Fleet Scientific Services	D.L. Vaught
Reviewed: PCP SME/ Corp Nuclear RP	L.A. Hammel
Reviewed: PCP SME/ CNS RP	D.L. Campbell
Reviewed: PCP SME/CNS Operations	C.D. Williams
Approved: Management/ CNS Operations	Chad Eurey
Approved: Plant Manager/ CNS	Clark E. Curry
Approved: Management/ Fleet Scientific Services	L.A. Haynes

DUKE ENERGY

RADIOACTIVE WASTE PROCESS CONTROL PROGRAM

CATAWBA NUCLEAR STATION PROCESS CONTROL PROGRAM

1. PURPOSE

The Catawba Nuclear Station (CNS) Process Control Program (PCP) lists the documents used to implement applicable requirements of the Process Control Program for radioactive waste solidified or dewatered to meet requirements for direct disposal at a 10CFR61 licensed disposal facility.

2. COMPOSITION

The CNS PCP consists of:

- A title page documenting approval of changes to the CNS Process Control Program
- A list of the documents for implementing the requirements of the Process Control Program
- References to diagrams related to PCP equipment
- Summary of changes in current revision

3. IMPLEMENTING PROCEDURES

Operations Radwaste Operating Procedures

3.1 OP/0/B/6500/111 “Nuclear Solid Waste (WS) Disposal System” (PIP C-04-2308)

3.2 OP/0/B/6500/046 “Transferring and Dewatering Bead resin in WSF”

3.3 OP/0/B/6500/069 “Monitor Tank Building (MTB) Ion Exchange and Filtration Media Operations”

3.4 OP/0/B/6500/131 "Secondary Contaminated Resin Operations"

3.5 OP/1/B/6500/071 "Transfer and Dewatering of Secondary Resin"

3.6 OP/2/B/6500/071 "Transfer and Dewatering of Secondary Resin"

3.7 OP/1/B/6250/008A "Steam Generator Blowdown Demineralizers"

3.8 OP/2/B/6250/008A "Steam Generator Blowdown Demineralizers"

Radiation Protection Procedures

3.9 AD-RP-ALL-5000 "Preparation and Shipment of Radioactive Material And Radioactive Waste"

Vendor Documents

3.10 FO-AD-002, Operating Guidelines for Use of Polyethylene High Integrity Containers

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3.11 CS-OP-PR-008, Setup and Operation of Energy Solutions Self-Engaging Dewatering System Fillhead.

3.12 CS-OP-PR-009, Ecodex Precoat/Powdex/Solka-Floc/Diatomaceous Earth/Zeolite Dewatering Procedure for Energy Solutions 14-215 Or Smaller Liners Utilizing Energy Solutions Self-Engaging Dewatering System (S.E.D.S.)

3.13 CS-OP-PR-010, 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.)

3.14 FO-OP-022, Ecodex Pre-Coat/Powdex/Solka-Floc/Diatomaceous/ Earth/Zeolite Dewatering Procedure for Energy Solutions 14-215 Or Smaller Liners

3.15 FO-OP-023, Bead Resin/Activated Carbon Dewatering Procedure for Energy Solutions 14-215 Or Smaller Liners

3.16 FO-OP-033, Set Up and Operation Of Universal Dewatering Fillhead

3.17 FO-OP-073, Removing Free Standing Water from Energy Solutions FEXM HICS

4. DIAGRAM REFERENCE

Plant Interfaces: All system interfaces are shown on diagrams or described in the applicable station procedure.

4.1 CN-1566-1.6

4.2 CN-1565-3.2

5. REVISION SUMMARY

Document changes due to CNS PCP revisions and minor changes as defined in the Corporate PCP.

Revision to update to reflect current organization and programs:

- Updated review and approval for the CNS PCP
- Updated current PCP related documents status
- Added vendor procedures used to implement the vendor PCP
- Editorially simplified wording
- Added this revision summary section

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 1/1/2018 - 12/31/2018

No major modifications to the Catawba Nuclear Station liquid, gaseous, solid, or mobile radioactive waste treatment systems that are anticipated to affect effluent releases occurred in 2018.

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 1/1/2018 - 12/31/2018

There is one (1) change to a previous year's ARERR.

The following contains an amended page to the Catawba Nuclear Station 2017 ARERR. The Amended page is identified with "Amendment #" on page. Specific changes are identified with change bars in the right margin.

Catawba Nuclear Station 2017 ARERR Amendment #1 requires the following changes to Attachment 6 (Reference NCR 02210093).

Catawba Nuclear Station 2017 ARERR Attachment 6, Table A.2, Page 6-3 as submitted:

Liquid Effluents Dose Summary

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
A. Batch Mode						
1. Maximum Organ Dose	mREM	2.78E-02	1.73E-02	1.62E-02	2.57E-02	8.42E-02
(a) Limit	mREM	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(b) % of Limit		2.78E-01	1.73E-01	1.62E-01	2.57E-01	4.21E-01
2. Maximum Total Body Dose	mREM	2.74E-02	1.65E-02	1.61E-02	2.55E-02	8.27E-02
(a) Limit	mREM	3.00E+00	3.00E+00	3.00E+00	3.00E+00	6.00E+00
(b) % of Limit		9.12E-01	5.50E-01	5.37E-01	8.49E-01	4.21E-01

Critical Age ***CHILD***
Critical Organ ***LIVER***
Critical Pathway ***POTABLE WATER***

Catawba Nuclear Station 2017 ARERR Attachment 6, Table A.2, Page 6-3 as amended (Amendment #1):

Liquid Effluents Dose Summary

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
A. Batch Mode						
1. Maximum Organ Dose	mREM	2.78E-02	1.73E-02	1.62E-02	2.57E-02	8.42E-02
(c) Limit	mREM	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(d) % of Limit		2.78E-01	1.73E-01	1.62E-01	2.57E-01	4.21E-01
2. Maximum Total Body Dose	mREM	2.74E-02	1.65E-02	1.61E-02	2.55E-02	8.27E-02
(c) Limit	mREM	3.00E+00	3.00E+00	3.00E+00	3.00E+00	6.00E+00
(d) % of Limit		9.12E-01	5.50E-01	5.37E-01	8.49E-01	1.38E+00

Critical Age ***CHILD***
Critical Organ ***LIVER***
Critical Pathway ***POTABLE WATER***

Attachment 12
Errata to a Previous Year's ARERR

Catawba Nuclear Station Units 1 & 2
Period 1/1/2018 - 12/31/2018

Liquid Effluents Dose Summary

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
B. Batch Mode						
1. Maximum Organ Dose	mREM	2.78E-02	1.73E-02	1.62E-02	2.57E-02	8.42E-02
(e) Limit	mREM	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(f) % of Limit		2.78E-01	1.73E-01	1.62E-01	2.57E-01	4.21E-01
2. Maximum Total Body Dose	mREM	2.74E-02	1.65E-02	1.61E-02	2.55E-02	8.27E-02
(e) Limit	mREM	3.00E+00	3.00E+00	3.00E+00	3.00E+00	6.00E+00
(f) % of Limit		9.12E-01	5.50E-01	5.37E-01	8.49E-01	1.38E+00

Critical Age ***CHILD***
Critical Organ ***LIVER***
Critical Pathway ***POTABLE WATER***

	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
C. Continuous Mode						
1. Maximum Organ Dose	mREM	1.12E-03	8.04E-04	0.00E+00	0.00E+00	1.78E-03
(a) Limit	mREM	1.00E+01	1.00E+01	1.00E+01	1.00E+01	2.00E+01
(b) % of Limit		1.12E-02	8.04E-03	0.00E+00	0.00E+00	8.88E-03
2. Maximum Total Body Dose	mREM	1.12E-03	8.04E-04	0.00E+00	0.00E+00	1.78E-03
(a) Limit	mREM	3.00E+00	3.00E+00	3.00E+00	3.00E+00	6.00E+00
(b) % of Limit		3.74E-02	2.68E-02	0.00E+00	0.00E+00	2.96E-02

Critical Age ***CHILD***
Critical Organ ***LIVER***
Critical Pathway ***POTABLE WATER***