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PART I

ADMINISTRATIVE SECTION

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1.0 INTRODUCTION

The OFFSITE DOSE CALCULATION MANUAL (ODCM) is the controlling document for the Fort Calhoun Station's (FCS) Radiological Effluent and Environmental Monitoring programs. The programs are necessary to ensure the requirements set forth in 10 CFR 20, 10 CFR 50.34a, 10 CFR 50.36a, and 10 CFR 50, Appendix I. The document is subdivided into four sections as outlined below:

Part I, Introduction - consists of information necessary for the effective use of the ODCM.

Part II, Radiological Effluent Controls - consists of 5 separate sections including:

Section 1 Radiological Effluent Release Limits

Section 2 Radiological Effluent Release Requirements

Section 3 Radiological Effluent Sampling and Analysis Requirements

Section 4 Radiological Effluent Reporting Requirements

Section 5 Radiological Environmental Monitoring Requirements

Together these sections provide the controls used to permit radioactive material releases from the Fort Calhoun Station.

Part III, Radiological Effluent Radiation Monitor Calculation - provides radiation monitor setpoint calculations for the liquid and gaseous release pathways.

Part IV, Radiological Effluent Monitoring Calculations - provides the methodology necessary to calculate doses to individuals as a result of radioactive gaseous and liquid releases from Fort Calhoun.

The ODCM has been prepared in accordance with the guidance of Nuclear Regulatory Commissions Reg. Guide 1.109, Rev. 1.

2.0 ADMINISTRATIVE

2.1 Responsibilities

2.1.1 Radiological Effluent Program

The Radiological Effluent Program consists of the following sections in the Radiological Effluent Controls:

2.1.1 Radiological Effluent Management Program (Continued)

A. Radiological Effluent Release Limits - All Sections

B. Radiological Effluent Release Requirements - All Sections

C. Radiological Effluent Sampling and Analysis Requirements - All Sections

D. Radiological Effluent Reporting Requirements - Sections 4.1 and 4.2

Nuclear Operation Division Chemistry Department is responsible for the implementation and maintenance of this program.

2.1.2 Radiological Environment Monitoring Program

The Radiological Environmental Monitoring Program consists of the following sections in the Radiological Effluent Controls:

A. Radiological Effluent Releases Limits - All Sections

B. Radiological Effluent Reporting Requirements - Sections 4.3, 4.4, and 4.5

C. Radiological Environmental Monitoring Requirements - All Sections

Production Engineering Division, Radiological Services is responsible for the implementation and maintenance of this program.

2.1.3 Other

All other portions of this ODCM provide the methodology necessary to implement the Radiological Effluent Controls. It is the joint responsibility of both Chemistry and Radiological Services for the maintenance of these sections.

2.2 Change Mechanism

The ODCM is the controlling document for all radioactive effluent releases. It is defined as a procedure under the guidance of Technical Specification 5.8. It will be revised and reviewed by the Plant Review Committee and approved by the Plant Manager in accordance with Technical Specification 5.17. All changes to the

2.2 Change Mechanism (Continued)

ODCM will be forwarded to the Nuclear Regulatory Commission during the next reporting period for the Semiannual Report in accordance with the requirements of Technical Specification 5.17.

3.0 METEOROLOGICAL DATA

The Annual Average χ/Q is utilized to determine the concentrations of radionuclides at the site boundary. This dispersion factor coincides with the highest calculated annual average value for the Fort Calhoun Station. It is based on 3 years of Onsite Meteorological data and the MESODIF II plume trajectory model. This model conforms with the Nuclear Regulatory Commissions Regulatory Guide 1.111. The model employs the sector averaged equations that are utilized for long-term releases. This type of release (long term) is not dependent solely on atmospheric conditions for complying with 10 CFR 20 concentration limits at the site boundary.

Real time meteorological data will be utilized in the preparation of the Semiannual Report. This data is used to calculate the joint frequency table and the dispersion coefficients and deposition factors in all 16 sectors. These are used in the calculation of doses to individuals in unrestricted areas as a result of the operation of Fort Calhoun Station. The models used, GASPAR and LADTAP, conform with the Nuclear Regulatory Commissions Reg. Guide 1.109 and 1.21 for the reporting of doses due to routine radioactive effluent releases.

4.0 DEFINITIONS

Channel Check

A qualitative determination of acceptable operability by observation of channel behavior during normal plant operation. This determination shall, where feasible, include comparison of the channel with other independent channels measuring the same variable.

Channel Function Test

Injection of a simulated signal into the channel to verify that it is operable, including any alarm and/or trip initiating action.

4.0 DEFINITIONS (Continued)

Operable - Operability

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

Purge-Purging

A means for the removal and replacement of gases within the containment building.

Sampler

An inline assembly utilized for the collection of a sample from a radioactive effluent stream. This sample is utilized for the determination of radionuclide releases from Fort Calhoun Station. No detection capabilities are required to exist for this configuration.

Source Check

Verification of channel response when the channel sensor is exposed to a radioactive source.

Venting

A means for the reduction of pressure greater than atmospheric within the containment structure.

Unrestricted Area

Any area at or beyond the site boundary access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials.

5.0 REFERENCES

Regulatory Guide 1.109, Rev. 1 - Calculation of Annual Dose to man from Routine Releases of Reactor Effluents for the purpose of evaluation compliance with 10 CFR 50, Appendix I

5.0 REFERENCES (Continued)

Regulatory Guide 1.111, Rev. 1 - Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors.

Regulatory Guide 1.113, Rev. 1 - Estimating Aquatic Dispersion of Effluents from Accidental and Routine Releases for the purpose of Implementing Appendix I.

Nureg-0133 - Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants.

Nureg-0472, Rev. 3 - Draft Radiological Effluent Technical Specifications for PWRs.

Regulatory Guide 1.21, Rev. 1 - Measuring, Evaluating, and Reporting Radioactivity is solid wastes and Releases of Radioactivity Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants.

Code of Federal Regulations, Title 10, Part 20

Code of Federal Regulations, Title 10, Part 50

Fort Calhoun Revised Environmental Report (Unit No. 1)-1972

Fort Calhoun Technical Specifications (Unit No. 1)

Updated Safety Analysis Report

PART II

RADIOLOGICAL EFFLUENT CONTROLS

1.0 RADIOACTIVE EFFLUENTS RELEASE LIMITS

The limits and conditions for the controlled release of radioactive material in liquid and gaseous effluents stated in this Section are to ensure that these releases result in concentrations of radioactive materials in liquid and gaseous effluents released to unrestricted areas that are within the limits specified in 10 CFR 20 and to ensure that the release of radioactive material to the environment above background be as low as reasonably achievable in conformance with 10 CFR 50.34a and 50.36a. To meet these criteria, the following requirements must be met for all radioactive liquid and gaseous effluents from FCS:

1.1 Liquid Effluents

1.1.1 The release rate of radioactive material in liquid effluents shall be controlled such that the instantaneous concentrations for radionuclides, other than dissolved or entrained noble gases, do not exceed the values specified in 10 CFR 20 for liquid effluents in unrestricted areas. For dissolved or entrained noble gases, the concentration shall be limited to 2.0 E-04 μCi/ml, total activity.

1.1.2 The dose or dose commitment to an individual in unrestricted areas from radioactive materials in liquid effluents during any calendar year shall not exceed <u>3</u> millirems to the <u>total body</u>.

1.1.3 The dose or dose commitment to an individual in unrestricted areas from radioactive materials in liquid effluents during any calendar year shall not exceed <u>10</u> millirems to <u>any organ</u>.

When the concentration of radioactive material released to unrestricted areas exceeds the above limits, appropriate corrective actions shall be taken immediately to restore concentrations within the above limits.

1.2 Gaseous Effluents

1.2.1 The release rate of radioactive material in gaseous effluents shall be controlled such that the instantaneous concentrations for these radionuclides do not exceed the values specified in 10 CFR 20 for gaseous effluents in unrestricted areas at and beyond the site boundary.

1.2 Gaseous Effluents (Continued)

1.2.2 The gamma air dose in unrestricted areas due to the release of noble gases in gaseous effluents shall not exceed 10 millirads during any calendar year;

1.2.3 The beta air dose in unrestricted areas due to the release of noble gases in gaseous effluents shall not exceed 20 millirads during any calendar year; and

1.2.4 The dose to an individual or dose commitment to any organ of an individual in unrestricted areas due to the release of I-131, Tritium, and radioactive materials in particulate form with half-lives greater than eight days (excluding noble gases) in gaseous effluents shall not exceed 15 millirems from all exposure pathways during any calendar year.

When the concentration of radioactive material released to unrestricted areas exceeds the above limits, appropriate corrective actions shall be taken immediately to restore concentrations within the above limits.

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS

The requirements for the release of radioactive liquid and gaseous effluents from FCS stated in this Section are to ensure that the limits of Section 1 will be met, as well as to allow for operational flexibility. When any of the requirements for release of radioactive effluents cannot be complied with, the release shall not be permitted to occur or it shall be immediately terminated, if it is in progress.

2.1 Liquid Effluent Releases

2.1.1 Monitor Tanks

During release of radioactive liquid effluents, excluding releases from the steam generators, the following conditions shall be met:

2.1.1.1 There shall be sufficient dilution flow so that, at site discharge:

$$\sum_{i=1}^{n} C_i / mpc_i \leq 1$$

where:

C_i = concentration of the i^{th} radionuclide in the liquid effluent at site discharge

mpc_i = 10 CFR 20, Appendix B, Table 2, Column 2 limits.

2.1.1.2 The overboard header effluent radiation monitor shall be set in accordance with Part III to alarm and automatically close the discharge valve prior to exceeding 10 CFR 20 limits.

2.1 Liquid Effluent Releases (Continued)

2.1.1 Monitor Tanks

2.1.1.3 The liquid effluent radioactivity shall be continuously monitored during the release. If the effluent radiation monitor is inoperable, effluent releases may continue provided that: (prior to initiating a release)

A. At lease two independent samples are analyzed in accordance with applicable chemistry procedures.

B. At least two shift qualified chemistry technicians independently verify the release rate calculations.

2.1.1.4 The liquid effluent radioactivity shall be continuously recorded during the release. If the process radiation monitor chart recorder is not operational and radioactivity levels cannot be recorded automatically, effluent releases may continue provided that the radioactivity level is recorded manually at least once per four hours during actual release.

2.1.1.5 The liquid effluent flow rate shall be continuously monitored and recorded during the release. If the flow rate recorder is inoperable, effluent releases may continue provided the flow rate is determined at least once per four hours during actual release.

2.1.2 Steam Generator

During the release of steam generator blowdown to the discharge tunnel, the following conditions shall be met:

2.1.2.1 There shall be sufficient dilution flow so that, at site discharge:

$$\sum_{i=1}^{n} C_i/mpc_i \leq 1$$

where:

C_i = concentration of the i^{th} radionuclide in the liquid effluent at site discharge.

mpc_i = 10 CFR 20, Appendix B, Table 2, Column 1 limit.

2.1.2.2 The steam generator blowdown radiation monitors shall be set in accordance with Part III to alarm and automatically close the blowdown isolation valves prior to exceeding 10 CFR 20 limits.

2.1.2.3 The radioactivity for each blowdown line shall be continuously monitored and recorded by the blowdown radiation monitors.

A. If one of the two radiation monitors is inoperable, the activity for both blowdown lines shall be monitored by the operable radiation monitor.

B. If both radiation monitors are inoperable, steam generator liquid releases may continue provided grab samples are analyzed for principal gamma emitters at a sensitivity of 5.0E-07 µCi/ml and recorded at least daily when the specific activity of Steam Generator Blowdown is less than or equal

2.1.2 Steam Generator (Continued)

2.1.2.3 to 0.01 μCi/gram dose equivalent I-131 and at least

B. Once per 12 hours when the specific activity of the secondary coolant is greater than 0.01 μCi/gram dose equivalent I-131.

2.1.2.4 The radioactivity for each blowdown line shall be continuously recorded. If the process radiation monitor chart recorder is not operational, Steam Generator releases may continue provided that the radioactivity level is recorded manually at least once per four hours during actual release.

2.2 Gaseous Effluent Releases

2.2.1 Gaseous Auxiliary Building Exhaust Stack

2.2.1.1 During release of gaseous radioactive effluents from containment pressure relief line to the Auxiliary Building Exhaust Stack, the following conditions shall be met:

A. The Auxiliary Building Exhaust Stack noble gas monitor, iodine sampler and particulate sampler shall be operational.

B. The Auxiliary Building Exhaust Stack noble gas radiation monitor shall be set in accordance with Part III to alarm and automatically terminate the release prior to exceeding 10 CFR 20 limits at site boundary (see Figure 1).

C. At least one Auxiliary Building exhaust fan shall be in operation.

2.2 Gaseous Effluent Releases

2.2.1 Gaseous Auxiliary Building Exhaust Stack

2.2.1.1 D. The Auxiliary Building Exhaust Stack gaseous radioactivity shall be monitored and recorded during the release. If the process radiation monitor chart recorder is not operational and gaseous radioactivity levels cannot be recorded automatically, releases from containment may continue provided that the gaseous radioactivity level is recorded manually at least once per four hours during the actual release.

E. The containment flow rate shall be monitored and automatically recorded during the release. If the flow rate recorder is inoperable, releases from the containment may continue provided the flow rate is determined at least once per four hours during actual release.

2.2.1.2 During the release of gaseous radioactive effluents from the containment purge line:

A. The conditions set forth in Section 2.2.1.1. shall be met.

B. A noble gas monitor shall monitor the containment building atmosphere. If the process radiation monitor chart recorder is not operational and gaseous radioactivity levels cannot be recorded automatically, releases from containment may continue provided that the gaseous radioactivity level is recorded manually at least once per four hours during the actual release.

2.2 Gaseous Effluent Releases

2.2.1 Gaseous Auxiliary Building Exhaust Stack

2.2.1.3 During the release of gaseous effluents from the gaseous waste discharge header:

A. The Auxiliary Building Exhaust Stack noble gas radiation monitor shall be set in accordance with Part III to alarm and automatically terminate the release prior to exceeding 10 CFR 20 limits at site boundary (see Figure 1).

B. If the Auxiliary Building Exhaust Stack radiation monitor is inoperable, effluent releases may continue provided that (prior to release):

i. At least two independent samples are analyzed in accordance with the applicable chemistry procedure.

ii. At least two shift qualified chemistry technicians independently verify the release rate calculations.

C. At least one Auxiliary Building exhaust fan shall be in operation.

D. The waste gas discharge header flow rate shall be monitored and automatically recorded during releases. If the flow rate recorder is inoperable, releases may continue provided the flow rate is determined at least once per four hours during actual release.

2.2.1.4 The Auxiliary Building Exhaust Stack noble gas monitor, particulate sampler, or iodine sampler may be inoperable provided that:

2.2 Gaseous Effluent Releases

2.2.1 Gaseous Auxiliary Building Exhaust Stack

2.2.1.4 A. Whenever the Auxiliary Building Exhaust Stack noble gas monitor is inoperable, releases from the containment pressure relief line and the containment purge line are to be secured in the most expeditious manner. Ventilation of the auxiliary building via the Auxiliary Building Exhaust stack may continue provided grab samples are taken and analyzed once per eight (8) hours for principal gamma emitters.

B. Whenever the Auxiliary Building Exhaust Stack iodine or particulate sampler(s) is/are inoperable, releases from the gaseous waste discharge header, containment pressure relief line or the containment purge line are to be secured in the most expeditious manner. These releases may continue provided samples are collected using auxiliary sample collection equipment in accordance with Table 2.

C. Whenever the Auxiliary Building Exhaust Stack iodine or particulate sampler(s) is/are inoperable, ventilation of the auxiliary building via the Auxiliary Building Exhaust Stack may continue provided sample collection using auxiliary sample collection equipment is initiated within 2 hours of the discovery of the inoperability in accordance with Table 2.

2.2.2 Condenser Offgas

2.2.2.1 During power operation, the condenser air ejector discharge shall be monitored for gross radioactivity. If this monitor is inoperable, grab samples shall be taken and analyzed daily for principal gamma emitters. (See Table 2)

2.2.3 Laboratory and Radioactive Waste Processing Building Stack

2.2.3.1 The Laboratory and Radioactive Waste Processing Building (LRWPB) Stack noble gas monitor, particulate sampler or iodine sampler may be inoperable and effluents via this pathway may continue provided:

2.2.3.1 A. If the noble gas monitor is inoperable, grab samples will be taken once per 24 hours and analyzed for principal gamma emitters.

B. If the iodine or particulate sampler(s) is/are inoperable, ventilation of the LRWPB may continue via the LRWPB Stack provided sample collection using auxiliary sample collecion equipment is initiated within 2 hours of the discovery of the inoperability in accordance with Table 2.

C. The LRWPB Stack flow rate shall be monitored and recorded during ventilation of the LRWPB. If the flow rate recorder is inoperable, ventilation may continue provided the flow rate is determined at least once per four hours.

3.0 RADIOLOGICAL EFFLUENT SAMPLING AND ANALYSIS REQUIREMENTS

The sampling and analysis requirements stated in this Section will provide reasonable assurance that radioactive materials present in the liquid and gaseous effluents will be properly identified and accurately quantified. This information will serve as the basis for determining doses to individuals as a result of radioactive effluents from FCS.

Records shall be maintained and reports of the sampling and results of analyses shall be submitted to the Nuclear Regulatory Commission in accordance with Section 4 of these Controls.

3.1 Liquid Effluents

3.1.1 Radioactive liquid waste sampling and activity analyses shall be performed in accordance with Table 1. The results of these analyses shall be used with the calculational methods in Part IV of this manual to assure that the concentration at the point of release does not exceed 10 CFR 20 limits for unrestricted areas.

3.1.2 Prior to release of each batch of liquid effluent, the batch shall be mixed, sampled, and analyzed for principal gamma emitters. When operational or other limitations preclude specific gamma radionuclide analysis of each batch:

3.1.2.1 Gross radioactivity measurements shall be made to estimate the quantity and concentrations of radioactive materials released in the batch.

3.1.2.2 A weekly sample composite from proportional aliquots from each batch released during the week shall be analyzed for the principal gamma-emitting radionuclides.

3.1.3 Records shall be maintained of the radioactive concentrations and volume before dilution of each batch of liquid effluent released and of the average dilution flow and length of time over which each discharge occurred. Analytical results shall be submitted to the Commission in accordance with Section 4 of these Controls.

3.1 Liquid Effluents (Continued)

3.1.4 The radiation monitors for liquid effluents shall have their operability verified in accordance with the requirements in Table 3, Part A.

3.2 Gaseous Effluents

3.2.1 Radioactive gaseous waste sampling and activity analyses shall be performed in accordance with Table 2. The results of these analyses shall be used with the calculational methods in Part IV of this manual to assure that the concentration of radioactive materials does not exceed 10 CFR 20 limits for unrestricted areas.

3.2.2 The radiation monitors for gaseous effluents shall have their operability verified in accordance with the requirements in Table 3, Part B.

3.3 Lower Limit of Detection (LLD)

The lower limit of detection (LLD) for liquid and gaseous discharges, referenced in Tables 1 and 2 of the Radiological Effluent Controls (Part II), is defined as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95 percent probability with only 5 percent probability of falsely concluding that a blank observation represents a "real" signal.

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

$$LLD = \frac{4.66 * s_b}{E * V * D * Y * \exp(-\lambda \Delta t)}$$

Where:

LLD = the lower limit of detection as defined above, in either picoCuries or microCuries, per unit mass or volume as a function of the value of D

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample, as appropriate, as counts per minute

3.3 Lower Limit of Detection (LLD) (Continued)

E = the counting efficiency, as counts per disintegration

V = the sample size in units of mass or volume

D = 2.22E+06 of disintegrations per minute per microCurie or 2.22 disintegrations per minute per picoCurie

Y = the fractional radiochemical yield, when applicable

λ = the radioactive decay constant for the particular radionuclide

Δt = the elapsed time for the plant effluent between the midpoint of sample collection and time of counting

Appropriate values of E, V, Y and Δt should be used in the calculation.

It should be recognized that the LLD is defined as an A Priori limit representing the capability of a measurement system and not as a limit for a particular measurement.

LLD verifications will be performed on a periodic basis. This determination is to ensure that the counting system is able to detect levels of radiation at the LLD values for the specific type of analysis required by Tables 1 and 2. They will be performed with a blank (non-radioactive) sample in the same counting geometry as the actual sample.

4.0 RADIOACTIVE LIQUID EFFLUENT REPORTING REQUIREMENTS

The reporting requirements for radioactive effluents stated in this Section are to provide assurance that the limits set forth in Section 1 are complied with. These reports will meet the requirements for documentation of radioactive effluents contained in 10 CFR 50.36a; Reg. Guide 1.21, Rev. 1; Reg. Guide 4.8, Table 1; and Reg. Guide 1.109, Rev. 1.

4.1 Liquid Effluents

4.1.1 The radiation dose contributions from radioactive materials in liquid effluents released to unrestricted areas shall be determined, in accordance with the ODCM, on a quarterly basis. If the dose contribution, due to the cumulative release of liquid effluents averaged over a calendar quarter, exceeds one-half of the annual design objectives, the following course of actions shall be taken:

A. Make an investigation to identify the causes for such releases.

B. Define and initiate a program of action to reduce such releases to the design levels.

C. Submit a special report, pursuant to Technical Specification 5.16, within 30 days from the end of the quarter during which the release(s) occurred, identifying the causes and describing the proposed program of action to reduce such releases to the design levels.

4.1.2 The equipment or subsystem(s) of the liquid radwaste treatment system as identified in the ODCM, shall be operable. If the radioactive liquid wastes were discharged without treatment by one or more of the pieces of equipment or subsystem(s) identified in the ODCM and it is confirmed that one-half of the annual dose objective will be exceeded during the calendar quarter, a special report, pursuant to Technical Specification 5.16, shall be prepared and submitted to the Nuclear Regulatory Commission within 30 days of the end of the quarter during which the equipment or subsystem(s) were inoperable. This report shall include the following information:

A. Identification of equipment or subsystem(s) not operable and reasons for inoperability.

4.1 Liquid Effluents (Continued)

B. Action(s) taken to restore the inoperable equipment to status.

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

4.2 Gaseous Effluents

4.2.1 The radiation dose contributions from radioactive materials in gaseous effluents shall be determined, in accordance with the ODCM, on a quarterly basis. If the dose contribution, due to the cumulative release of gaseous effluents averaged over a calendar quarter exceeds one-half of the annual design objectives, the following course of actions shall be taken:

A. Make an investigation to identify the cause for such release rates.

B. Define and initiate a program of action to reduce such releases to design levels.

C. Submit a special report, pursuant to Technical Specification 5.16, within 30 days from the end of the quarter during which the release(s) occurred, identifying the causes and describing the proposed program of action to reduce dose contributions.

4.2 Gaseous Effluents

4.2.2 The equipment or subsystem(s) of the gaseous radwaste treatment system as identified in the ODCM shall be operable. If the radioactive gaseous wastes were discharged without treatment by one or more of the equipment or subsystems(s) identified in the ODCM and it is confirmed that one-half of the annual dose objective will be exceeded during the calendar quarter, a special report, pursuant to Technical Specification 5.16, shall be prepared and submitted to the Nuclear Regulatory Commission within 30 days of the end of the quarter during which the equipment or subsystem(s) were inoperable. This report shall include the following information:

A. Identification of equipment or subsystem(s) not operable and reason for inoperability.

B. Action(s) taken to restore the inoperable equipment to operable status.

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

4.3 Semi-Annual Report

A report covering the operation of the Fort Calhoun Station during the previous six months shall be submitted within 60 days after January 1 and July 1 of each year per the requirements of 10CFR 50.36a.

The radioactive effluent release report shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the plant as outlined in Regulatory Guide 1.21, Revision 1.

The radioactive effluent release report shall include a summary of the meteorological conditions concurrent with the release of gaseous effluents during each quarter as outlined in Regulatory Guide 1.21, Revision 1.

The radioactive effluent release report shall include an assessment of radiation doses from the radioactive liquid and gaseous effluents released from the unit during each calendar quarter as outlined in Regulatory Guide 1.21, Revision 1. The assessment of radiation doses shall be performed in accordance with calculational methodology of the Regulatory Guide 1.109, Revision 1.

4.3 Semi-Annual Report

The radioactive effluent release report shall include any changes to the Process Control Program (PCP) or to the Offsite Dose Calculation Manual (ODCM) made during the reporting period. These changes can be initiated either by the licensee (implementation: subject to review by the PRC) or by the Nuclear Regulatory Commission (implementation: subject to their applicability to the Fort Calhoun Station design, review by the PRC and followed by a review by the SARC). A level of detail commensurate to the significance of the change will be provided.

4.4 Annual Report

The Annual Radiological Environmental Operating Report for the previous one year of operation shall be submitted prior to May 1 of each year. This report contains the data gathered from the radiological environmental monitoring program. The content of the report shall include:

4.4.1 Summarized and tabulated results of the radiological environmental sampling/analysis activities following the format of Regulatory Guide 4.8, Table 1. In the event that some results are not available, 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.

4.4.2 Interpretations and statistical evaluation of the results, including an assessment of the observed impacts of the plant operation and environment.

4.4.3 The results of participation in a NRC approved Interlaboratory Comparison Program.

4.4.4 The results of land use survey required by Part II, Section 5.1.4.

4.4.5 The results of specific activity analysis in which the primary coolant exceeded the limits of Technical Specification 2.1.3. The following information shall be included:

4.4.5.1 Reactor power history starting 48 hours prior to the first sample in which the limit was exceeded;

4.4 Annual Report (Continued)

4.4.5 4.4.5.1 A. Results of the last isotopic analysis for radioiodine performed prior to exceeding the limit, results of analysis while limit was exceeded and results of one analysis after the radioiodine activity was reduced to less than the limit. Each result should include date and time of sampling and the radioiodine concentrations;

B. Purification system flow history starting 48 hours prior to the first sample in which the limit was exceeded;

C. Graph of the I-131 concentration and one other radioiodine isotope concentration in microCuries per gram as a function of time for the duration of the specific activity above the steady-state level; and

D. The time duration when the specific activity of the primary coolant exceeded the radioiodine limit.

4.5 Non-Routine Report

If a confirmed measured radionuclide concentration in an environmental sampling medium averaged over any calendar quarter sampling period exceeds the reporting level referenced in Table 7, and if the radioactivity is attributable to plant operation, a written report shall be submitted to the Nuclear Regulatory Commission within 30 days from the end of the quarter.

The report shall include an evaluation of any release conditions, environmental factors, or other aspects necessary to explain the anomalous result.

5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING REQUIREMENTS

The requirements set forth in this Section will provide reasonable assurance that radioactive liquid and gaseous effluent releases to the environment in and around Fort Calhoun Station are monitored and that any deviation of radiation levels above background will be identified.

5.1.1 The radiological environmental monitoring program shall be conducted according to Table 4. No changes shall be made to the ODCM which might reduce the effectiveness of the program. Analytical results of this program and deviations from the sampling schedule shall be reported to the Nuclear Regulatory Commission in the Annual Radiological Environmental Operating Report (Part II, Section 4.4).

5.1.2 If the level of radioactivity, from calculated doses, in the Semiannual Report leads to a higher exposure pathway to individuals, this pathway shall be added to the Radiological Environmental Monitoring Program.

5.1.3 If the level of radioactivity in an environmental sampling medium exceeds the reporting level specified in Table 7, a Non-routine Report shall be prepared and submitted to the Nuclear Regulatory Commission in a Non-routine Report (Part II, Section 4.5). The detection capabilities of the equipment used for the analysis of Environmental Samples must meet the requirements of Table 6 for Lower Level of Detection (LLD).

5.1.4 A land use survey shall be conducted once per 24 months between the dates of June 1 and October 1. This survey shall identify the location of the nearest milk animal, nearest meat animal, nearest vegetable garden, and the nearest residence in each of the 16 cardinal sectors within a distance of five miles. The results of the land use survey shall be submitted to the Nuclear Regulatory Commission in the Annual Radiological Environmental Operating Report (Part II, Section 4.4). The survey shall be conducted under the following conditions:

A. Within a one-mile radius from the plant site, enumeration by door-to-door or equivalent counting techniques.

B. Within a five-mile radius, enumeration by using referenced information from county agricultural agents or other reliable sources.

5.1.4 (Continued)

B. If it is learned from this survey that milk animals are present at a location which yields a calculated dose greater than from previously sampled location(s), the new location(s) shall be added to the monitoring program. The sampling location(s) having the lowest calculated dose may then be dropped from the monitoring program at the end of the grazing and/or growing season during which the survey was conducted and the new location is then added to the monitoring program. Also, any location(s) from which milk can no longer be obtained may be dropped and replaced if practicable from the monitoring program and the Nuclear Regulatory Commission shall be notified in the Annual Radiological Environmental Operating Report (Part II, Section 4.4).

C. Radiological Environmental Sampling locations and the media that is utilized for analysis are presented in Table 5.

5.1.5 Analyses shall be performed on radioactive materials as part of an Interlaboratory Comparison Program that has been approved by the Nuclear Regulatory Commission. The results of these analyses shall be included in the Annual Radiological Environmental Operating Report.

5.1.6 Deviations from the monitoring program, presented in this section and detailed in Table 4, are permitted if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of equipment, or if a person discontinues participation in the program and other legitimate reasons. If the equipment malfunctions, corrective actions will be complete as soon as practicable. If a person no longer supplies samples, a replacement will be made. All deviations from the sampling schedule will be described in the Annual Radiological Environmental Operating Report, pursuant to part II, Section 4.4.

TABLE 1

Radioactive Liquid Waste Sampling and Analysis

A. Monitor & Hotel Waste Tanks Releases

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml)(1)
Each Batch	Principal Gamma Emitters(2)(3)	5.0 E-07
	I-131(2)	1.0 E-06
Monthly From One Batch	Dissolved Noble Gases(2) (Gamma Emitters)	1.0 E-05
Monthly Composite(7)	H-3	1.0 E-05
	Gross α	1.0 E-07
Quarterly Composite(7)	Sr-89, Sr-90	5.0 E-08

B. Steam Generator Blowdown

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml)(1)
Weekly Composite(7)	Principal Gamma Emitters(3)	5.0 E-07
	I-131(5)	1.0 E-06
Monthly	Dissolved Noble Gases (Gamma Emitters)	1.0 E-05
Monthly Composite(7)	H-3	1.0 E-05
	Gross α	1.0 E-07
Quarterly Composite(7)	Sr-89, Sr-90	5.0 E-08

TABLE 2

Radioactive Gaseous Waste Sampling and Analysis

A. Gas Decay Tank Releases

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml)(1)
Prior to each release	Principal Gamma Emitters(4)	1.0 E-04

B. Containment Purge Releases or Containment Pressure Relief Line Releases

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml)(1)
Prior to each release	Principal Gamma Emitters(4)	1.0 E-04
Prior to each release	H-3	1.0 E-06

C. Condenser Air Ejector Release

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml)(1)
Monthly(6)	Tritium (H-3)	1.0 E-06
Monthly	Principal Gamma Emitters(4)	1.0 E-04

D. Auxiliary Building Exhaust Stack and Laboratory and Radwaste Building Exhaust Stack

Sampling Frequency(8)	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml)(1)
Weekly (Charcoal Sample)	I-131	1.0 E-12
Weekly (Particulates)	Principal Gamma Emitters(4), I-131 and Particulates with half-lives ≥ than eight days.	1.0 E-11
Monthly Composite	Gross α	1.0 E-11
Quarterly Composite (Particulates)	Sr-89, Sr-90	1.0 E-11

TABLES 1 and 2
(Continued)

NOTES:

(1) LLD is defined in Section 3.3, Part I.

(2) Gross Radioactivity is defined as the determination of radioactivity levels without regard to specific radionuclide identification and individual isotopic quantification.

(3) The principal gamma emitters for which the LLD specification applies exclusively are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144.

(4) The principal gamma emitters for which the LLD specification applies exclusively are the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 for gaseous emissions and Mn-54, FE-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, Ce-144 for particulate emissions.

(5) A weekly grab sample and analyses program including gamma isotopic identification will be initiated for the turbine building sump effluent when the steam generator blowdown water composite analysis indicates the I-131 concentration is greater than 1.0 E-06 microCurie/milliliter.

(6) Required only when steam generator blowdown radioactivity for tritium (Table 3-11, Section B) exceeds 3.0 E-03 microCurie/milliliter.

(7) To be representative of the average quantities and concentrations of radioactive materials in liquid effluents, samples should be collected in proportion to the rate of flow of the effluent stream. Prior to analyses, all samples taken for the composite should be mixed in order for the composite sample to be representative of the average effluent release.

(8) These samples are continuously collected during the release of radioactive effluents. However, releases are allowed to continue for periods of up to 30 days when the continuous sampler is not in service provided that samples are collected using auxiliary sampling equipment.

TABLE 3

Radiation and Environmental Monitors
Operability Requirements

A. Liquid Monitors	Daily Channel Check(1)	Monthly Source Check(2)	Quarterly Channel Func. Test(3)	Refueling Calibration(4)	Source Check Prior to Release(5)
RM-054 A/B	X(9)	X	X	X	X
RM-055/55A	-(9)	-	X	X	X

B. Gaseous Monitors	Daily Channel Check(1)	Monthly Source Check(2)	Quarterly Channel Func. Test(3)	Refueling Calibration(4)	Source Check Prior to Release(5)
RM-043	X	X	X	X	-
RM-057	X	X	-	X	-
RM-062/51(6)	X	X	X	X	X

C. Envirmentl. Monitors	Monthly Operations Check(7)	Annual Airflow Calibration(8)
RM-035 → 039	X	X

NOTES:

(1) Documentation is provided by signoff on OP-SI-SHIFT-0001.

(2) Documentation is provided by signoff on IC-ST-RM-0050.

(3) Documentation is provided by signoff on IC-ST-RM-0050.

(4) Documentation is provided by completion of appropriate calibration procedure. Air or liquid flowrate calibrations must be included for RM-054 A/B and RM-043, RM-057, and RM-062/51.

(5) Documentation is provided by signoff on applicable Release Permit Form

(6) RM-051 will be substituted for RM-062 when it is sampling the Auxiliary Building Ventilation Stack.

(7) Documentation is provided by signoff on IC-ST-RM-0100.

(8) Documentation is provided by completion of calibration procedure

(9) Visual flowcheck daily

TABLE 4

Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Collection Site(1)	Types of Analysis(2)	Frequency
1. Direct Radiation	A. Ten TLD indicator stations, one control station, total of 11.	Gamma Isotopic	Quarterly
	B. An inner-ring of 16 stations, one in each meteorological sector in the general area of the site boundary and within 2.5 miles.	Gamma dose during site Area and General Emergencies only.	Replaced Annually
	C. An outer-ring of 16 stations, 1 in each meteorological sector located outside of the inner-ring but no more distant than approximately 5 miles.	Gamma dose during site Area and General Emergencies only.	Replaced Annually
2. Air Monitoring	A. Indicator stations	1) Filter for Gross Beta(3)	Weekly
	1. 3 stations in the general area of the Site Boundary.	2) Charcoal for I-131	Weekly
	2. City of Blair	3) Filter for Gamma Isotopic	Quarterly composite of wkly. fltrs.
	B. One background station	Same as A. above	
3. Water	A. Missouri River at nearest downstream drinking water intake.	Gamma Isotopic, H-3	Monthly composite for Gamma Isotopic Analysis
	B. Missouri River downstream near the mixing zone.		Quarterly composite for H-3 Analysis
	C. Missouri River upstream of plant intake (background).		
4. Milk(4)	A. Nearest family cow when available or one dairy farm within 5 miles.	Gamma Isotopic and I-131	Semimonthly grazing season (May to October)
	B. One dairy farm between 5 miles and 18.75 miles. (Background)		
5. Fish	A. Four fish samples within vicinity of plant discharge.	Gamma Isotopic	Once per season (May to October)
	B. One background sample upstream of plant discharge.		
6. Sediment	One sample from downstream area on the station side of the Missouri River.	Gamma Isotopic	Semiannually

TABLE 4
(Continued)

Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Collection Site(1)	Types of Analysis(2)	Frequency
7. **Vegetables or Food Products**	A. One sample outside of 5 miles. (Background) B. One sample in the highest exposure pathway.	Gamma Isotopic	Once per season (May to October)

Notes:

(1) See Table 6 of this Manual for required detection limits.

(2) The Lower Limit of Detection (LLD) for analysis is defined in the ODCM in accordance with the wording of NUREG-0472, Rev. 3, Draft 7.

(3) When a gross beta count indicates radioactivity greater than 1E-12 µCi/ml or 1 pCi/m^3, a gamma spectral analysis will be performed.

(4) When milk samples are not available, a broad leaf vegetation or pasture grass sample shall be collected, when available.

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TABLE 5

Radiological Environmental Sampling Locations and Media

Location Number	Location Description	Distance From FCS Reactor Bldg. (miles)	Direction (Degrees from (north)	Airborne Particulate	Airborne Iodine	TLD	Surface Water	Fresh Milk	Bottom Sediment	Fish	Vegetation
1	Onsite Station No. 1, 110-meter weather tower	0.5	293°	X	X	X					
2	Onsite Station No. 2, adjacent to old plant access road	0.6	208°	X	X	X					
3	Offsite Station No. 3, intersection of Hwy. 75 and farm access road	0.8	145°	X	X	X					
4	Blair OPPD office	3.0	303°	X	X	X					
5	EOF Building, North Omaha Power Station	17.5	157°	X	X	X					
6	Fort Calhoun City Hall	4.8	149°			X					
7	Fence around intake gate, Desoto Wildlife Refuge	2.[illegible]	101°			X					
8	Entrance to Plant Site from Hwy. 75	0.6	180°			X					
9	NW of Plant	1.0	310°			X					
10	WSW of Plant	0.7	250°			X					
11	SE of Plant	0.9	130°			X					
12	Met. Utilities Dist., Florence Treatment Plant North Omaha, NE	17.0	156°				X				
13	West bank Missouri River, downstream from reactor building	0.5	106°				X		X		
14	125' upstream from intake bldg., west bank of river	0.1	345°				X		X		

TABLE 5
(Continued)

Radiological Environmental Sampling Locations and Media

Location Number	Location Description	Distance From FCS Reactor Bldg. (miles)	Direction (Degrees from (north)	Airborne Particulate	Airborne Iodine	TLD	Well Water	Fresh Milk	Bottom Sediment	Fish	Vegetation
15	Smith Farm(1)	1.9	133°				X				
16	OPPD Onsite Well(1)	0.1	154°				X				
17	Headquarters Bldg.,(1) Desoto Wildlife Refuge	3.1	53°				X				
18	Miller Farm(3) (Discontinued Milk)	0.8	206°								X
19	Flynn Dairy(2)	3.4	310°					X			
20	Mohr Dairy(1)(2)(3)	7.9	187°					X			X
21	Japp Dairy(2)	6.3	219°					X			
22	Fish Sampling Area - Missouri River	R.M. 645.0	-							X	
23	Fish Sampling Area - Missouri River	R.M. 66[illegible].0	-							X	
24	Legenhausen Farm (Discontinued)	0.[illegible]	207°								
25	Seltz Farm(2)	2.7	168°					X			
26	Vegetation(3) (High Expos. Pthwy. for Veg.)										X
27	Vegetation(3) (Background)										X

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Notes:

(1) Sampling not required for pathway modeling, collections performed for additional information only.

(2) When a milk sample is not available at a location, a broad leaf vegetation sample will be collected at that location as a substitute.

(3) Vegetation sites chosen based on Land Use Survey and Semiannual Radioactive Effluent Release Report.

TABLE 6

Detection Capabilities for Environmental Sample Analysis(1)(2)(3)
Lower Limit of Detection (LLD)

Sample	Units	Gross Beta	H-3	Mn-54	Fe-59	Co-58, 60	Zn-65	Zr-95	Nb-95	I-131	Cs-134	Cs-137	Ba-140
Water	Pci/L	--	2.0E+03	1.5E+01	3.0E+01	1.5E+01	3.0E+01	1.5E+01	1.5E+01	1.0E+00	1.5E+01	1.8E+01	1.5E+01
Fish	Pci/kg (wet)	--	--	1.3E+02	2.6E+02	1.3E+02	2.6E+02	--	--	--	1.3E+02	1.5E+02	--
Milk	Pci/L	--	--	--	--	--	--	--	--	1.0E+00	1.5E+01	1.8E+01	1.5E+01
Air Particulate or Gases	Pci/m^3	1.0E-02	--	--	--	--	--	--	--	7.0E-02	--	--	--
Sediment	Pci/kg (dry)	--	--	--	--	--	--	--	--	--	1.5E+02	1.8E+02	--
Grass or Broad Leaf Vegetation/ Vegetables	Pci/kg (wet)	--	--	--	--	--	--	--	--	6.0E+01	6.0E+01	8.0E+01	--

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(1) This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable as plant effluents, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Surveillance Report pursuant to Control 5.1.b.

(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 specifications, as the smallest concentration or radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

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

$$LLD = \frac{4.66\ s_b}{E \cdot V \cdot 2.22E{+}06 \cdot Y \cdot \exp(-\lambda\Delta t)}$$

TABLE 7

Reporting Levels for Radioactivity Concentrations in Environmental Samples[1]

Sample	Units	H-3	Mn-54	Fe-59	Co-58	Co-60	Zn-65	Zr-95	Nb-95	I-131	Cs-134	Cs-137	Ba-140
Water	Pci/L	2.0E+04	1.0E+03	4.0E+02	1.0E+03	3.0E+02	3.0E+02	4.0E+02	4.0E+02	2.0E+00	3.0E+01	5.0E+01	2.0E+02
Fish	Pci/kg (wet)	--	3.0E+04	1.0E+04	3.0E+04	1.0E+04	2.0E+04	--	--	--	1.0E+03	2.0E+03	--
Milk	Pci/L	--	--	--	--	--	--	--	--	3.0E+00	6.0E+01	7.0E+01	3.0E+02
Air Particulate or Gases	Pci/m^3	--	--	--	--	--	--	--	--	9.0E-01	--	--	--
Grass or Broad Leaf Vegetation/ Vegetables	Pci/kg (wet)	--	--	--	--	--	--	--	--	1.0E+02	1.0E+03	2.0E+03	--

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(1) A Non-routine report shall be submitted when more than one of the radionuclides listed above are detected in the sampling medium and:

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

When radionuclides other than those listed above are detected and are the result of plant effluents, this report shall be submitted if the potential annual dose to a member of the general public is equal to or greater than the dose objectives of Radiological Effluent Control Section 1.1 and 1.2. This report is not required if the measured level of radioactivity was not the result of plant effluents; however, in such an event, the condition shall be reported and described in the Annual Radiological Environmental Operating Report.

PART III

RADIOLOGICAL EFFLUENT RADIATION MONITOR CALCULATIONS

1.0 EFFLUENT MONITOR SETPOINTS

1.1 Liquid Effluents

There are two liquid discharge pathways to the Missouri River. These pathways originate with the radioactive liquid waste processing system (monitor or hotel tanks) and the steam generator blowdown system. Both of these pathways empty into the circulating water system which discharges to the Missouri River (see Figure 1). Figure 2 depicts the liquid discharge pathways and associated radiation monitors. Figure 3 depicts the methods of liquid effluent treatment. A detailed discussion of the liquid effluent treatment system is presented in Section 2.1.

The flowrate for dilution water varies with the number of circulating water pumps in service and with the operation of the warm water recirculation. Some warm water from the condenser outlet is diverted from the circulating water discharge to upstream of the intake structure to help prevent ice from forming on the circulating water pump intakes during winter months. The varying dilution flowrate is accounted for in the dilution calculations for monitor tank and stream generation releases.

Alarm setpoints shall be established for the liquid effluent monitoring instrumentation to ensure that the concentration of radioactive material released in liquid effluents to unrestricted areas shall be less than the concentrations specified in 10 CFR 20, Appendix B, Table 2, Column 2.

Cs-137 is the most abundant radionuclide in liquid effluent streams and is used to calibrate the liquid effluent monitors.

1.2 Liquid Effluent Radiation Monitors

1.2.1 Steam Generator Blowdown Monitors (RM-054A and B)

These process radiation detectors monitor the flow through the steam generator blowdown lines and automatically close the blowdown isolation valves if the monitor high alarm setpoint is reached. The high alarm setpoint calculations are based on controlling the discharge at 10 CFR 20 limits of 1.0E-07 μCi/ml for unrestricted areas.

The following calculations for maximum concentration and alarm setpoints are valid when steam generator blowdown is the only liquid release pathway. For simultaneous radioactive liquid releases of steam generator blowdown and monitor tank discharge, refer to Section 1.5.1.

The maximum allowable concentration in the blowdown line is calculated as follows:

$$A_o = \frac{(1.0E\text{-}07\ \mu Ci/ml)\ (X_o)}{Y_o}$$

Where:

1.0E-07 μCi/ml = 10 CFR 20 Limit for unidentified radionuclides at site discharge (I-129, Ra-226 and Ra-228 are not present).

X_o = Total dilution flow in the discharge tunnel (gpm). (Normal flow is based on 1 circulating water pump at 120,000 gpm. Other flowrates may be used, as required.)

Y_o = Blowdown flow rate (gpm). (Normal blowdown flow rate is based on 2 transfer pumps with a design flow of 135 gpm each, 270 gpm total. Other flow rates may be used, as required.)

A_o = Maximum allowable blowdown concentration (μCi/ml).

1.2.1 Steam Generator Blowdown Monitors (RM-054A and B) (Continued)

The high alarm setpoint (CPM) =

$$.85 \ [\ (S_f)\ (A_o) + B\ ]$$

Where:

.85 = Correction factor for instrument meter error.

S_F = Detector sensitivity factor (CPM/μCi/ml). (Sensitivity based on Cs-137).

A_o = Maximum allowable blowdown line activity (μCi/ml).

B = Background (CPM).

Setpoints may be recalculated based on adjusted dilution flow and adjusted blowdown flow.

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified prior to automatic actuation of the blowdown isolation valves.

1.2.2 Overboard Discharge Header Monitor (RM-055 or RM-055A)

This process radiation monitor provides control of the waste monitor tank effluent by monitoring the overboard header prior to its discharge into the circulating water discharge tunnel. The concentration of activity at discharge is controlled below the 10 CFR 20 limit of 1.0E-07 μCi/ml for unrestricted areas for unidentified isotopes by the high alarm setpoint which closes the overboard flow control valve.

The following calculations for maximum concentration and alarm setpoints are valid when Monitor Tank discharge is the only liquid release pathway. For simultaneous radioactive liquid releases of monitor tank discharge and steam generator blowdown, refer to Section 1.5.1.

1.2.2 Overboard Discharge Header Monitor (RM-055 or RM-055A) (Continued)

The maximum allowable concentration in the overboard discharge header is:

$$A_o = \frac{(1.0E\text{-}07\ \mu Ci/ml)\ (X_o)}{Y_o}$$

Where:

1.0E-07 μCi/ml = 10 CFR 20 Limit for unidentified radionuclides at site discharge (I-129, Ra-226 and Ra-228 are not present).

X_o = Total dilution flow in the discharge tunnel (gpm). (Normal flow is based on 1 circulating water pump at 120,000 gpm. Other flowrates may be used, as required.)

Y_o = Maximum monitor tank discharge flow rate (gpm). (Normal monitor tank maximum flow is 50 gpm. Other flow rates may be used, as required.)

A_o = Maximum allowable activity in discharge header (μCi/ml).

1.2.? Overboard Discharge Header Monitor (RM-055 or RM-055A) (Continued)

The high alarm setpoint (CPM) =

$$.85\ [\ (S_f)\ (A_o) + B\ ]$$

Where:

.85 = Correction factor for instrument meter error.

S_F = Detector sensitivity factor (CPM/μCi/ml). (Sensitivity based on Cs-137).

A_o = Maximum allowable concentration in discharge header (μCi/ml).

B = Background (CPM).

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified, prior to automatic actuation of the overboard flow control valve.

1.3 Gaseous Effluents

The gaseous effluent monitoring instrumentation for controlling and monitoring normal radioactive material releases in accordance with 10 CFR 20, appendix B, Table 2, Column 1 limits for unrestricted areas (see Figure 1), are summarized as follows:

A. Auxiliary Building - The Auxiliary Building Exhaust Stack receives discharges from the waste gas decay tanks, containment purge, containment vent systems and the auxiliary building ventilation system. Effluents are monitored by RM-062, a noble gas activity monitor. Additionally, noble gas activity monitor, RM-051, provides redundant back-up monitoring capabilities to the RM-062 monitor. Iodine monitoring and sampling capabilities are provided by RM-060. Particulate monitoring is provided by RM-061. Redundant particulate monitoring is provided by RM-050. Ventilation Isolation Actuation Signal (VIAS) is actuated by exceeding a monitor's alarm setpoint. Actuation of VIAS will isolate releases from containment and waste gas decay tanks. The Auxiliary Building Exhaust fans will remain in operation.

B. Laboratory and Radioactive Waste Processing Building (LRWPB) - Noble gas, iodine, and particulate monitoring is provided by Radiation Monitors RM-043, RM-042, and RM-041, respectively. These radiation monitors do not serve a control function.

C. Condenser Off-Gas Monitors - Noble gas activity is monitored by RM-057. The condenser off-gas is discharged directly to the environment. Exceeding the high alarm setpoint on RM-057 will activate isolation of main steam to the Auxiliary Steam System.

A gaseous radioactive waste flow diagram with the applicable, associated radiation monitoring instrumentation and controls is presented as Figure 4. The gaseous waste disposal system is presented in Figure 5. A detailed discussion of the gaseous effluent treatment system is presented in Section 2.2.

1.4 Gaseous Effluent Radiation Monitors

1.4.1 Auxiliary Building Exhaust Stack Particulate Monitors (RM-061/RM-050)

Either of these monitors may be used to measure airborne particulate activity in the exhaust stack. The detector is located adjacent to a section of moveable filter paper on a capstan drive. The monitor alarm setpoint is based on 10 CFR 20 limits of 1.0 E-10 μCi/cc at the site boundary.

The following calculations for maximum release rate and alarm setpoint are valid when the Auxiliary Building Exhaust Stack is the only gaseous release pathway. For simultaneous gaseous releases from Auxiliary Building Exhaust Stack, condenser off-gas, and the LRWPB Exhaust Stack, refer to Section 1.5.2. The maximum allowable release rate for stack particulates is calculated as follows:

$$\frac{(1.0E\text{-}10\ \mu Ci/cc)}{(5.0E\text{-}06\ sec/m^3)} \times (1.0E{+}06\, cc/m^3) = 2.0E{+}01\ \mu Ci/sec$$

Where:

1.0E-10 μCi/cc = 10 CFR 20 Limit at site boundary for unidentified isotopes.

5.0E-06 sec/m³ = Annual average dispersion factor at the site boundary.

1.0E+06 cc/m³ = Constant of unit conversion.

The high alarm setpoint (CPM):

$$Setpoint = .85\ \left[\frac{(2.0E{+}01)\ (S_p)\ (F_s)\ (T)}{(F_v)} + B \right]$$

1.4.1 Auxiliary Building Exhaust Stack Particulate Monitors (RM-061/RM-050) (Continued)

Where:

.85 = Correction for instrument meter error.

S_p = Detector sensitivity factor (CPM/μCi). (Sensitivity based on Cs-137).

F_s = Monitor sample flow rate (SCFM).

T = Effective monitor response time (sec).

F_v = Auxiliary Building Exhaust stack flow rate (SCFM). (Default maximum flow rate is 122500 cfm for 3 Auxiliary Building exhaust fans and 2 containment purge fans in operation. Other flow rates may be used, as required.)

B = Background (CPM).

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified, prior to exceeding the alarm setpoint.

1.4.2 Auxiliary Building Exhaust Stack Gaseous Activity Monitors (RM-062/RM-051)

Either of these monitors may be used to measure gaseous activity in the exhaust stack. The gas is monitored after passing through a particulate filter. The monitor controls gaseous activity releases so that the 10 CFR 20 limit for the unrestricted areas of 3.0E-07 µCi/cc, based upon Xe-133, is not exceeded. The Ventilation Isolation Actuation Signal is initiated when the high alarm setpoint is reached.

The following calculations for maximum release rate and alarm setpoint are valid when Auxiliary Building Exhaust Stack is the only gaseous release pathway. For simultaneous gaseous releases from Auxiliary Building Exhaust Stack, condenser off-gas and the LRWPB Exhaust Stack, refer to Section 1.5.2.

The maximum allowable release rate for stack gaseous activity is calculated as follows:

$$\frac{(3.0E\text{-}07\ \mu Ci/cc)}{(5.0E\text{-}06\ sec/m^3)} \times (1.0E{+}06\ cc/m^3) = 6.0E{+}04\ \ \mu Ci/sec$$

Where:

3.0E-07 µCi/cc = 10 CFR 20 Limit at site boundary (based upon Xe-133).

5.0E-06 sec/m³ = Annual average dispersion factor at the site boundary.

1.0E+06 cc/m³ = Constant of unit conversion.

The high alarm setpoint (CPM):

$$Setpoint = .85\ \left[\ \frac{(6.00E{+}04)\ (S_F)\ (60)}{(F_v)\ (28317)} + B\ \right]$$

1.4.2 Auxiliary Building Exhaust Stack Gaseous Activity Monitors (RM-062/RM-051) (Continued)

Where:

.85 = Correction for instrument meter error.

S_F = Detector sensitivity factor (CPM/ µCi/cc). (Sensitivity based on Xe-133)

60 = Conversion (seconds to minutes).

28317 = Conversion factor (ft^3 to cc).

F_v = Auxiliary Building Exhaust stack flow rate (SCFM). (Default maximum flow rate is 122500 cfm for 3 Auxiliary Building exhaust fans and 2 containment purge fans in operation. Other flow rates may be used, as required.)

B = Background (CPM).

An alarm setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified, prior to actuation of VIAS.

1.4.3 Auxiliary Building Exhaust Stack Iodine Monitor (RM-060)

RM-060 monitors the gaseous waste discharged from the exhaust stack for Iodine-131 activity by continuously counting a charcoal cartridge and pre-filter through which a sample of exhaust stack air is passing at a known rate. The monitor alarm setpoint is based on the 10 CFR 20 limit for Iodine-131 at the site boundary.

The following calculations for maximum release rate and alarm setpoint are valid when Auxiliary Building Exhaust Stack is the only gaseous release pathway. For simultaneous gaseous releases from Auxiliary Building Exhaust Stack, condenser off-gas and the LRWPB Exhaust Stack, refer to Section 1.5.2.

The maximum allowable release rate for stack iodine is calculated as follows:

$$\frac{(1.0E\text{-}10\ \mu Ci/cc)}{(5.0E\text{-}06\ sec/m^3)} \times (1.0E{+}06\ cc/m^3) = 2.0E{+}01\ \mu Ci/sec$$

Where:

1.0E-10 µCi/cc = 10 CFR 20 Limit at site boundary (based upon I-131).

5.0E-06 sec/m^3 = Annual average dispersion factor at site boundary.

1.0E+06 cc/m^3 = Constant of unit conversion.

The high alarm setpoint (CPM):

$$Setpoint = .85\ \left[\frac{(2.0E{+}01)\ (S_p)\ (F_s)\ (T)\ (E)}{(F_v)} + B \right]$$

1.4.3 Auxiliary Building Exhaust Stack Iodine Monitor (RM-060) (Continued)

Where:

.85 = Correction for instrument meter error.

S_p = Detector sensitivity factor (CPM/μCi). (Sensitivity based on I-131)

F_s = Monitor sample flow rate (SCFM).

T = Effective monitor response time (sec).

F_v = Auxiliary Building Exhaust stack flow rate (SCFM). (Default maximum flow rate is 122500 cfm for 3 Auxiliary Building exhaust fans and 2 containment purge fans in operation. Other flow rates may be used, as required.)

E = Charcoal filter collection efficiency.

B = Background (CPM).

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified.

1.4.4 Condenser Air Ejector Monitor (RM-057)

This monitor is located in the turbine building and monitors the condenser off-gas. The purpose of this monitor is to monitor the condenser off-gas discharges so that the 10 CFR 20 limit for unrestricted areas of 3.0E-07 μCi/cc, based upon Xe-133, is not exceeded.

The following calculations for maximum release rate and alarm setpoint are valid when condenser off-gas is the only gaseous release pathway. For simultaneous gaseous releases from condenser off-gas, Auxiliary Building Exhaust Stack, and the LRWPB Exhaust Stack, refer to Section 1.5.2.

The maximum allowable release rate for condenser air ejector monitor is as follows:

$$\frac{(3.0E\text{-}07\ \mu Ci/cc)}{(5.0E\text{-}06\ sec/m^3)} \times (1.0E{+}06\ cc/m^3) = 6.0E{+}04\ \mu Ci/sec$$

Where:

3.0E-07 μCi/cc = 10 CFR 20 Limit at site boundary (based upon Xe-133).

5.0E-06 sec/m³ = Annual average dispersion factor at the site boundary.

1.0E+06 cc/m³ = Constant of unit conversion.

The high alarm setpoint (CPM):

$$Setpoint = .85\ \left[\frac{(6.00E{+}04)\ (S_p)\ (60)}{(F_v)\ (28317)} + B \right]$$

1.4.4 Condenser Air Ejector Monitor (RM-057) (Continued)

Where:

.85 = Correction for instrument meter error.

S_p = Detector sensitivity factor (CPM/μCi/cc). (Sensitivity based on Xe-133)

60 = Conversion (seconds to minutes).

28317 = Conversion factor (ft^3 to cc).

F_v = Vent stack flow rate (SCFM). Default maximum flow rate is 4755 scfm (3 vacuum pumps in hogging mode. Other flow rates may be used, as required.)

B = Background (CPM).

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified, allowing time for corrective actions prior to exceeding the alarm setpoint and tripping of the auxiliary steam supply valve, RCV-978.

1.4.5 Laboratory and Radioactive Waste Processing Building (LRWPB) Exhaust Stack Particulate Monitor (RM-041)

This monitor is used to measure airborne particulate activity in the LRWPB exhaust stack. The detector is located adjacent to a removable filter paper. The monitor alarm setpoint is based on 10 CFR 20 limits of 1.0E-10 μCi/cc at the site boundary.

The following calculations for maximum release rate and alarm setpoint are valid when LRWPB Exhaust Stack is the only gaseous release pathway. For simultaneous gaseous releases from Auxiliary Building Exhaust Stack, condenser off-gas, and the LRWPB Exhaust Stack, refer to Section 1.5.2.

The maximum allowable release rate for stack particulates is calculated as follows:

$$\frac{(1.0E\text{-}10\ \mu Ci/cc)}{(5.0E\text{-}06\ sec/m^3)} \times (1.0E\text{+}06\ cc/m^3) = 2.0E\text{+}01\ \mu Ci/sec$$

Where:

1.0E-10 μCi/cc = 10 CFR 20 Limits at site boundary for unidentified isotopes.

5.0E-06 sec/m³ = Annual average dispersion factor at the site boundary.

1.0E+06 cc/m³ = Constant of unit conversion.

The high alarm setpoint (CPM):

$$Setpoint = .85\ \left[\frac{(2.0E\text{+}01)\ (S_p)\ (F)\ (T)}{(F_v)} + B \right]$$

1.4.5 Laboratory and Radioactive Waste Processing Building (LRWPB) Exhaust Stack Particulate Monitor (RM-041) (Continued)

Where:

.85 = Correction for instrument meter error.

S_p = Detector sensitivity factor (CPM/μCi). (Sensitivity based on Cs-137).

F_s = Monitor sample flow rate (SCFM).

T = Effective monitor response time (sec).

F_v = LRWPB Exhaust stack flow rate (SCFM). (Default maximum flow rate is 28700 cfm. Other flow rates may be used, if required.)

B = Background (CPM).

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified, prior to exceeding the alarm setpoint.

This monitor alarms in the Control Room. There are no automatic control functions associated with the actuation of the alarm.

1.4.6 Laboratory and Radioactive Waste Processing Building Exhaust Stack Iodine Monitor (RM-042)

RM-042 monitors the gaseous waste discharged from the LRWPB for Iodine-131 activity by continuously counting a charcoal filter cartridge through which a sample of LRWPB exhaust air is passing at a known rate. The monitor alarm setpoint is based on the 10 CFR 20 limit for Iodine-131 at the site boundary.

The following calculations for maximum release rate and alarm setpoint are valid when LRWPB Exhaust Stack is the only gaseous release pathway. For simultaneous gaseous releases from Auxiliary Building Exhaust Stack, condenser off-gas, and the LRWPB Exhaust Stack, refer to Section 1.5.2.

The maximum allowable release rate for stack iodine is calculated as follows:

$$\frac{(1.0E\text{-}10\ \mu Ci/cc)}{(5.0E\text{-}06\ sec/m^3)} \times (1.0E\text{+}06\,cc/m^3) = 2.0E\text{+}01\ \mu Ci/sec$$

Where:

$1.0E\text{-}10\ \mu Ci/cc$ = 10 CFR 20 Limit at site boundary (based upon I-131).

$5.0E\text{-}06\ sec/m^3$ = Annual average dispersion factor at the site boundary.

$1.0E\text{+}06\ cc/m^3$ = Constant of unit conversion.

The high alarm setpoint (CPM):

$$Setpoint = .85\ \left[\ \frac{(2.0E\text{+}01)\ (S_F)\ (F)\ (T)\ (E)}{(F_V)} + B\ \right]$$

1.4.6 Laboratory and Radioactive Waste Processing Building Exhaust Stack Iodine Monitor (RM-042) (Continued)

Where:

.85 = Correction for instrument meter error.

S_F = Detector sensitivity factor (CPM/μCi). (Sensitivity based on I-131)

F_s = Monitor sample flow rate (SCFM).

T = Effective monitor response time (sec).

F_v = LRWPB Exhaust stack flow rate (SCFM). (Default flow rate is 28700 cfm. Other flow rates may be used, if required.)

E = Charcoal filter collection efficiency.

B = Background (CPM).

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified.

This monitor alarms in the Control Room. There are no automatic control functions associated with the actuation of the alarm.

1.4.7 Laboratory and Radioactive Waste Processing Building Exhaust Stack Noble Gas Monitor (RM-043)

RM-043 is located in the Radwaste Building and samples the LRWPB Exhaust Stack. The monitor alarm setpoint is based on the 10 CFR 20 limit for Xe-133 at the site boundary.

The following calculations for maximum release rate and alarm setpoint are valid when the LRWPB Exhaust Stack is the only gaseous release pathway. For simultaneous gaseous releases from condenser off-gas, Auxiliary Building Exhaust Stack, and the LRWPB Exhaust Stack, refer to Section 1.5.2.

The maximum allowable release rate for RM-043 is as follows:

$$\frac{(3.0E\text{-}07\ \mu Ci/cc)}{(5.0E\text{-}06\ sec/m^3)} \times (1.0E\text{+}06\ cc/m^3) = 6.0E\text{+}04\ \mu Ci/sec$$

Where:

$3.0E\text{-}07\ \mu Ci/cc$ = 10 CFR 20 Limit at site boundary (based upon Xe-133).

$5.0E\text{-}06\ sec/m^3$ = Annual average dispersion factor at the site boundary.

$1.0E\text{+}06\ cc/m^3$ = Constant of unit conversion.

The high alarm setpoint (CPM):

$$Setpoint = .85\ \left[\frac{(6.00E\text{+}04)\ (S_F)\ (60)}{(F_v)\ (28317)} + B \right]$$

1.4.7 Laboratory and Radioactive Waste Processing Building Exhaust Stack Noble Gas Monitor (RM-043) (Continued)

Where:

.85 = Correction for instrument meter error.

S_F = Detector sensitivity factor (CPM/µCi/cc). (Sensitivity based on XE-133)

60 = Conversion (seconds to minutes).

28317 = Conversion factor (ft^3 to cc).

F_v = LRWPB Exhaust stack flow rate (SCFM). (Default flow rate is 28700 cfm. Other flow rates may be used if required.

B = Background (CPM).

This monitor alarms in the Control Room. There are no automatic control functions associated with the actuation of the alarm.

1.5 Simultaneous Release Pathways

1.5.1 Liquid Release Pathways

The liquid radiation monitors (RM054A and B, RM055, and RM055A) control liquid releases so that 10 CFR 20 limits of 1.0E-07 μCi/ml for unidentified isotopes in unrestricted areas are not exceeded. There are two liquid release pathways that contribute to the concentration at discharge to unrestricted areas. These are Steam Generator Blowdown and Monitor Tank Overboard Discharge Header. When more than one pathway is utilized for radioactive releases, it is necessary to adjust the alarm setpoints given in Section 1.2 so that unrestricted area concentration limits are not exceeded.

The calculations for the alarm setpoints for the liquid effluent monitors will be adjusted as follows:

$$A_T = K_o A_o + K_1 A_1$$

$$A_T = \frac{K_o\,(1.0E\text{-}07\ \mu Ci/ml)\,(X_o)}{Y_o} + \frac{K_1\,(1.0E\text{-}07\ \mu Ci/ml)\,(X_o)}{Y_1}$$

Where:

A_T = Sum of individual maximum allowable concentrations for Steam Generator and Monitor Tank prior to dilution for simultaneous liquid releases (μCi/ml)

A_o = Maximum allowable concentration in Steam Generator blowdown Line (μCi/ml)

A_1 = Maximum allowable concentration in Monitor Tank Discharge Line (μCi/ml)

K_o = Proportionality constant for Steam Generator (See Table 1)

K_1 = Proportionality constant for Monitor Tank (See Table 1)

X_o = Total dilution flow in Discharge Tunnel (GPM)

1.5.1 Liquid Release Pathways (Continued)

Where:

Y_o = Steam Generator Blowdown flowrate (GPM)

Y_1 = Monitor Tank Discharge flowrate (GPM)

The High Alarm Setpoint for Steam Generator Blowdown monitors, RM054A and B, will then be:

$$\textit{Alarm Setpoint (CPM)} = .85\ [K_o\ S_{Fo}\ A_o + B_o]$$

The High Alarm Setpoint for Monitor Tank Discharge monitors, RM055 and 55A, will then be:

$$\textit{Alarm Setpoint (CPM)} = .85\ [K_1\ S_{F1}\ A_1 + B_1]$$

Where:

S_{Fo} = Detector Sensitivity factor for RM054A/B, CPM/(μCi/ml), based on Cs-137.

S_{F1} = Detector Sensitivity factor for RM055/55A, CPM/(μCi/ml), based on Cs-137.

A_o = Maximum allowable concentration in SG Blowdown line. (μCi/ml)

A_1 = Maximum allowable concentration in MT Discharge line. (μCi/ml)

B_o = RM054 A or B background countrate. (CPM)

B_1 = RM055 or 55A background countrate. (CPM)

1.5.1 Liquid Release Pathways (Continued)

Where:

K_o, K_1 = Proportionality constants. See Table I.

1.5.2 Gaseous Release Pathway

The gaseous radiation monitors (RM041, RM042, RM043, RM057, RM060, RM061, and RM062) control gaseous releases so that 10 CFR 20 limits of 3.0E-07 μCi/cc for gases and 1.0E-10 μCi/cc for iodines and particulates in unrestricted areas are not exceeded. There are three pathways that contribute to the concentration at site boundary. These are the Auxiliary Building Exhaust Stack, Condenser Off-gas, and the LRWPB Exhaust Stack. When more than one pathway is utilized for radioactive releases, it is necessary to adjust the alarm setpoints given in Section 1.4 to ensure that unrestricted area concentration limits are not exceeded.

The calculations for the alarm setpoints for the gaseous effluent monitors will be adjusted as follows:

The maximum allowable release rates for simultaneous releases is:

$$Max.\ Release\ Rate = \sum_{i=0}^{6} K_i R_i = \sum_{i=0}^{6} K_i \frac{Conc_i}{\chi/Q}$$

Where:

R_o = RM061/RM050 release rate (μCi/sec)
R_1 = RM062/RM051 release rate (μCi/sec)
R_2 = RM060 release rate (μCi/sec)
R_3 = RM057 release rate (μCi/sec)
R_4 = RM041 release rate (μCi/sec)
R_5 = RM042 release rate (μCi/sec)
R_6 = RM043 release rate (μCi/sec)

$K_o \rightarrow K_6$ = Proportionality constants. See Table 1.

$Conc_i$ = Radionuclide concentration for the monitor of interest.

1.5.2 Gaseous Release Pathway (Continued)

The maximum release rate is then:

$$[\frac{K_0(1.0E\text{-}10\ \mu Ci/cc)}{5.0E\text{-}06\ sec/m^3} + \frac{K_1(3.0E\text{-}07\ \mu Ci/cc)}{5.0E\text{-}06\ sec/m^3} + \frac{K_2(1.0E\text{-}10\ \mu Ci/cc)}{5.0E\text{-}06\ sec/m^3} +$$

$$\frac{K_3(3.0E\text{-}07\ \mu Ci/cc)}{5.0E\text{-}06\ sec/m^3} + \frac{K_4(1.0E\text{-}10\ \mu Ci/cc)}{5.0E\text{-}06\ sec/m^3} + \frac{K_5(1.0E\text{-}10\ \mu Ci/cc)}{5.0E\text{-}06\ sec/m^3} +$$

$$\frac{K_6(3.0E\text{-}07\ \mu Ci/cc)}{5.0E\text{-}06\ sec/m^3}]\ 1.0E\text{+}06\ \frac{cc}{m^3} = Max.\ Release\ Rate$$

The alarm setpoints for the gaseous effluent monitors will then be:

$$RM061/50 = .85\ [\ K_0\ \frac{(2.0\ E\text{+}01)\ (S_F)\ (F_S)\ (T)}{F_V} + B\ ]$$

$$RM062/51 = .85\ [\ K_1\ \frac{(6.0\ E\text{+}04)\ (S_F)\ (60)}{F_V\ \ (28317)} + B\ ]$$

$$RM060 = .85\ [\ K_2\ \frac{(2.0\ E\text{+}01)\ (S_F)\ (F_S)\ (T)\ (E)}{F_V} + B\ ]$$

$$RM057 = .85\ [\ K_3\ \frac{(6.0\ E\text{+}04)\ (S_F)\ (60)}{(F_V)\ \ (28317)} + B\ ]$$

$$RM041 = .85\ [\ K_4\ \frac{(2.0\ E\text{+}01)\ (S_F)\ (F_S)\ (T)}{(F_V)} + B\ ]$$

$$RM042 = .85\ [\ K_5\ \frac{(2.0\ E\text{+}01)\ (S_F)\ (F_S)\ (T)\ (E)}{(F_V)} + B\ ]$$

$$RM043 = .85\ [\ K_6\ \frac{(6.0\ E\text{+}04)\ (S_F)\ (60)}{(F_V)\ \ (28317)} + B\ ]$$

Where:

1.5.2 Gaseous Release Pathway (Continued)

.85 = Correction factor for instrument meter error.

$K_0 \rightarrow K_6$ = Proportionality contents. See Table 1.

S_F = Detector sensitivity factor.

F_S = Monitor sample flow rate.

T = Effective monitor response time.

E = Charcoal filter collection efficiency.

F_V = Vent stack flowrate. (Condenser off-gas flowrate for RM057, LRWPB Exhaust stack flow rate for RM041/42/43, Auxiliary Building Exhaust Stack flow rate for RM061/50, 62/51 and 60).

B = Monitor background count rate.

60 = Constant of unit conversion (60 sec/min).

TABLE 1

Proportionally Constants for Simultaneous Release Pathways

a.	Liquid Effluents	$K_0 + K_1 \leq 1$
	$K_0 = .30$	RM054A/B
	$K_1 = .70$	RM055/55A
b.	Gaseous Effluents	$\Sigma_i K_i \leq 1$
	$K_0 = .05$	RM061/50
	$K_1 = .40$	RM062/51
	$K_2 = .35$	RM060
	$K_3 = .05$	RM057
	$K_4 = .05$	RM041
	$K_5 = .05$	RM042
	$K_6 = .05$	RM043

NOTE: The constants are based on prior knowledge and may be updated as necessary to provide for plant operations.

2.0 RADIOACTIVE WASTE TREATMENT SYSTEM

2.1 Liquid Radwaste Treatment System

The major equipment or subsystem(s) of the liquid radwaste treatment system are comprised of the waste filters, monitor tanks, and evaporator. This equipment, including associated pumps, valves and piping, is used in different combinations on an as-needed basis to process the liquid effluent to provide compliance with the as low as is reasonably achievable philosophy and the applicable section of 10 CFR Part 20. The liquid radwaste treatment system is described in Section 11.1.2 of the USAR. For effluent release points and monitor locations refer to P&ID's 11405-M-100, M-9 and M-8.

A filtration/ion exchange (FIX) system may be utilized for processing liquid radwaste in the event the waste evaporator is not in service. The system consists of a booster pump, charcoal pretreatment filter, and pressure vessels containing organic/inorganic resins, which can be configured for optimum performance. The effluent from the FIX system is directed to the monitor tanks for release.

Waste filters (WD-17A and WD-17B) are used only on those occasions when considered necessary, otherwise the flows from the low activity fluids may bypass the filters. No credit for decontamination factors (iodines, Cs, Rb, others) was taken for these filters during the Appendix I dose design objective evaluation; therefore, the inoperability of these filters does not affect the dose contributions to any individual in the unrestricted areas via liquid pathways. The inoperability of waste filters will not be considered a reportable event in accordance with Specification 2.9.1(1)c.

Every effort will be made to process all liquid waste, except from the hotel waste tanks, through the evaporator or FIX before entering the monitor tanks. If the radioactive liquid waste is discharged without processing and it appears that 1/2 of the annual objective will be exceeded during the calendar quarter, a special report shall be submitted to the Commission pursuant to Specification 2.9.1(1)c within 30 days.

The quantity of radioactive material contained in each unprotected outdoor liquid holdup tank shall not exceed 10 curies, excluding tritium and dissolved or entrained noble gases.

2.2 Gaseous Radwaste Treatment System

The waste gases at Fort Calhoun Station are collected in the vent header where the gas compressors take suction, compress the gas and deliver it to one of the four gas decay tanks. The waste gases are treated in these gas decay tanks by holding the gases for radioactive decay prior to final controlled release to the environs. In order to provide conformance with the dose design objectives, gas decay tanks are normally stored for approximately 30 days, with earlier release allowed to support plant operation only and thus achieve decay of short half-life radioactive materials, e.g., I-131, Xe-133. If the radioactive gaseous wastes from the gas decay tanks are discharged without processing in accordance with the above conditions, a special report shall be submitted to the Commission pursuant to Specification 2.9.1(2)c.

The radioactive effluents from the controlled access area of the auxiliary building are filtered by the HEPA filters in the auxiliary building ventilation system. If the radioactive gaseous wastes are discharged without the HEPA filters, a special report shall be submitted to the NRC pursuant to Specification 2.9.1(2)c.

The discharge from the gas decay tanks is routed through charcoal and HEPA filter unit VA-82. No credit was taken for the operation of hydrogen purge filters during the Appendix I dose design evaluation and doses through the gaseous pathways were well below the design objectives. The unavailability of hydrogen purge filters will not be considered a reportable event as per Specification 2.9.1(2)c.

The containment air is processed through at least one of the redundant containment HEPA and charcoal filters in the Containment air Cooling and Filtering Units prior to purging. If the containment purges are made without processing through one of the Containment Air Cooling and Filtering Units, a special report shall be submitted to the Commission pursuant to Specification 2.9.1(2)c.

The gaseous radwaste treatment system is described in Section 11.1.3 of the USAR. For effluent release points and monitor locations refer to P&ID's 11405-M-1 and M-261.

PART IV

RADIOLOGICAL EFFLUENT MONITORING CALCULATIONS

1.0 EFFLUENT CONCENTRATION LIMITS - 10 CFR 20

1.1 Liquid Effluent Concentration Limits

1.1.1 10 CFR 20 limits the concentration of radioactive material in liquid effluents (after dilution in the Circulating Water System) to less than the concentrations as specified in Appendix B, Table 2, Column 2 for radionuclides other than noble gases. Noble gases are limited to a diluted concentration of 2.0E-04 μCi/ml. Gross alpha activity is limited to 3.0E-08 μCi/ml. Release rates are controlled and radiation monitor alarm setpoints are established as addressed above to ensure that these concentration limits are not exceeded. For batch releases (Monitor and Hotel Waste Tanks and Steam Generators) and for continuous releases (Steam Generator Blowdown), the analyses will be performed in accordance with Table 1 of the Radiological Effluent Controls and the concentration of each radionuclide at the point of discharge will be calculated, based on the following equation:

Radionuclide concentration at Site Boundary:

$$a_i = \frac{C_i f}{F + f}$$

$$\text{and} \sum_{i=1}^{n} a_i / MPC_i$$

Where:

a_i = concentration at the point of discharge for nuclide, i, in μCi/ml.

C_i = concentration of nuclide, i, in the undiluted effluent in μCi/ml.

f = total undiluted effluent flowrate, in gpm.

F = total dilution water flowrate in gpm.

1.2 Liquid Effluent Concentration Limits (Continued)

MPC_i = maximum permissible concentration for nuclide, i, per 10 CFR 20, Appendix B, Table 2, Column 2.

1.3 Gas Effluent Concentration Limits

10 CFR 20 limits the concentration at the site boundary, due to noble gas releases, to less than Appendix B, Table 2, Column 1, values for unrestricted areas. Radiation monitor alarm setpoints are established to ensure that these release limits are not exceeded. In the event a gaseous release from the station result in an alarm setpoint being exceeded, an evaluation of the site boundary concentration resulting from the release will be performed:

To determine the concentration and MPC fraction summation at site boundary, the following equations will be used:

$$a_i = K_o Q_i (\chi/Q)$$

$$\text{and} \sum_{i=1}^{n} a_i/MPC_i \leq 1$$

Where:

a_i = Concentration of radionuclide, i, at site boundary

K_o = Constant of unit conversion. (1E-6m^3/cc)

MPC_i = Maximum permissible concentration (10 CFR 20, Appendix B, Table 2, Column 1 value for radionuclide, i)

Q_i = The release rate of radionuclides, i, in gaseous effluents from all vent releases (in µCi/sec.)

(χ/Q) = 5E-6 sec/m^3. For all vent releases. The highest calculated annual average relative concentration for any area at or beyond the unrestricted area boundary

1.2 Gas Effluent Concentration Limits (Continued)

As appropriate, simultaneous releases from the Auxiliary Building Ventilation Stack, Laboratory and Radwaste Building Stack and condenser off gas will be considered in evaluating compliance with the release rate limits of 10 CFR 20. Monitor indications (readings) may be averaged over a time period not to exceed 15 minutes when determining noble gas release rate based on correlation of the monitor reading and monitor sensitivity. Historical annual average dispersion parameters, as presented in Table 3, may be used for evaluating the gaseous effluent dose rate.

NOTE: For administrative purposes, more conservative alarm setpoints than those as prescribed above may be imposed. However, conditions exceeding those more limiting alarm setpoints do not necessarily indicate radioactive material release rates exceeding 10 CFR 20 limits. Provided actual releases do not result in radiation monitor indications exceeding alarm setpoint values based upon the above criteria, no further analyses are required for demonstrating compliance with 10 CFR 20.

2.0 RADIOACTIVE EFFLUENT DOSE LIMITS

2.1 Liquid Effluent Dose Calculations

Three pathways for human exposure to liquid releases from FCS to the Missouri River exists: 1) fish, 2) drinking water, and 3) Shoreline deposition. Fish are considered to be taken from the vicinity of the plant discharge. The drinking water for Omaha is located 19 miles downstream from FCS. The dilution factor for this pathway is derived from the Revised Environmental Report for FCS, (1974), (page 4-29 and 4-31). This report states that during Low-Low river conditions, the concentration at Omaha's water intake will be ≤14% of the concentration at discharge from FCS. This equates to a dilution factor of 7.14, which is used to calculate the dose to an individual from liquid pathways. All pathways combine to give the dose to an individual in unrestricted areas.

10 CFR 50, App. I restricts the dose to individuals in the unrestricted areas from radioactive materials in liquid effluents from the Fort Calhoun Station to the following limits:

- during any calendar quarter
  ≤1.5 mrem to total body
  ≤5.0 mrem to any organ and

2.1 Liquid Effluent Dose Calculation (Continued)

- during any calendar year
  $\leq$ 3.0 mrem to total body
  $\leq$ 10.0 mrem to any organ

The following calculational methods shall be used for determining the dose or dose commitment from liquid effluents.

Doses from Liquid Effluent Pathways

A. POTABLE WATER

$$R_{apj} = 1100 \frac{U_{ap}M_p}{F} \sum_{i=1}^{n} Q_i D_{aipj} \exp(-\lambda_i t_p)$$

where:

R_{apj} = is the total annual dose to organ j of individuals of age group a from all of the nuclides i in pathway p, in mrem/yr.

U_{ap} = is a usage factor that specifies the exposure time or intake rate for an individual of age group a associated with pathway p, in hr/yr, ℓ/yr or kg/yr. Table 5

M_p = is the mixing ratio (reciprocal of the dilution factor) at the point of exposure or the point of withdrawal of drinking water or point of harvest of aquatic food), dimensionless. Table 3

F = is the flow rate of the liquid effluent, in ft^3/sec.

Q_i = is the release rate of nuclide i, in Ci/yr.

D_{aipj} = is the dose factor specific to a given age group a, radionuclide i, pathway p, and organ j which can be used to calculate the radiation dose from an intake of a radionuclide, in mrem/pCi or from exposure to a given concentration of a radionuclide in sediment, expressed as a ratio of the dose rate (in mrem/hr) and the areal radionuclide concentration (in pCi/m^2). Tables 11-14

λ_i = is the radioactive decay constant of nuclide i, in hr^{-1}.

t_p = is the average transit time required for nuclides to reach the point of exposure. For internal

Doses from Liquid Effluent Pathways (Continued)

dose, t_p is the total time elapsed between release of the nuclides and ingestion of food or water, in hours. Table 15

1100 = Constant (pCi * yr * /Ci * sec * L)

B. AQUATIC FOODS

$$R_{apj} = 1100 \frac{U_{ap} M_p}{F} \sum_{i=1}^{n} Q_i B_{ip} D_{aipj} \exp(-\lambda_i t_p)$$

Where:

R_{apj} = is the total annual dose to organ j of individuals of age group a from all of the nuclides i in pathway p, in mrem/yr.

U_{ap} = is a usage factor that specifies the exposure time or intake rate for an individual of age group a associated with pathway p, in hr/yr, ℓ/yr or kg/yr. Table 5

M_p = is the mixing ratio (reciprocal of the dilution factor) at the point of exposure or the point of withdrawal of drinking water or point of harvest of aquatic food), dimensionless. Table 3

F = is the flow rate of the liquid effluent, in ft^3/sec.

Q_i = is the release rate of nuclide i, in Ci/yr.

B_{ip} = is the equilibrium bioaccumulation factor for nuclide i in pathway p, expressed as the ratio of the concentration in biota (in Pci/kg) to the radionuclide concentration in water (in Pci/liter), in liters/kg. Table 2

D_{aipj} = is the dose factor specific to a given age group a, radionuclide i, pathway p, and organ j which can be used to calculate the radiation dose from an intake of a radionuclide, in mrem/ Pci or from exposure to a given concentration of a radionuclide in sediment, expressed as a ratio of the dose rate (in mrem/hr) and the areal radionuclide concentration (in pCi/m^2). Tables 11-14

λ_i = is the radioactive decay constant of nuclide i, in hr^{-1}.

Doses from Liquid Effluent Pathways

B. AQUATIC FOODS

Where: (con't)

t_p = is the average transit time required for nuclides to reach the point of exposure. For internal dose, t_p is the total time elapsed between release of the nuclides and ingestion of food or water, in hours. Table 15

1100 = Constant (pCi * yr * ft^3/Ci * sec * L)

C. SHORELINE DEPOSITS

$$R_{apj} = 110{,}000 \frac{U_{ap}M_p}{F} \sum_{i=1}^{n} Q_i T_{ip} D_{aipj} [\exp(-\lambda_i t_p)] [1-\exp(-\lambda_i t_b)]$$

Where:

R_{apj} = is the total annual dose to organ j of individuals of age group a from all of the nuclides i in pathway p, in mrem/yr.

U_{ap} = is a usage factor that specifies the exposure time or intake rate for an individual of age group a associated with pathway p, in hr/yr, ℓ/yr or kg/yr. Table 5

M_p = is the mixing ratio (reciprocal of the dilution factor) at the point of exposure or the point of withdrawal of drinking water or point of harvest of aquatic food), dimensionless. Table 3

F = is the flow rate of the liquid effluent, in ft^3/sec.

Q_i = is the release rate of nuclide i, in Ci/yr.

T_{ip} = is the radioactive half life of nuclide i, in days.

D_{aipj} = is the dose factor specific to a given age group a, radionuclide i, pathway p, and organ j which can be used to calculate the radiation dose from an intake of a radionuclide, in mrem/pCi or from exposure to a given concentration of a radionuclide in sediment, expressed as a ratio of the dose rate (in mrem/hr) and the areal radionuclide concentration (in pCi/m^2). Tables 11-14

Doses from Liquid Effluent Pathways

C. SHORELINE DEPOSITS

Where: (con't)

λ_i = is the radioactive decay constant of nuclide i, in hr^{-1}.

t_p = is the average transit time required for nuclides to reach the point of exposure. For internal dose, t_p is the total time elapsed between release of the nucli es and ingestion of food or water, in hours. Table 15

t_b = is the period of time for which sediment or soil is exposed to the contaminated water, in hours. Table 15

110,000= Constant [(100 * pCi * yr * ft^3)/(Ci * sec * L)]

2.2 Gaseous Effluent Dose Calculations

2.2.1 Noble Gas

10 CFR 50, App. I, restricts the dose to individuals in the unrestricted areas from radioactive materials in gaseous effluents from the Fort Calhoun Station to the following limits:

- During any calendar quarter
  ≤5 mrad-gamma air dose
  ≤10 mrad-beta air dose
  and
- During any calendar year
  ≤10 mrad-gamma air dose
  ≤20 mrad-beta air dose

The following general equations shall be used to calculate the gamma-air and beta-air doses:

Doses from Gaseous Effluent Pathways

A. Annual Gamma/Beta Air Dose from All Other Noble Gas Releases

$$D^{\gamma}(r,\Theta) \text{ or } D^{\beta}(r,\Theta) = 3.17 \times 10^4 \sum_{i=1}^{n} Q_i [\chi/Q]^D(r,\Theta)\,(DF_i^{\gamma} \text{ or } DF_i^{\beta})$$

Where:

$DF_i^{\gamma}, DF_i^{\beta}$ = are the gamma and beta air dose factors for a uniform semi-infinite cloud of radionuclide i, in mrad-m^3/pCi-yr. Table 1

$D^{\gamma}(r,\Theta)$ or $D^{\beta}(r,\Theta)$ = are the annual gamma and beta air doses at the distance r in the section at angle Θ from the discharge point, in mrad/yr.

Q_i = is the release rate of the radionuclide i, in Ci/yr.

$[\chi/Q]^D(r,\Theta)$ = is the annual average gaseous dispersion factor at the distance r in section θ in sec/m^3. Table 3

3.17×10^4 = is the number of pCi per Ci divided by the number of seconds per year.

B. Annual Total Body Dose from All Other Noble Gas Releases

$$D_{\infty}^{T}(r,\Theta) = S_F \sum_{i=1}^{n} \chi_i(r,\Theta)\,DFB_i$$

Where:

DFB_i = is the total body dose factor for a semi-infinite cloud of the radionuclide i, which includes the attenuation of 5 g/cm^2 of tissue, in mrem-m^3/pCi-yr. Table 3

$D_{\infty}^{T}(r,\Theta)$ = is the annual total body dose due to immersion in a semi-infinite cloud at the distance r in sector Θ, in mrem/yr.

$\chi_i(r,\Theta)$ = is the annual average ground-level concentration of radionuclide i at the distance r in sector Θ, in pCi/m^3. Table 3

S_F = Shielding Factor. Table 15

C. Annual Skin Dose from All Other Noble Gas Releases

$$D_{\infty}^{T}(r,\Theta) = 1.11\ S_F \sum_{i=1}^{n} \chi_i(r,\Theta)\, DF_i^{\gamma} + \sum_{i=1}^{n} \chi_i(r,\Theta)\, DFS_i$$

Where:

$D_{\infty}^{T}(r,\Theta)$ = is the annual skin dose due to immersion in a semi-infinite cloud at the distance r in sector Θ, in mrem/yr.

DFS_i = is the beta skin dose factor for a semi-infinite cloud of radionuclide i in mrem-m^3/pCi-yr.

All other parameters are as defined above.

2.2.2 Radioiodine, Tritium, and Particulates

10 CFR 50, App. I, restricts the dose to individuals in the unrestricted areas from radioactive materials in gaseous effluents from the Fort Calhoun Station to:

- During any calendar quarter
  $\leq$7.5 mrem to any organ
  and
- During any calendar year
  $\leq$15 mrem to any organ

The dose to an individual from radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases with half-lives greater than 8 days in gaseous effluents released to unrestricted areas (See Figure 3) should be determined by the following expressions:

NOTE: In all cases, for releases of tritium, use the dispersion parameter for inhalation (χ/Q).

A. Annual Organ Dose from External Irradiation from Radioactivity Deposited on the Ground Plane

A.1 The ground plane concentration of radionuclide i at the location (r,θ) with respect to the release point may be determined by:

$$C_i^G(r,\Theta) = \frac{[1.0x10^{12}]\ [\delta_i(r,\Theta)Q_i]}{\lambda_i}\ [1-\exp(-\lambda_i t_b)]$$

Where:

C_i^G = is the ground plane concentration of the radionuclide i in the sector at angle θ at the distance r from the release point, in pCi/m^2.

Q_i = is the annual release rate of nuclide i to the atmosphere, in Ci/yr.

t_b = is the time period over which the accumulation is evaluated, which is 15 years (mid-point of plant operating life). Table 15

$\delta_i(r,\theta)$ = is the annual average relative deposition of effluent species i at location (r,θ), considering depletion of the plume during transport, in m^{-2}. Table 3

λ_i = is the radiological decay constant for nuclide i, in yr^{-1}.

1.0×10^{12} = is the number of pCi per Ci

A.2 The annual organ dose is then calculated using the following equation:

$$D_j^G(r,\Theta) = 8760\, S_F \sum_{i=1}^{n} C_i^G(r,\Theta)\, DFG_{ij}$$

Where:

$C_i^G(r,\theta)$ = is the ground plane concentration of radionuclide i at distance r in sector θ, in pCi/m^2.

DFG_{ij} = is the open field ground plane dose conversion factor for organ j from radionuclide i, in mRem-m^2/pCi-hr. Table 15

$D_j^G(r,\theta)$ = is the annual dose to the organ j at location (r,θ), in mRem/yr.

S_F = is the shielding factor that accounts for the dose reduction due to shielding provided by residential structures during occupancy, dimensionless. Table 15

8760 = is the number of hours in a year

B. Annual Dose from Inhalation of Radionuclides in Air

B.1 The annual average airborne concentration of radionuclide i at the location (r,θ) with respect to the release point may be determined as:

$$\chi_i(r,\theta) = 3.17 \times 10^4 Q_i [\chi/Q]^D(r,\theta)$$

Where:

Q_i = is the release rate of nuclide i to the atmosphere, in Ci/yr.

$\chi_i(r,\theta)$ = is the annual average ground-level concentration of nuclide i in air at sector θ at distance r, in pCi/m^3.

$[\chi/Q]^D(r,\theta)$ = is the annual average atmosphere dispersion factor, in sec/m^3 (see R.G. 1.111). This includes depletion (for radioiodines and particulates) and radioactive decay of the plume. Table 3

3.17×10^4 = is the number of pCi/Ci divided by the number of sec/yr.

B.2 The annual dose associated with inhalation of all radionuclides to organ j of an individual in age group a, is then:

$$D_{ja}^{A}(r,\Theta) = R_a \sum_{i=1}^{n} \chi_i(r,\theta)\, DFA_{ija}$$

Where:

$D_{ja}^{A}(r,\theta)$ = is the annual dose to organ j of an individual in the age group a, at location (r,θ) due to inhalation in mRem/yr.

R_a = is the annual air intake for individuals in the age group a, in m^3/yr. Table 5

DFA_{ija} = is the inhalation dose factor for radionuclide i, organ j, and age group a, in mRem/pCi

C. Annual Dose from Atmospherically Released Radionuclides in Food

C.1 Concentrations of Airborne Radionuclides in Foods

C.1.1 Parameters for Calculating Nuclide Concentrations in Forage, Produce, and Leafy Vegetables

For all radioiodines and particulate radionuclides, excluding Tritium and Carbon-14, the concentration of nuclide i in and on vegetation at the location (r,θ) is estimated using:

$$C_i^V(r,\theta) = d_i(r,\theta)\left[\frac{r[1-\exp(-\lambda_{Ei}t_e)]}{Y_v\lambda_{Ei}} + \frac{B_{iv}[1-\exp(-\lambda_i t_b)]}{P\lambda_i}\right]\exp(-\lambda_i t_h)$$

Where:

$C_i^V(r,\theta)$ = is the concentration of nuclide i in and on vegetation at the location (r,θ), in Pci/kg.

$d_i(r,\theta)$ = is the deposition rate of nuclide i, in Pci/m^2 p/hr.

The deposition rate from the plume is defined by: (Reg. Guide 1.109, Rev. 1, Page 1.109-26, Equa. C-6)

$$d_i(r,\theta) = 1.1 \times 10^8 \delta_i(r,\theta) Q_i$$

Where:

$d_i(r,\theta)$ = is the deposition rate of radionuclide i onto ground at location (r,θ), in pCi/m^2-hr

$\delta_i(r,\theta)$ = is the relative deposition of radionuclide i, considering depletion and decay in transit to location (r,θ), in m^{-2} (see Regulatory Guide 1.111). Table 3

1.1×10^8 = is the number of pCi/Ci (10^{12}) divided by the number of hours per year (8760).

Q_i = is the release rate of nuclide i to the atmosphere, in Ci/yr.

r = is the fraction of deposited activity retained on crops, dimensionless. Table 15

λ_{Ei} = is the effective removal rate constant for radionuclide i from crops, in hr^{-1}. $\lambda_{Ei} = \lambda_i + \lambda_w$ $\lambda_w = 0.0021$/hr. Table 15

t_e = is the time period that crops are exposed to contamination during the growing season, in hours. Table 15

Y_v = is the agricultural productivity (yield) in kg (wet weight)/m^2. Table 15

B_{iv} = is the concentration factor for uptake of radionuclide i from soil by edible parts of crops, in pCi/kg (wet weight) per pCi/kg dry soil. Table 4

Where: (con't)

λ_i = is the radioactive decay constant of nuclide i, in hr^{-1}

t_b = is the period of time for which sediment or soil is exposed to the contaminated water, in hours (mid-point of plant life). Table 15

P = is the effective "surface density" for soil, in kg (dry soil)/m^2. Table 15

t_h = is the holdup time that represents the time interval between harvest and consumption of the food, in hours. Table 15

For the parameters t_e, Y_v, and t_h, different values are used to allow the use of the Equation for different purposes: estimating concentrations in produce consumed by man; in leafy vegetables consumed by man; in forage consumed directly as pasture grass by dairy cows, beef cattle, or goats; and in forage consumed as stored feed by dairy cows, beef cattle or goats.

C.1.2 Parameters for Calculating Nuclide Concentration in Milk

The Concentration of Radionuclide i, excluding Carbon-14 and Tritium, in the Animal's (Milk Cow, Beef Cow, and Goat) Feed

$$C_i^V(r,\Theta) = f_p f_s C_i^P(r,\Theta) + (1 - f_p) C_i^S(r,\Theta) + f_p(1 - f_s) C_i^S(r,\Theta)$$

Where:

$C_i^V(r,\theta)$ = is the concentration of radionuclide i in the animal's feed, in pCi/kg.

$C_i^P(r,\theta)$ = is the concentration of radionuclide i on pasture grass (calculated using Equation C-5 with t_h=0), in pCi/kg.

$C_i^S(r,\theta)$ = is the concentration of radionuclide i in stored feeds (calculated using Equation C-5 with t_h=90 days), in pCi/kg.

t_p = is the fraction of the year that animals graze on pasture. Table 15

f_s = is the fraction of daily feed that is pasture grass when the animal grazes on pasture. Table 15

C.1.3 Parameters for Calculating the Nuclide Concentration in Cow and Goat Milk, excluding C-14 and Tritium

$$C_i^M(r,\Theta) = F_m C_i^V(r,\Theta) Q_F \exp(-\lambda_i t_f)$$

<u>Where</u>:

$C_i^M(r,\theta)$ = is the concentration in milk of nuclide i, in pCi/liter.

$C_i^V(r,\theta)$ = is the concentration of radionuclide i in the animal's feed, in pCi/kg.

F_m = is the average fraction of the animal's daily intake of radionuclide i which appears in each liter of milk, in days/liter. Table 4

Q_F = is the amount of feed consumed by the animal per day, in kg/day. Table 6

t_f = is the average transport time of the activity from the feed into the milk and to the receptor (a value of 2 days is assumed). Table 15

λ_i = is the radiological decay constant of nuclide i, in days^{-1}.

C.1.4 Parameters for Calculating the Carbon-14 Concentrations in Vegetation

Carbon-14 is assumed to be released in oxide form (CO or CO_2). The concentration of Carbon-14 in vegetation is calculated by assuming that its ratio to the natural carbon in vegetation is the same as the ratio of Carbon-14 to natural carbon in the atmosphere surrounding the vegetation. Also, in the case of intermittent releases, such as from gaseous waste decay tanks, the parameter p is employed to account for the fractional equilibrium ratio achieved. The parameter p is defined as the ratio of the total annual release time (for Carbon-14 atmospheric releases) to the total annual time during which photosynthesis occurs (taken to be 4400 hrs), under the condition that the value of p should never exceed unity. For continuous Carbon-14 releases, p is taken to be unity. These considerations yield the following relationship:

$$C_{14}^{V}(r,\Theta) = 3.17 \times 10^{7} p Q_{14} [\chi/Q](r,\Theta)\ 0.11/0.16$$

$$= 2.2 \times 10^{7} p Q_{14} [\chi/Q](r,\Theta)$$

Where:

$C^{v}_{14}(r,\theta)$ = is the concentration of Carbon-14 in vegetation grown at location (r,θ), in pCi/kg.

Q_{14} = is the annual release rate of Carbon 14, in Ci/yr.

$[\chi/Q](r,\theta)$ = is the atmospheric dispersion factor, in sec/m^3. Table 3

p = is the fractional equilibrium ratio, dimensionless. P=1 (Reg. Guide 1.109, Rev. 1, pg. 26).

0.11 = is the fraction of total plant mass that is natural carbon, dimensionless.

0.16 = is equal to the concentration of natural carbon in the atmosphere, in g/m^3.

3.17×10^7 = is equal to $(1.0 \times 10^{12}$ pCi/Ci$)(1.0 \times 10^3$ g/kg$)$ $(3.15 \times 10^7$ sec/yr$)$.

C.1.5 Parameters for Calculating Tritium Concentrations in Vegetation

The concentration of tritium in vegetation is calculated from its concentration in the air surrounding the vegetation. The NRC staff derived the following equation:

$$C_{T}^{V}(r,\Theta) = 3.17 \times 10^{7} Q_{T} [\chi/Q](r,\Theta)\ (0.75)(0.5/H)$$

$$= 1.2 \times 10^{7} Q_{T} [\chi/Q](r,\Theta)/H$$

Where:

$C^{v}_{T}(r,\theta)$ = is the concentration of Tritium in vegetation grown at location (r,θ), in Pci/kg.

H = is the absolute humidity of the atmosphere at location (r,θ), in g/m^3. H=8 gm/kg.

Q_T = is the annual release rate of Tritium, in Ci/yr.

$[\chi/Q](r,\theta)$ = is the atmospheric dispersion factor, in sec/m^3. Table 3

Where: (con't)

0.5 = is the ratio of tritium concentration in plant water to tritium concentration in atmospheric water, dimensionless, and

0.75 = is the fraction of total plant mass that is water, dimensionless.

C.2 Annual Dose from Atmospherically Released Radionuclides in Foods

The annual dose to organ j of an individual in age group a, resulting from ingestion of all radionuclides in produce, milk, and leafy vegetables is given by:

$$D_{ja}^{D}(r,\Theta) = \sum_i DFI_{ija}\left[U_a^V f_g C_i^V(r,\Theta) + U_a^m C_i^m(r,\Theta) + U_a^F C_i^F(r,\Theta) + U_a^L f_l C_i^L(r,\Theta)\right]$$

Where:

$D_{ja}^{D}(r,\theta)$ = is the annual dose to organ j of an individual in age group a from dietary intake of atmospherically released radionuclides, in Mrem/yr.

DFI_{ija} = is the dose conversion factor for the ingestion of nuclide i, organ j, and age group a, in Mrem/Pci.

U_a^v, U_a^m, U_a^F, U_a^L = are the ingestion rates of produce (non-leafy vegetables, fruits, and grains); milk, meat, and leafy vegetables, respectively for individuals in age group a. Table 5.

All other symbols are as defined in previous 1.109 equations. Values of F_g and f_l are 0.76 and 1.0, respectively.

C.2.1 Calculating the Ingested Dose from Leafy and Non-Leafy (produce) Vegetation for Radionuclide i to Each Organ J and Age Group a

$$D_{ja}^{D}(r,\Theta) = DFI_{ija}\left[U_a^L f_l C_i^L(r,\Theta) + U_a^V f_g C_i^V(r,\Theta)\right]$$

Where:

$D_{ja}^{D}(r,\theta)$ = is the annual dose from the ingestion of nuclide i to organ j of an individual in age group a from dietary intake of atmospherically released radionuclides in vegetation, in mRem/yr.

DFI_{ija} = is the dose conversion factor for the ingestion of nuclide i, organ j, and age group a, in mRem/pCi. Tables 11-14

U_a^L, U_a^v = are the ingestion rates of leafy vegetables and produce (non-leafy vegetables, fruits, and grains), for individuals in age group a, in kg/yr. Table 5

Where: (con't)

C_i^L = is the concentration of nuclide i in and on leafy vegetation, in pCi/kg.

C_i^V = is the concentration of nuclide i in and on produce, in pCi/kg.

All other symbols are as previously defined in previous 1.109 equations. Values of F_g and F_l are 0.76 and 1.0, respectively.

C.2.2 Calculation Determining the Ingested Dose from Cow Milk for Radionuclide i, excluding Carbon-14 and Tritium, to Organ j and Age Group a.

$$D_{ja}^{D}(r,\Theta) = DFI_{ija}\left[U_a^M C_i^M(r,\Theta)\right]$$

Where:

$D_{ja}^{D}(r,\theta)$ = is the annual dose from the ingestion of nuclide i to organ j of an individual in age group a from dietary intake of atmospherically released radionuclides in cow milk, in mRem/yr.

DFI_{ija} = is the dose conversion factor for the ingestion of nuclide i, organ j, and age group a, in mRem/pCi. Tables 11-14

U_a^M = is the ingestion rate of cow milk for individuals in age group a, in ℓ/yr. Table 5

C_i^M = is the radionuclide concentration in cow milk, in pCi/kg.

C.2.3 Calculation Determining the Ingested Dose from Meat for Radionuclide J to Organ K and Age Group a

$$D_{ja}^{D}(r,\Theta) = DFI_{ija}\left[U_a^F C_i^F(r,\Theta)\right]$$

Where:

$D_{ja}^{D}(r,\theta)$ = is the annual dose from the ingestion of nuclide i to organ j of an individual in age group a, from dietary intake of atmospherically released radionuclides in meat, in mRem/yr.

DFI_{ija} = is the dose conversion factor for the ingestion of nuclide i, organ j, and age group a, in mRem/pCi. Tables 11-14

U_a^F = is the ingestion rate of meat for individuals in age group a in kg/yr. Table 5

<u>Where</u>: (con't)

C_i^F = is the radionuclide concentration in meat, [illegible] kg.

TABLE 1

DOSE FACTORS FOR EXPOSURE TO A SEMI-INFINITE CLOUD OF NOBLE GASES

Nuclide	β-[illegible]F$_i^\beta$)	β-Skin**(DFS_i)	γ-Air*(DF_i^γ)	γ-Body**(DFB_i)
KR-83m	2.88E-04	--	1.93E-05	7.56E-08
KR-85m	1.97E-03	1.46E-03	1.23E-03	1.17E-03
KR-85	1.95E-03	1.34E-03	1.72E-05	1.61E-05
KR-87	1.03E-02	9.73E-03	6.17E-03	5.92E-03
KR-88	2.93E-03	2.37E-03	1.52E-02	1.47E-02
KR-89	1.06E-02	1.01E-02	1.73E-02	1.6[illegible]-02
KR-90	7.83E-03	7.29E-03	1.63E-02	1.56E-02
Xe-131m	1.11E-03	4.76E-04	1.56E-04	9.15E-05
Xe-133m	1.48E-03	9.94E-04	3.27E-04	2.51E-04
Xe-133	1.05E-03	3.06E-04	3.53E-04	2.94E-04
Xe-135m	7.39E-04	7.11E-04	3.36E-03	3.12E-03
Xe-135	2.46E-03	1.86E-03	1.92E-03	1.81E-03
Xe-137	1.27E-02	1.22E-02	1.51E-03	1.42E-03
Xe-138	4.75E-03	4.13E-03	9.21E-03	8.83E-03
Ar-41	3.28E-03	2.69E-03	9.30E-03	8.84E-03

* $\frac{\text{mrad-m}^3}{\text{pCi/yr}}$

** $\frac{\text{mrem-m}^3}{\text{pCi/yr}}$

*** 2.88E-04 = 2.88×10^{-4}

TABLE 2

BIOACCUMULATION FACTORS
(pCi/kg per pCi/liter)

Element	FRESHWATER Fish	FRESHWATER Invertebrate
H	9.0E-01	9.0E-01
C	4.6E-03	9.1E-03
NA	1.0E-02	2.0E-02
P	[illegible].0E-05	2.0E-04
CR	2.0E-02	2.0E-03
MN	4.0E-02	9.0E-04
FE	1.0E-02	3.2E-03
CO	5.0E-01	2.0E-02
NI	1.0E-02	1.0E-02
CU	5.0E-01	4.0E-02
ZN	2.0E-03	1.0E-04
BR	4.2E-02	3.3E-02
RB	2.0E-03	1.0E-03
SR	3.0E-01	1.0E-02
Y	2.5E-01	1.0E-03
ZR	3.3E-00	6.7E-00
NB	3.0E-04	1.0E-02
MO	1.0E-01	1.0E-01
TC	1.5E-01	5.0E-00
RU	1.0E-01	3.0E-02
RH	1.0E-01	3.0E-02
TE	4.0E-02	6.1E-03
I	1.5E-01	5.0E-00
CS	2.0E-03	1.0E-03
BA	4.0E-01	2.0E-02
LA	2.5E-01	1.0E-03
CE	1.0E-00	1.0E-03
PR	2.5E-01	1.0E-03
ND	2.5E-01	1.0E-03
W	1.2E-03	1.0E-01
NP	1.0E-01	4.0E-02

TABLE 3

CONTROLLING LOCATIONS, PATHWAYS AND ATMOSPHERIC DISPERSION FOR DOSE CALCULATIONS

Location	Pathway(s)	Controlling Age Group	Atmospheric Dispersion χ/Q ($\chi/Q(r,\Theta)$) (sec/m³)	D/Q ($\delta(r,\Theta)$) (1/m³)
Site Boundary	Noble Gases Direct Exposure	N/A	5.0E-06	N/A
Site Boundary	Inhalation	Child	5.0E-06	N/A
Site Boundary	Gamma-Air Beta-Air	N/A	5.0E-06	N/A
Miller Farm* 0.8 miles SSW	milk, ground plane, meat, inhalation, and vegetation	Child	2.5E-06	1.6E-08
Site Boundary	Liquid	N/A	Mixing Ratio, M_r	7.14

TABLE 4

STABLE ELEMENT TRANSFER DATA

Element	B_{iv} Veg/Soil	F_m (Cow) Milk (d/λ)	F_f Meat (d/kg)
H	4.8E+00	1.0E-02	1.2E-02
C	5.5E+00	1.2E-02	3.1E-02
Na	5.2E-02	4.0E-02	3.0E-02
P	1.1E+00	2.5E-02	4.6E-02
Cr	2.5E-04	2.2E-03	2.4E-03
Mn	2.9E-02	2.5E-04	8.0E-04
Fe	6.6E-04	1.2E-03	4.0E-02
Co	9.4E-03	1.0E-03	1.3E-02
Ni	1.9E-02	6.7E-03	5.3E-02
Cu	1.2E-01	1.4E-02	8.0E-03
Zn	4.0E-01	3.9E-02	3.0E-02
Rb	1.3E-01	3.0E-02	3.1E-02
Sr	1.7E-02	8.0E-04	6.0E-04
Y	2.6E-03	1.0E-05	4.6E-03
Zr	1.7E-04	5.0E-06	3.4E-02
Nb	9.4E-03	2.5E-03	2.8E-01
Mo	1.2E-01	7.5E-03	8.0E-03
Tc	2.5E-01	2.5E-02	4.0E-01
Ru	5.0E-02	1.0E-06	4.0E-01
Rh	1.3E-01	1.0E-02	1.5E-03
Ag	1.5E-01	5.0E-02	1.7E-02
Te	1.3E+00	1.0E-03	.7E-02
I	2.0E-02	6.0E-03	2.9E-03
Cs	1.0E-02	1.2E-02	4.0E-03
Ba	5.0E-03	4.0E-04	3.2E-03
La	2.5E-03	5.0E-06	2.0E-04
Ce	2.5E-03	1.0E-04	1.2E-03
Pr	2.5E-03	5.0E-06	4.73-03
Nd	2.4E-03	5.0E-06	3.3E-03
W	1.8E-02	5.0E-04	1.3E-03
Np	2.5E-03	5.0E-06	2.0E-04

TABLE 5

RECOMMENDED VALUES FOR U_{AP} TO BE USED FOR THE MAXIMUM EXPOSED INDIVIDUAL IN LIEU OF SITE SPECIFIC DATA

Pathway	Infant	Child	Teen	Adult
Fruits, vegetables, & grain (kg/yr)	-	520	630	520
Leafy vegetables (kg/yr)	-	26	42	64
Milk (ℓ/yr)	330	330	400	310
Meat & poultry (kg/yr)	-	41	65	110
Fish (fresh or salt) (kg/yr)	-	6.9	16	21
Other Seafood (kg/yr)	-	1.7	3.8	5
Drinking water (ℓ/yr)	330	510	510	730
Shoreline recreation (hr/yr)	-	14	67	12
Inhalation (m^3/yr)	1400	3700	8000	8000

TABLE 6

ANIMAL CONSUMPTION RATES

Animal	Q_F Fee or Forage [Kg/day (wet weigh)]	Q_{AW} Water (ℓ/day)
Milk	50	60
Beef Cattle	50	50
Goats	6	8

TABLE 7
INHALATION DOSE FACTORS FOR ADULT
(mRem per pCi Inhaled)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07
C 14	2.27E-06	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07
NA 24	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06
P 32	1.65E-04	9.64E-06	6.26E-06	-	-	-	1.08E-05
CR 51	-	-	1.25E-08	7.44E-09	2.85E-09	1.80E-06	4.15E-07
MN 54	-	4.95E-06	7.87E-07	-	1.23E-06	1.75E-04	9.67E-06
MN 56	-	1.55E-10	2.29E-11	-	1.63E-10	1.18E-06	2.53E-06
FE 55	3.07E-06	2.12E-06	4.93E-07	-	-	9.01E-06	7.54E-07
FE 59	1.47E-06	3.47E-06	1.32E-06	-	-	1.27E-04	2.35E-05
CO 58	-	1.98E-07	2.59E-07	-	-	1.16E-04	1.33E-05
CO 60	-	1.44E-06	1.85E-06	-	-	7.46E-04	3.56E-05
NI 63	5.40E-05	3.93E-06	1.81E-06	-	-	2.23E-05	1.67E-06
NI 65	1.92E-10	2.62E-11	1.14E-11	-	-	7.00E-07	1.54E-06
CU 64	-	1.83E-10	7.69E-11	-	5.78E-10	8.48E-07	6.12E-06
ZN 65	4.05E-06	1.29E-05	5.82E-06	-	8.62E-06	1.08E-04	6.68E-06
ZN 69	4.23E-12	8.14E-12	5.65E-13	-	5.27E-12	1.15E-07	2.04E-09
BR 83	-	-	3.01E-08	-	-	-	2.90E-08
BR 84	-	-	3.91E-08	-	-	-	2.05E-13
BR 85	-	-	1.60E-09	-	-	-	LT E-24
RB 86	-	1.69E-05	7.37E-06	-	-	-	2.08E-06
RB 88	-	4.84E-08	2.41E-08	-	-	-	4.18E-19
RB 89	-	3.20E-08	2.12E-08	-	-	-	1.16E-21
SR 89	3.80E-05	-	1.09E-06	-	-	1.75E-04	4.37E-05
SR 90	1.24E-02	-	7.62E-04	-	-	1.20E-03	9.02E-05
SR 91	7.74E-09	-	3.13E-10	-	-	4.56E-06	2.39E-05
SR 92	8.43E-10	-	3.64E-11	-	-	2.06E-06	5.38E-06
Y 90	2.61E-07	-	7.01E-09	-	-	2.12E-05	6.32E-05
Y 91M	3.26E-11	-	1.27E-12	-	-	2.40E-07	1.66E-10
Y 91	5.78E-05	-	1.55E-06	-	-	2.13E-04	4.81E-05
Y 92	1.29E-09	-	3.77E-11	-	-	1.96E-06	9.19E-06
Y 93	1.18E-08	-	3.26E-10	-	-	6.06E-06	5.27E-00
ZR 95	1.34E-05	4.30E-06	2.91E-06	-	6.77E-06	2.21E-04	1.88E-05
ZR 97	1.21E-08	2.45E-09	1.13E-09	-	3.71E-09	9.84E-06	6.54E-05
NB 95	1.76E-06	9.77E-07	5.26E-07	-	9.67E-07	6.31E-05	1.30E-05
MO 99	-	1.51E-08	2.87E-09	-	3.64E-08	1.14E-05	3.10E-05
TC 99M	1.29E-13	3.64E-13	4.63E-12	-	5.52E-12	9.55E-08	5.20E-07

INHALATION DOSE FACTORS FOR ADULT
(mRem per pCi Inhaled)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	5.22E-15	7.52E-15	7.38E-14	-	1.35E-13	4.99E-08	1.36E-21
RU 103	1.91E-07	-	8.23E-08	-	7.29E-07	6.31E-05	1.38E-05
RU 105	9.88E-11	-	3.89E-11	-	1.27E-10	1.37E-04	6.02E-06
RU 106	8.64E-06	-	1.09E-06	-	1.67E-05	1.17E-03	1.14E-04
AG 110M	1.35E-06	1.25E-06	7.43E-07	-	2.46E-06	[illegible]E-04	3.78E-05
TE 125M	4.27E-07	1.98E-07	5.84E-08	1.31E-07	1.55E-06	3.92E-05	8.83E-06
TE 127M	1.58E-06	7.21E-07	1.96E-07	4.11E-07	5.72E-06	1.20E-04	1.87E-05
TE 127	1.75E-10	8.03E-11	3.87E-11	1.32E-10	6.37E-10	8.14E-07	7.17E-06
TE 129M	1.22E-06	5.84E-07	1.98E-07	4.30E-07	4.57E-06	1.45E-04	4.79E-05
TE 129	6.22E-12	2.99E-12	1.55E-12	4.87E-12	2.34E-11	2.42E-07	1.96E-08
TE 131M	8.74E-09	5.45E-09	3.63E-09	6.88E-09	3.86E-08	1.82E-05	6.95E-05
TE 131	1.39E-12	7.44E-13	4.49E-13	1.17E-12	5.46E-12	1.74E-07	2.30E-09
TE 132	3.25E-08	2.69E-08	2.02E-08	2.37E-08	1.82E-07	3.60E-05	6.37E-05
I 130	5.72E-07	1.68E-06	6.60E-07	1.42E-04	2.61E-06	-	9.61E-07
I 131	3.15E-06	4.47E-06	2.56E-06	1.49E-03	7.66E-06	-	7.85E-07
I 132	1.45E-04	4.07E-07	1.45E-07	1.43E-05	6.48E-07	-	5.08E-08
I 133	1.08E-06	1.85E-06	5.65E-07	2.69E-04	3.23E-06	-	1.11E-06
I 134	8.05E-08	2.16E-07	7.69E-08	3.73E-06	3.44E-07	-	1.26E-10
I 135	3.35E-07	8.73E-07	3.21E-07	5.60E-05	1.39E-06	-	6.56E-07
CS 134	4.66E-05	1.06E-04	9.10E-05	-	3.59E-05	1.22E-05	1.30E-06
CS 136	4.88E-06	1.83E-05	1.38E-05	-	1.07E-05	1.50E-06	1.46E-06
CS 137	5.98E-05	7.76E-05	5.35E-05	-	2.78E-05	9.40E-06	1.05E-06
CS 138	4.14E-08	7.76E-08	4.05E-08	-	6.00E-09	6.07E-09	2.33E-13
BA 139	1.17E-10	8.32E-14	3.42E-12	-	7.78E-14	4.70E-07	1.12E-07
BA 140	4.88E-06	6.13E-09	3.21E-07	-	2.09E-09	1.59E-04	2.73E-05
BA 141	1.25E-11	9.41E-15	4.20E-13	-	8.75E-15	2.42E-07	1.45E-17
BA 142	3.29E-12	3.38E-15	2.07E-13	-	2.86E-15	1.49E-07	1.96E-26
LA 140	4.30E-08	2.17E-08	5.73E-09	-	-	1.70E-05	5.73E-05
LA 142	8.54E-11	3.88E-11	9.65E-12	-	-	7.91E-07	2.64E-07
CE 141	2.49E-06	1.69E-06	1.91E-07	-	7.83E-07	4.52E-05	1.50E-05
CE 143	2.33E-08	1.72E-08	1.91E-09	-	7.60E-09	9.97E-06	2.83E-05
CE 144	4.29E-04	1.79E-04	2.30E-05	-	1.06E-04	9.72E-04	1.02E-04
PR 143	1.17E-06	4.69E-07	5.80E-08	-	2.70E-07	3.51E-05	2.50E-05
PR 144	3.76E-12	1.56E-12	1.91E-13	-	8.81E-13	1.27E-07	2.69E-18
ND 147	6.59E-07	7.62E-07	4.56E-08	-	4.45E-07	2.76E-05	2.16E-05
W 187	1.06E-09	8.85E-10	3.10E-10	-	-	3.63E-06	1.94E-05
NP 239	2.87E-08	2.82E-09	1.55E-09	-	8.75E-09	4.70E-06	1.49E-05

TABLE 8
INHALATION DOSE FACTORS FOR TEENAGER
(mRem per pCi Inhaled)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07
C 14	3.25E-06	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07
NA 24	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06
P 32	2.36E-04	1.37E-05	8.95E-06	-	-	-	1.16E-05
CR 51	-	-	1.69E-08	9.37E-09	3.84E-09	2.62E-06	3.75E-07
MN 54	-	6.39E-06	1.05E-06	-	1.59E-06	2.48E-04	8.35E-06
MN 56	-	2.12E-10	3.15E-11	-	2.24E-10	1.90E-06	7.18E-06
FE 55	4.18E-06	2.98E-06	6.93E-07	-	-	1.55E-05	7.99E-07
FE 59	1.99E-06	4.62E-06	1.79E-06	-	-	1.91E-04	2.23E-05
CO 58	-	2.59E-07	3.47E-07	-	-	1.68E-04	1.19E-05
CO 60	-	1.89E-06	2.48E-06	-	-	1.09E-03	3.24E-05
NI 63	7.25E-05	5.43E-06	2.47E-06	-	-	3.84E-05	1.77E-06
NI 65	2.73E-10	3.66E-11	1.59E-11	-	-	1.17E-06	4.59E-06
CU 64	-	2.54E-10	1.06E-10	-	8.01E-10	1.39E-06	7.68E-06
ZN 65	4.82E-06	1.67E-05	7.80E-06	-	1.08E-05	1.55E-04	5.83E-06
ZN 69	6.04E-12	1.15E-11	8.07E-13	-	7.53E-12	1.98E-07	3.56E-08
BR 83	-	-	4.30E-08	-	-	-	LT E-24
BR 84	-	-	5.41E-08	-	-	-	LT E-24
BR 85	-	-	2.29E-09	-	-	-	LT E-24
RB 86	-	2.38E-05	1.05E-05	-	-	-	2.21E-06
RB 88	-	6.82E-08	3.40E-08	-	-	-	3.65E-15
RB 89	-	4.40E-08	2.91E-08	-	-	-	4.22E-17
SR 89	5.43E-05	-	1.56E-06	-	-	3.02E-04	4.64E-05
SR 90	1.35E-02	-	8.35E-04	-	-	2.06E-03	9.56E-05
SR 91	1.10E-08	-	4.39E-10	-	-	7.59E-06	3.24E-05
SR 92	1.19E-09	-	5.08E-11	-	-	3.43E-06	1.49E-06
Y 90	3.73E-07	-	1.00E-08	-	-	3.66E-05	6.99E-05
Y 91M	4.63E-11	-	1.77E-12	-	-	4.00E-07	3.77E-09
Y 91	8.26E-05	-	2.21E-06	-	-	3.67E-04	5.11E-05
Y 92	1.84E-09	-	5.36E-11	-	-	3.35E-06	2.06E-05
Y 93	1.69E-08	-	4.65E-10	-	-	1.04E-05	7.24E-00
ZR 95	1.82E-05	5.73E-06	3.94E-06	-	8.42E-06	3.36E-04	1.86E-05
ZR 97	1.72E-08	3.40E-09	1.57E-09	-	5.15E-09	1.62E-05	7.88E-05
NB 95	2.32E-06	1.29E-06	7.08E-07	-	1.25E-06	9.39E-05	1.21E-05
MO 99	-	2.11E-08	4.03E-09	-	5.14E-08	1.92E-05	3.36E-05
TC 99M	1.73E-13	4.83E-13	6.24E-12	-	7.20E-12	1.44E-07	7.66E-07

INHALATION DOSE FACTORS FOR TEENAGER
(mRem per pCi Inhaled)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	7.40E-15	1.05E-14	1.03E-13	-	1.90E-13	8.34E-08	1.09E-16
RU 103	2.63E-07	-	1.12E-07	-	9.29E-07	9.79E-05	1.36E-05
RU 105	1.40E-11	-	5.42E-11	-	1.76E-10	2.27E-06	1.13E-05
RU 106	1.23E-05	-	1.55E-06	-	2.38E-05	2.01E-03	1.20E-04
AG 110M	1.73E-06	1.64E-06	9.99E-07	-	3.13E-06	8.44E-04	3.41E-05
TE 125M	6.10E-07	2.80E-07	8.34E-08	1.75E-07	-	6.70E-05	9.38E-06
TE 127M	2.25E-06	1.02E-06	2.73E-07	5.48E-07	8.17E-06	2.07E-04	1.99E-05
TE 127	2.51E-10	1.14E-10	5.52E-11	1.77E-10	9.10E-10	1.40E-06	1.01E-06
TE 129M	1.74E-06	8.23E-07	2.81E-07	5.72E-07	6.49E-06	2.47E-04	5.06E-05
TE 129	8.87E-12	4.22E-12	2.20E-12	6.48E-12	3.32E-11	4.12E-07	2.02E-08
TE 131M	1.23E-08	7.51E-09	5.03E-09	9.06E-09	5.49E-08	2.97E-05	7.76E-05
TE 131	1.97E-12	1.04E-12	6.30E-13	1.55E-12	7.72E-12	2.92E-07	1.89E-09
TE 132	4.50E-08	3.63E-08	2.74E-08	3.07E-08	2.44E-07	5.61E-05	5.79E-05
I 130	7.80E-07	2.24E-06	8.96E-07	1.86E-04	3.44E-06	-	1.14E-06
I 131	4.43E-06	6.14E-06	3.30E-06	1.83E-03	1.05E-05	-	8.11E-07
I 132	1.99E-07	5.47E-07	1.97E-07	1.89E-05	8.65E-07	-	1.59E-07
I 133	1.52E-06	2.56E-06	7.78E-07	3.65E-04	4.49E-06	-	1.29E-06
I 134	1.11E-07	2.90E-07	1.05E-07	4.94E-06	4.58E-07	-	2.55E-09
I 135	4.62E-07	1.18E-06	4.36E-07	7.76E-05	1.86E-06	-	8.69E-07
CS 134	6.28E-05	1.41E-04	6.86E-05	-	4.69E-05	1.83E-05	1.22E-06
CS 136	6.44E-06	2.42E-05	1.71E-05	-	1.38E-05	2.22E-06	1.36E-06
CS 137	8.38E-05	1.06E-04	3.89E-05	-	3.80E-05	1.51E-05	1.06E-06
CS 138	5.82E-08	1.07E-07	5.58E-08	-	8.28E-08	9.84E-09	3.38E-11
BA 139	1.67E-10	1.18E-13	4.87E-12	-	1.11E-13	8.08E-07	8.06E-07
BA 140	6.84E-06	8.38E-09	4.40E-07	-	2.85E-09	2.54E-04	2.86E-05
BA 141	1.78E-11	1.32E-14	5.93E-13	-	1.23E-14	4.11E-07	9.33E-14
BA 142	4.62E-12	4.63E-15	2.84E-13	-	3.92E-15	2.39E-07	5.99E-20
LA 140	5.99E-08	2.95E-08	7.82E-09	-	-	2.68E-05	6.09E-05
LA 142	1.20E-10	5.31E-11	1.32E-11	-	-	1.27E-06	1.50E-06
CE 141	3.55E-06	2.37E-06	2.71E-07	-	1.11E-06	7.67E-05	1.58E-05
CE 143	3.32E-08	2.42E-08	2.70E-09	-	1.08E-08	1.63E-05	3.19E-05
CE 144	6.11E-04	2.53E-04	3.28E-05	-	1.51E-04	1.67E-03	1.08E-04
PR 143	1.67E-06	6.64E-07	8.28E-08	-	3.86E-07	6.04E-05	2.67E-05
PR 144	5.37E-12	2.20E-12	2.72E-13	-	1.26E-12	2.19E-07	2.94E-14
ND 147	9.83E-07	1.07E-06	6.41E-08	-	6.28E-07	4.65E-05	2.28E-05
W 187	1.50E-09	1.22E-09	4.29E-10	-	-	5.92E-06	2.21E-05
NP 239	4.23E-08	3.99E-09	2.21E-09	-	1.25E-08	8.11E-06	1.65E-05

TABLE 9
INHALATION DOSE FACTORS FOR CHILD
(mRem per pCi Inhaled)
Page 1 of 2

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07
C 14	9.70E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06
NA 24	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06
P 32	7.04E-04	3.09E-05	2.67E-05	-	-	-	1.14E-05
CR 51	-	-	4.17E-08	2.31E-08	6.57E-09	4.59E-06	2.93E-07
MN 54	-	1.16E-05	2.57E-06	-	2.71E-06	4.26E-04	6.19E-06
MN 56	-	4.48E-10	8.43E-11	-	4.52E-10	3.55E-06	3.33E-05
FE 55	1.28E-05	6.80E-06	2.10E-06	-	-	3.00E-05	7.75E-07
FE 59	5.59E-06	9.04E-06	4.51E-06	-	-	3.43E-04	1.91E-05
CO 58	-	4.79E-07	8.55E-07	-	-	2.99E-04	9.29E-06
CO 60	-	3.55E-06	6.12E-06	-	-	1.91E-03	2.60E-05
NI 63	2.22E-04	1.25E-06	7.56E-06	-	-	7.43E-05	1.71E-06
NI 65	8.08E-10	7.99E-11	4.44E-11	-	-	2.21E-06	2.27E-05
CU 64	-	5.39E-10	2.90E-10	-	1.63E-09	2.59E-06	9.92E-06
ZN 65	1.15E-05	3.06E-05	1.90E-05	-	1.93E-05	2.69E-04	4.41E-06
ZN 69	1.81E-11	2.61E-11	2.41E-12	-	1.58E-11	3.84E-07	2.75E-06
BR 83	-	-	1.28E-08	-	-	-	LT E-24
BR 84	-	-	1.48E-07	-	-	-	LT E-24
BR 85	-	-	6.84E-09	-	-	-	LT E-24
RB 86	-	5.36E-05	3.09E-05	-	-	-	2.16E-06
RB 88	-	1.52E-07	9.90E-08	-	-	-	4.66E-09
RB 89	-	9.33E-08	7.85E-08	-	-	-	5.11E-10
SR 89	1.62E-04	-	4.66E-06	-	-	5.83E-04	4.52E-05
SR 90	2.73E-02	-	1.74E-03	-	-	3.99E-03	9.28E-05
SR 91	3.28E-08	-	1.24E-09	-	-	1.44E-05	4.70E-05
SR 92	3.54E-09	-	1.42E-10	-	-	6.49E-06	6.55E-05
Y 90	1.11E-06	-	2.99E-08	-	-	7.07E-05	7.24E-05
Y 91M	1.37E-10	-	4.98E-12	-	-	7.60E-07	4.64E-07
Y 91	2.47E-04	-	6.59E-06	-	-	7.10E-04	4.97E-05
Y 92	5.50E-09	-	1.57E-10	-	-	6.46E-06	6.46E-05
Y 93	5.04E-08	1.13E-05	1.38E-09	-	-	2.01E-05	1.05E-04
ZR 95	5.13E-05	1.13E-05	1.00E-05	-	1.61E-05	6.03E-04	1.65E-05
ZR 97	5.07E-08	7.34E-09	4.32E-09	-	1.05E-08	3.06E-05	9.49E-05
NB 95	6.35E-06	2.48E-06	1.77E-06	-	2.33E-06	1.66E-04	1.00E-05
MO 99	-	4.66E-08	1.15E-08	-	1.06E-07	3.66E-05	3.42E-05
TC 99M	4.81E-13	9.41E-13	1.56E-11	-	1.37E-11	2.57E-07	1.30E-06

INHALATION DOSE FACTORS FOR CHILD
(mRem per pCi Inhaled)
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Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	2.19E-14	2.30E-14	2.91E-13	-	3.92E-13	1.58E-07	4.41E-09
RU 103	7.55E-07	-	2.90E-07	-	1.90E-06	1.79E-04	1.21E-05
RU 105	4.13E-10	-	1.50E-10	-	3.63E-10	4.30E-06	2.69E-05
RU 106	3.68E-05	-	4.57E-06	-	4.97E-05	3.87E-03	1.16E-04
AG 110M	4.56E-06	3.08E-06	2.47E-06	-	5.74E-06	1.48E-03	2.71E-05
TE 125M	1.82E-06	6.29E-07	2.47E-07	5.20E-07	-	1.29E-04	9.13E-06
TE 127M	6.72E-06	2.31E-06	8.16E-07	1.64E-06	1.72E-05	4.00E-04	1.93E-05
TE 127	7.49E-10	2.57E-10	1.65E-10	5.30E-10	1.91E-09	2.71E-06	1.52E-05
TE 129M	5.19E-06	1.85E-06	8.22E-07	1.71E-06	1.36E-05	4.76E-04	4.91E-05
TE 129	2.64E-11	9.45E-12	6.44E-12	1.93E-11	6.94E-11	7.93E-07	6.89E-06
TE 131M	3.63E-08	1.60E-08	1.37E-08	2.64E-08	1.08E-07	5.56E-05	8.32E-05
TE 131	5.87E-12	2.28E-12	1.78E-12	4.59E-12	1.59E-11	5.55E-07	3.60E-07
TE 132	1.30E-07	7.36E-08	7.12E-08	8.58E-08	4.79E-07	1.02E-04	3.72E-05
I 130	2.21E-06	4.43E-06	2.28E-06	4.99E-04	6.61E-06	-	1.38E-06
I 131	1.30E-05	1.30E-05	2.28E-06	4.39E-03	2.13E-05	-	7.68E-07
I 132	5.72E-07	1.10E-06	5.07E-07	5.23E-05	1.69E-06	-	8.65E-07
I 133	4.48E-06	5.49E-06	2.08E-06	1.04E-03	9.13E-06	-	1.48E-06
I 134	3.17E-07	5.84E-07	2.69E-07	1.37E-05	8.92E-07	-	2.58E-07
I 135	1.33E-06	2.36E-06	1.12E-06	2.14E-04	3.62E-06	-	1.20E-06
CS 134	1.76E-04	2.74E-04	6.07E-05	-	8.93E-05	3.27E-05	1.04E-06
CS 136	1.76E-05	4.62E-05	3.14E-05	-	2.58E-05	3.93E-06	1.13E-06
CS 137	2.45E-04	2.23E-04	3.47E-05	-	7.63E-05	2.81E-05	9.78E-07
CS 138	1.71E-07	2.27E-07	1.50E-07	-	1.68E-07	1.84E-08	7.29E-08
BA 139	4.98E-10	2.66E-13	1.45E-11	-	2.33E-13	1.56E-06	1.56E-05
BA 140	2.00E-05	1.75E-08	1.17E-06	-	5.71E-09	4.71E-04	2.75E-05
BA 141	5.29E-11	2.95E-14	1.72E-12	-	2.56E-14	7.89E-07	7.44E-08
BA 142	1.35E-11	9.73E-15	7.54E-13	-	7.87E-15	4.44E-07	7.41E-10
LA 140	1.74E-07	6.08E-08	2.04E-08	-	-	4.94E-05	6.10E-05
LA 142	3.50E-10	1.11E-10	3.49E-11	-	-	2.35E-06	2.05E-05
CE 141	1.06E-05	5.28E-06	7.83E-07	-	2.31E-06	1.47E-04	1.53E-05
CE 143	9.89E-08	5.37E-08	7.77E-09	-	2.26E-08	3.12E-05	3.44E-05
CE 144	1.83E-03	5.72E-04	9.77E-05	-	3.17E-04	3.23E-03	1.05E-04
PR 143	4.99E-06	1.50E-06	2.47E-07	-	8.11E-07	1.17E-04	2.63E-05
PR 144	1.61E-11	4.99E-12	8.1[illegible]E-13	-	2.64E-12	4.23E-07	5.32E-08
ND 147	2.92E-06	2.36E-06	1[illegible]07	-	1.30E-06	8.87E-05	2.22E-05
W 187	4.41E-09	2.61E-09	1.[illegible]E-09	-	-	1.11E-05	2.46E-05
NP 239	1.26E-07	9.04E-09	6.35E-09	-	2.63E-08	1.57E-05	1.73E-05

TABLE 10

INHALATION DOSE FACTORS FOR INFANT
(mRem per pCi Inhaled)

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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07
C 14	1.89E-05	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06
NA 24	1.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06
P 32	1.45E-03	8.03E-05	5.53E-05	-	-	-	1.15E-05
CR 51	-	-	6.39E-08	4.11E-08	9.45E-09	9.17E-06	2.55E-07
MN 54	-	1.81E-05	3.56E-06	-	3.56E-06	7.14E-04	5.04E-06
MN 56	-	1.10E-09	1.58E-10	-	7.86E-10	8.95E-06	5.12E-05
FE 55	1.41E-05	8.39E-06	2.38E-06	-	-	6.21E-05	7.82E-07
FE 59	9.69E-06	1.68E-05	6.77E-06	-	-	7.25E-04	1.77E-05
CO 58	-	8.71E-07	1.30E-06	-	-	5.55E-04	7.95E-06
CO 60	-	5.73E-06	8.41E-06	-	-	3.22E-03	2.28E-05
NI 63	2.42E-04	1.46E-05	8.29E-06	-	-	1.49E-04	1.73E-06
NI 65	1.71E-09	2.03E-10	8.79E-11	-	-	5.80E-06	3.58E-05
CU 64	-	1.34E-09	5.53E-10	-	2.84E-09	6.64E-06	1.07E-05
ZN 65	1.38E-05	4.47E-05	2.22E-05	-	2.32E-05	4.62E-04	3.67E-05
ZN 69	3.85E-11	6.9[illegible]E-11	5.13E-12	-	2.87E-11	1.05E-06	9.44E-06
BR 83	-	-	2.72E-07	-	-	-	LT E-24
BR 84	-	-	2.86E-07	-	-	-	LT E-24
BR 85	-	-	1.46E-08	-	-	-	LT E-24
RB 86	-	1.36E-04	6.30E-05	-	-	-	2.17E-06
RB 88	-	3.98E-07	2.05E-07	-	-	-	2.42E-07
RB 89	-	2.29E-07	1.47E-07	-	-	-	4.87E-08
SR 89	2.84E-04	-	8.15E-06	-	-	1.45E-03	4.57E-05
SR 90	2.92E-02	-	1.85E-03	-	-	8.03E-03	9.36E-05
SR 91	6.83E-08	-	2.47E-09	-	-	3.76E-05	5.24E-05
SR 92	7.50E-09	-	2.79E-10	-	-	1.70E-05	1.00E-04
Y 90	2.35E-06	-	6.30E-08	-	-	1.92E-04	7.43E-05
Y 91M	2.91E-10	-	9.90E-12	-	-	1.99E-06	1.68E-06
Y 91	4.20E-04	-	1.12E-05	-	-	1.75E-03	5.02E-05
Y 92	1.17E-08	-	3.29E-10	-	-	1.75E-05	9.04E-05
Y 93	1.07E-07	-	2.91E-09	-	-	5.46E-05	1.19E-04
ZR 95	8.24E-05	1.99E-05	1.45E-05	-	2.22E-05	1.25E-03	1.55E-05
ZR 97	1.07E-07	1.83E-08	8.36E-09	-	1.85E-08	7.88E-05	1.00E-04
NB 95	1.12E-05	4.59E-06	2.70E-06	-	3.37E-06	3.42E-04	9.05E-06
MO 99	-	1.18E-07	2.31E-08	-	1.89E-07	9.63E-05	3.48E-05
TC 99M	9.98E-13	2.06E-12	2.66E-11	-	2.22E-11	5.79E-07	1.45E-06

INHALATION DOSE FACTORS FOR INFANT
(mRem per pCi Inhaled)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	4.65E-14	5.88E-14	5.80E-13	-	6.99E-13	4.17E-07	6.03E-07
RU 103	1.44E-06	-	4.85E-07	-	3.03E-06	3.94E-04	1.15E-05
RU 105	8.74E-10	-	2.93E-10	-	6.42E-10	1.12E-05	3.46E-05
RU 106	6.20E-05	-	7.77E-06	-	7.61E-05	8.26E-03	1.17E-04
AG 110M	7.13E-06	5.16E-06	3.57E-06	-	7.80E-06	2.62E-03	2.36E-05
TE 125M	3.40E-06	1.42E-06	4.70E-07	1.16E-06	-	3.19E-04	9.22E-06
TE 127M	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.68E-05	9.37E-04	1.95E-05
TE 127	1.59E-09	6.81E-10	3.40E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
TE 129M	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
TE 129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
TE 131M	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
TE 131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-0[illegible]
TE 132	2.66E-07	1.69E-07	1.26E-07	1.99E-07	7.39E-07	2.43E-04	3.15E-05
I 130	4.54E-06	9.91E-06	3.98E-06	1.14E-03	1.09E-05	-	1.42E-06
I 131	2.71E-05	3.17E-05	1.40E-05	1.06E-02	3.70E-05	-	7.56E-07
I 132	1.21E-06	2.53E-06	8.99E-07	1.21E-04	2.82E-06	-	1.36E-06
I 133	9.46E-06	1.37E-05	4.00E-06	2.54E-03	1.60E-05	-	1.54E-06
I 134	6.58E-07	1.34E-06	4.75E-07	.18E-05	1.49E-06	-	9.21E-07
I 135	2.76E-06	5.43E-06	1.98E-06	4.97E-04	6.05E-06	-	1.31E-06
CS 134	2.83E-04	5.02E-04	5.32E-05	-	1.36E-04	5.69E-05	9.53E-07
CS 136	3.45E-05	9.61E-05	3.78E-05	-	4.03E-05	8.40E-06	1.02E-06
CS 137	3.92E-04	4.37E-04	3.25E-05	-	1.23E-04	5.09E-05	9.53E-07
CS 138	3.61E-07	5.58E-07	2.84E-07	-	2.93E-07	4.67E-08	6.26E-07
BA 139	1.06E-09	7.03E-13	3.07E-11	-	4.23E-13	4.25E-06	3.64E-05
BA 140	4.00E-05	4.00E-08	2.07E-06	-	9.59E-09	1.14E-03	2.74E-05
BA 141	1.12E-10	7.70E-14	3.55E-12	-	4.64E-14	2.12E-06	3.39E-06
BA 142	2.84E-11	2.36E-14	1.40E-12	-	1.36E-14	1.11E-06	4.95E-07
LA 140	3.61E-07	1.43E-08	3.68E-08	-	-	1.20E-04	6.06E-05
LA 142	7.36E-10	2.69E-10	6.46E-11	-	-	5.87E-06	4.25E-05
CE 141	1.98E-05	1.19E-05	1.42E-06	-	3.75E-06	3.69E-04	1.54E-05
CE 143	2.09E-07	1.38E-07	1.58E-08	-	4.03E-08	8.30E-05	3.55E-05
CE 144	2.28E-03	8.65E-04	1.26E-04	-	3.84E-04	7.03E-03	1.06E-04
PR 143	1.00E-05	3.74E-06	4.99E-07	-	1.41E-06	3.09E-04	2.66E-05
PR 144	3.42E-11	1.32E-11	1.72E-12	-	4.80E-12	1.15E-06	3.06E-06
ND 147	5.67E-06	5.81E-06	3.57E-07	-	2.25E-06	2.30E-04	2.23E-05
W 187	9.26E-09	6.44E-09	2.23E-09	-	-	2.83E-05	2.54E-05
NP 239	2.65E-07	2.37E-08	1.34E-08	-	4.73E-08	4.25E-05	1.78E-05

TABLE 11
INGESTION DOSE FACTORS FOR ADULT
(mRem per pCi Ingested)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07
C 14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
NA 24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P 32	1.93E-04	1.20E-05	7.46E-06	-	-	-	2.17E-05
CR 51	-	-	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
MN 54	-	4.57E-06	8.72E-07	-	1.36E-06	-	1.40E-05
MN 56	-	1.15E-07	2.04E-08	-	1.46E-07	-	3.67E-06
FE 55	2.75E-06	1.90E-06	4.43E-07	-	-	1.06E-06	1.09E-06
FE 59	4.34E-06	1.02E-05	3.91E-06	-	-	2.85E-06	3.40E-05
CO 58	-	7.45E-07	1.67E-06	-	-	-	1.51E-05
CO 60	-	2.14E-06	4.72E-06	-	-	-	4.02E-05
NI 63	1.30E-04	9.01E-06	4.36E-06	-	-	-	1.88E-06
NI 65	5.28E-07	6.86E-08	3.13E-08	-	-	-	1.74E-06
CU 64	-	8.33E-08	3.91E-08	-	2.10E-07	-	7.10E-06
ZN 65	4.84E-06	1.54E-05	6.96E-06	-	1.03E-05	-	9.70E-06
ZN 69	1.03E-08	1.97E-08	1.37E-09	-	1.28E-08	-	2.96E-09
BR 83	-	-	4.02E-08	-	-	-	5.79E-08
BR 84	-	-	5.21E-08	-	-	-	4.09E-13
BR 85	-	-	2.14E-09	-	-	-	LT E-24
RB 86	-	2.11E-05	9.83E-06	-	-	-	4.16E-06
RB 88	-	6.05E-08	3.21E-08	-	-	-	8.36E-19
RB 89	-	4.01E-08	2.82E-08	-	-	-	2.33E-21
SR 89	3.08E-04	-	8.84E-06	-	-	1.45E-03	4.94E-05
SR 90	7.58E-03	-	1.86E-03	-	-	8.03E-03	2.19E-04
SR 91	5.67E-06	-	2.29E-07	-	-	3.76E-05	2.70E-05
SR 92	2.15E-06	-	9.30E-08	-	-	1.70E-05	4.26E-05
Y 90	9.62E-09	-	2.58E-10	-	-	1.92E-04	1.02E-04
Y 91M	9.09E-11	-	3.52E-12	-	-	1.99E-06	2.67E-10
Y 91	1.41E-07	-	3.77E-09	-	-	1.75E-03	7.76E-05
Y 92	2.45E-10	-	2.47E-11	-	-	1.75E-05	1.48E-05
Y 93	2.68E-09	-	7.40E-11	-	-	-	8.50E-05
ZR 95	3.04E-08	9.75E-09	6.60E-09	-	1.53E-08	-	3.09E-05
ZR 97	1.68E-09	3.39E-10	1.55E-10	-	5.12E-10	-	1.05E-04
NB 95	6.22E-09	3.46E-09	1.86E-09	-	3.42E-09	-	2.10E-05
MO 99	-	4.31E-06	8.20E-07	-	9.76E-06	-	9.99E-06
TC 99M	2.47E-10	6.98E-10	8.89E-09	-	1.06E-08	3.42E-10	4.13E-07

INGESTION DOSE FACTORS FOR ADULT
(mRem per pCi Ingested)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	2.54E-10	3.66E-10	3.59E-09	-	6.59E-09	1.87E-10	1.10E-21
RU 103	1.85E-07	-	7.97E-08	-	7.06E-07	-	2.16E-05
RU 105	1.54E-08	-	6.08E-09	-	1.99E-07	-	9.42E-06
RU 106	2.75E-06	-	3.48E-07	-	5.31E-06	-	1.78E-04
AG 110M	1.60E-07	1.48E-07	8.79E-08	-	2.91E-07	-	6.04E-05
TE 125M	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	-	1.07E-05
TE 127M	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	-	2.27E-05
TE 127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	-	8.68E-06
TE 129M	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	-	5.79E-05
TE 129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	-	2.37E-08
TE 131M	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	-	8.40E-05
TE 131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	-	2.79E-09
TE 132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	-	7.71E-05
I 130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	-	1.92E-06
I 131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	-	1.57E-06
I 132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	-	1.02E-07
I 133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	-	2.22E-06
I 134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	-	2.51E-10
I 135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	-	1.31E-06
CS 134	6.22E-05	1.48E-04	1.21E-04	-	4.79E-05	1.59E-05	2.59E-06
CS 136	6.51E-06	2.57E-05	1.85E-05	-	1.43E-05	1.96E-06	2.92E-06
CS 137	7.97E-05	1.09E-04	7.14E-05	-	3.70E-05	1.23E-05	2.11E-06
CS 138	5.52E-08	1.09E-07	5.40E-08	-	8.01E-08	7.91E-09	4.65E-13
BA 139	9.70E-08	6.91E-11	2.84E-09	-	6.46E-11	3.92E-11	1.72E-07
BA 140	2.03E-05	2.55E-08	1.33E-06	-	8.67E-09	1.46E-08	4.18E-05
BA 141	4.71E-08	3.56E-11	1.59E-09	-	3.31E-11	2.02E-11	2.22E-17
BA 142	2.13E-08	2.19E-11	1.34E-09	-	1.85E-11	1.24E-11	3.00E-26
LA 140	2.50E-09	1.26E-09	3.33E-10	-	-	-	9.25E-05
LA 142	1.28E-10	5.82E-11	1.45E-11	-	-	-	4.25E-07
CE 141	9.36E-09	6.33E-09	7.18E-10	-	2.94E-09	-	2.42E-05
CE 143	1.65E-09	1.22E-06	1.35E-10	-	5.37E-10	-	4.56E-05
CE 144	4.88E-07	2.04E-07	2.62E-08	-	1.21E-07	-	1.65E-04
PR 143	9.20E-09	3.69E-09	4.56E-10	-	2.13E-09	-	4.03E-05
PR 144	3.01E-11	1.25E-11	1.53E-12	-	7.05E-12	-	4.33E-18
ND 147	6.29E-09	7.27E-09	4.35E-10	-	4.25E-09	-	3.49E-05
W 187	1.03E-07	8.61E-08	3.01E-08	-	-	-	2.82E-05
NP 239	1.19E-09	1.17E-10	6.45E-11	-	3.65E-10	-	2.40E-05

TABLE 12
INGESTION DOSE FACTORS FOR TEENAGER
(mRem per pCi Ingested)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07
C 14	4.06E-06	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07
NA 24	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06
P 32	2.76E-04	1.71E-05	1.07E-05	-	-	-	2.32E-05
CR 51	-	-	3.60E-09	2.00E-09	7.89E-10	5.14E-09	6.05E-07
MN 54	-	5.90E-06	1.17E-06	-	1.76E-06	-	1.21E-05
MN 56	-	1.58E-07	2.81E-08	-	2.00E-07	-	1.04E-05
FE 55	3.78E-06	2.68E-06	6.25E-07	-	-	1.70E-06	1.16E-06
FE 59	5.87E-06	1.37E-05	5.29E-06	-	-	4.32E-06	3.24E-05
CO 58	-	9.72E-07	2 [illegible]4E-06	-	-	-	1.34E-05
CO 60	-	2.81E-06	[illegible]3E-06	-	-	-	3.66E-05
NI 63	1.77E-04	1.25E-05	[illegible]0E-06	-	-	-	1.99E-06
NI 65	7.49E-07	9.57E-08	4.36E-08	-	-	-	5.19E-06
CU 64	-	1.15E-07	5.41E-08	-	2.91E-07	-	8.92E-06
ZN 65	5.76E-06	2.00E-05	9.33E-06	-	1.28E-05	-	8.47E-06
ZN 69	1.47E-08	2.80E-08	1.96E-09	-	1.83E-08	-	5.16E-08
BR 83	-	-	5.74E-08	-	-	-	LT E-24
BR 84	-	-	7.22E-08	-	-	-	LT E-24
BR 85	-	-	3.05E-09	-	-	-	LT E-24
RB 86	-	2.98E-05	1.40E-05	-	-	-	4.41E-06
RB 88	-	8.52E-08	4.54E-08	-	-	-	7.30E-15
RB 89	-	5.50E-08	3.89E-08	-	-	-	8.43E-17
SR 89	4.40E-04	-	1.26E-05	-	-	-	5.24E-05
SR 90	8.30E-03	-	2.05E-03	-	-	-	2.33E-04
SR 91	8.07E-06	-	3.21E-07	-	-	-	3.66E-05
SR 92	3.05E-06	-	1.30E-07	-	-	-	7.77E-05
Y 90	1.37E-08	-	3.69E-10	-	-	-	1.13E-04
Y 91M	1.29E-10	-	4.93E-12	-	-	-	6.09E-09
Y 91	2.01E-07	-	5.39E-09	-	-	-	8.24E-05
Y 92	1.21E-09	-	3.50E-11	-	-	-	3.32E-05
Y 93	2.68E-09	-	7.40E-11	-	-	-	8.50E-05
ZR 95	3.04E-08	9.75E-09	6.60E-09	-	1.53E-08	-	3.09E-05
ZR 97	1.68E-09	3.39E-10	1.55E-10	-	5.12E-10	-	1.05E-04
NB 95	6.22E-09	3.46E-09	1.86E-09	-	3.42E-09	-	2.10E-05
MO 99	-	4.31E-06	8.20E-07	-	9.76E-06	-	9.99E-06
TC 99M	2.47E-10	6.98E-10	8.89E-09	-	1.06E-08	3.42E-10	4.13E-07

INGESTION DOSE FACTORS FOR TEENAGER
(mRem per pCi Ingested)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	2.54E-10	3.66E-10	3.59E-09	-	6.59E-09	1.87E-10	1.10E-21
RU 103	1.85E-07	-	7.97E-08	-	7.06E-07	-	2.16E-05
RU 105	1.54E-08	-	6.08E-09	-	1.99E-07	-	9.42E-06
RU 106	2.75E-06	-	3.48E-07	-	5.31E-06	-	1.78E-04
AG 110M	1.60E-07	1.46E-07	8.79E-08	-	2.91E-07	-	6.04E-05
TE 125M	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	-	1.07E-05
TE 127M	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	-	2.27E-05
TE 127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	-	8.68E-06
TE 129M	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	-	5.79E-05
TE 129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	-	2.37E-08
TE 131M	1.73E-06	8.46E-07	7.05E-07	1.54E-06	8.57E-06	-	8.40E-05
TE 131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	-	2.79E-09
TE 132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	-	7.71E-05
I 130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	-	1.92E-06
I 131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	-	1.57E-06
I 132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	-	1.02E-07
I 133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	-	2.22E-06
I 134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	-	2.51E-10
I 135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	-	1.31E-06
CS 134	6.22E-05	1.48E-04	1.21E-04	-	4.79E-05	1.59E-05	2.59E-06
CS 136	6.51E-06	2.57E-05	1.85E-05	-	1.43E-05	1.96E-06	2.92E-06
CS 137	7.97E-05	1.09E-04	7.14E-05	-	3.70E-05	1.23E-05	2.11E-06
CS 138	5.52E-08	1.09E-07	5.40E-08	-	8.01E-08	7.91E-09	4.65E-13
BA 139	9.70E-08	6.91E-11	2.84E-09	-	6.46E-11	3.92E-11	1.72E-07
BA 140	2.03E-05	2.55E-08	1.33E-06	-	8.67E-09	1.46E-08	4.18E-05
BA 141	4.71E-08	3.56E-11	1.59E-09	-	3.31E-11	2.02E-11	2.22E-17
BA 142	2.13E-08	2.19E-11	1.34E-09	-	1.85E-11	1.24E-11	3.00E-26
LA 140	2.50E-09	1.26E-09	3.33E-10	-	-	-	9.25E-05
LA 142	1.28E-10	5.82E-11	1.45E-11	-	-	-	4.25E-07
CE 141	9.36E-09	6.33E-09	7.18E-10	-	2.94E-09	-	2.42E-05
CE 143	1.65E-09	1.22E-06	1.35E-10	-	5.37E-10	-	4.56E-05
CE 144	4.88E-07	2.04E-07	2.62E-08	-	1.21E-07	-	1.65E-04
PR 143	9.20E-09	3.69E-09	4.56E-10	-	2.13E-09	-	4.03E-05
PR 144	3.01E-11	1.25E-11	1.53E-12	-	7.05E-12	-	4.33E-18
ND 147	6.29E-09	7.27E-09	4.35E-10	-	4.25E-09	-	3.49E-05
W 187	1.03E-07	8.61E-08	3.01E-08	-	-	-	2.82E-05
NP 239	1.19E-09	1.17E-10	6.45E-11	-	3.65E-10	-	2.40E-05

TABLE 13
INGESTION DOSE FACTORS FOR CHILD
(mRem per pCi Ingested)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07
C 14	1.21E-05	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06
NA 24	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06
P 32	8.25E-04	3.86E-05	3.18E-05	-	-	-	2.28E-05
CR 51	-	-	8.90E-09	4.94E-09	1.35E-09	9.02E-09	4.72E-07
MN 54	-	1.07E-05	2.85E-06	-	3.00E-06	-	8.98E-06
MN 56	-	3.34E-07	7.54E-08	-	4.04E-07	-	4.84E-05
FE 55	1.15E-05	6.10E-06	1.89E-06	-	-	3.45E-06	1.13E-06
FE 59	1.65E-05	2.67E-05	1.33E-05	-	-	7.74E-06	2.78E-05
CO 58	-	1.80E-06	5.51E-06	-	-	-	1.05E-05
CO 60	-	5.29E-06	1.56E-05	-	-	-	2.93E-05
NI 63	5.38E-04	2.88E-05	1.83E-05	-	-	-	1.94E-06
NI 65	2.22E-06	2.09E-07	1.22E-07	-	-	-	2.56E-05
CU 64	-	2.45E-07	1.48E-07	-	5.92E-07	-	1.15E-05
ZN 65	1.37E-05	3.65E-05	2.27E-05	-	2.30E-05	-	6.41E-06
ZN 69	4.38E-08	6.33E-08	5.85E-09	-	3.84E-08	-	3.99E-06
BR 83	-	-	1.71E-07	-	-	-	LT E-24
BR 84	-	-	1.98E-07	-	-	-	LT E-24
BR 85	-	-	9.12E-09	-	-	-	LT E-24
RB 86	-	6.70E-05	4.12E-05	-	-	-	4.31E-06
RB 88	-	1.90E-07	1.32E-07	-	-	-	9.32E-09
RB 89	-	1.17E-07	1.04E-07	-	-	-	1.02E-09
SR 89	1.32E-03	-	3.77E-05	-	-	-	5.11E-05
SR 90	1.70E-02	-	4.31E-03	-	-	-	2.29E-04
SR 91	2.40E-05	-	9.06E-07	-	-	-	5.30E-05
SR 92	9.03E-06	-	3.62E-07	-	-	-	1.71E-04
Y 90	4.11E-08	-	1.10E-09	-	-	-	1.17E-04
Y 91M	3.82E-10	-	1.39E-11	-	-	-	7.48E-07
Y 91	6.02E-07	-	1.61E-08	-	-	-	8.02E-05
Y 92	3.60E-09	-	1.03E-10	-	-	-	1.04E-04
Y 93	1.14E-08	-	3.13E-10	-	-	-	1.70E-04
ZR 95	1.16E-07	2.55E-08	2.27E-08	-	3.65E-08	-	2.66E-05
ZR 97	6.99E-09	1.01E-09	5.96E-10	-	1.45E-09	-	1.53E-04
NB 95	2.25E-08	8.76E-09	6.26E-09	-	8.23E-09	-	1.62E-05
MO 99	-	1.33E-05	3.29E-06	-	2.84E-05	-	1.10E-05
TC 99M	9.23E-10	1.81E-09	3.00E-08	-	2.63E-08	9.19E-10	1.03E-06

INGESTION DOSE FACTORS FOR CHILD
(mRem per pCi Ingested)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	1.07E-09	1.12E-09	1.42E-08	-	1.91E-08	5.92E-10	3.56F-09
RU 103	7.31E-07	-	2.81E-07	-	1.84E-06	-	1.89E-05
RU 105	6.45E-08	-	2.34E-08	-	5.67E-07	-	4.21E-05
RU 106	1.17E-05	-	1.46E-06	-	1.58E-05	-	1.82E-04
AG 110M	5.39E-07	3.64E-07	2.91E-07	-	6.78E-07	-	4.33E-05
TE 125M	1.14E-05	3.09E-06	1.52E-06	3.20E-06	-	-	1.10E-05
TE 127M	2.89E-05	7.78E-06	3.43E-06	6.91E-06	8.24E-05	-	2.34E-05
TE 127	4.71E-07	1.27E-07	1.01E-07	3.26E-07	1.34E-06	-	1.84E-05
TE 129M	4.87E-05	1.36E-05	7.56E-06	1.57E-05	1.43E-04	-	5.94E-05
TE 129	1.34E-07	3.74E-08	3.18E-08	9.56E-08	3.92E-07	-	8.34E-06
TE 131M	7.20E-06	2.49E-06	2.65E-06	5.12E-06	2.41E-05	-	1.01E-04
TE 131	8.30E-08	2.53E-08	2.47E-08	6.35E-08	2.51E-07	-	4.36E-07
TE 132	1.01E-05	4.47E-06	5.40E-06	6.51E-06	4.15E-05	-	4.50E-05
I 130	2.92E-06	5.90E-06	3.04E-06	6.50E-04	8.82E-06	-	2.76E-06
I 131	1.72E-05	1.73E-05	9.83E-06	5.72E-03	2.84E-05	-	1.54E-06
I 132	8.00E-07	1.47E-06	6.76E-07	6.82E-05	2.25E-06	-	1.73E-06
I 133	5.92E-06	7.32E-06	2.77E-06	1.36E-03	1.22E-05	-	2.95E-06
I 134	4.19E-07	7.78E-07	3.58E-07	1.79E-05	1.19E-06	-	5.16E-07
I 135	1.75E-06	3.15E-06	1.49E-06	2.79E-04	4.83E-06	-	2.40E-06
CS 134	2.34E-04	3.84E-04	8.10E-05	-	1.19E-04	4.27E-05	2.07E-06
CS 136	2.35E-05	6.46E-05	4.18E-05	-	3.44E-05	5.13E-06	2.27E-06
CS 137	3.27E-04	3.13E-04	4.62E-05	-	1.02E-04	3.67E-05	1.96E-06
CS 138	2.28E-07	3.17E-07	2.01E-07	-	2.23E-07	2.40E-08	1.46E-07
BA 139	4.14E-07	2.21E-10	1.20E-08	-	1.93E-10	1.30E-10	2.39E-05
BA 140	8.31E-05	7.28E-08	4.85E-06	-	2.37E-08	4.34E-08	4.21E-05
BA 141	2.00E-07	1.12E-10	6.51E-09	-	9.69E-11	6.58E-10	1.14E-07
BA 142	8.74E-08	6.29E-11	4.88E-09	-	5.09E-11	3.70E-11	1.14E-09
LA 140	1.01E-08	3.53E-09	1.19E-09	-	-	-	9.84E-05
LA 142	5.24E-10	1.67E-10	5.23E-11	-	-	-	3.31E-05
CE 141	3.97E-08	1.98E-08	2.94E-09	-	8.68E-09	-	2.47E-05
CE 143	6.99E-09	3.79E-06	5.49E-10	-	1.59E-09	-	5.55E-05
CE 144	2.08E-06	6.52E-07	1.11E-07	-	3.61E-07	-	1.70E-04
PR 143	3.93E-08	1.18E-08	1.95E-09	-	6.39E-09	-	4.24E-05
PR 144	1.29E-10	3.99E-11	6.49E-12	-	2.11E-11	-	8.59E-08
ND 147	2.79E-08	2.26E-08	1.75E-09	-	1.24E-08	-	3.58E-05
W 187	4.29E-07	2.54E-07	1.14E-07	-	-	-	3.57E-05
NP 239	5.25E-09	3.77E-10	2.65E-10	-	1.09E-09	-	2.79E-05

TABLE 14
INGESTION DOSE FACTORS FOR INFANT
(mRem per pCi Ingested)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-07
C 14	2.37E-05	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06
NA 24	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05
P 32	1.70E-03	1.00E-04	6.59E-05	-	-	-	2.30E-05
CR 51	-	-	1.41E-08	9.20E-09	2.01E-09	1.7[illegible]E-08	4.11E-07
MN 54	-	1.99E-05	4.51E-06	-	4.41E-06	-	7.31E-06
MN 56	-	8.18E-07	1.41E-07	-	7.03E-07	-	7.43E-05
FE 55	1.39E-05	8.98E-06	2.40E-06	-	-	4.36E-06	1.14E-06
FE 59	3.08E-05	5.38E-05	2.12E-05	-	-	1.59E-05	2.57E-05
CO 58	-	3.60E-06	8.98E-06	-	-	-	8.97E-06
CO 60	-	1.08E-05	2.55E-05	-	-	-	2.57E-05
NI 63	6.34E-04	3.92E-05	2.20E-05	-	-	-	1.95E-06
NI 65	4.70E-06	5.32E-07	2.42E-07	-	-	-	4.05E-05
CU 64	-	6.09E-07	2.82E-07	-	1.03E-06	-	1.25E-05
ZN 65	1.84E-05	6.31E-05	2.91E-05	-	3.06E-05	-	5.33E-05
ZN 69	9.33E-08	1.68E-07	1.25E-08	-	6.98E-08	-	1.37E-05
BR 83	-	-	3.63E-07	-	-	-	LT E-24
BR 84	-	-	3.82E-07	-	-	-	LT E-24
BR 85	-	-	1.94E-08	-	-	-	LT E-24
RB 86	-	1.70E-04	8.40E-05	-	-	-	4.35E-06
RB 88	-	4.98E-07	2.73E-07	-	-	-	4.85E-07
RB 89	-	2.86E-07	1.97E-07	-	-	-	9.74E-08
SR 89	2.51E-03	-	7.20E-05	-	-	-	5.16E-05
SR 90	1.85E-02	-	4.71E-03	-	-	-	2.31E-04
SR 91	5.00E-05	-	1.81E-06	-	-	-	5.92E-05
SR 92	1.92E-05	-	7.13E-07	-	-	-	2.07E-04
Y 90	8.69E-08	-	2.33E-09	-	-	-	1.20E-04
Y 91M	8.10E-10	-	2.76E-11	-	-	-	2.70E-06
Y 91	1.13E-06	-	3.01E-08	-	-	-	8.10E-05
Y 92	7.65E-09	-	2.15E-10	-	-	-	1.46E-04
Y 93	2.43E-08	-	6.62E-10	-	-	-	1.92E-04
ZR 95	2.06E-07	5.02E-08	3.56E-08	-	5.41E-08	-	2.50E-05
ZR 97	1.48E-08	2.54E-09	1.16E-09	-	2.56E-09	-	1.62E-04
NB 95	4.20E-08	1.73E-08	1.00E-08	-	1.24E-08	-	1.46E-05
MO 99	-	3.40E-05	6.63E-06	-	5.08E-05	-	1.12E-05
TC 99M	1.92E-09	3.96E-09	5.10E-08	-	4.26E-08	2.07E-09	1.15E-06

INGESTION DOSE FACTORS FOR INFANT
(mRem per pCi Ingested)
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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	2.27E-09	2.86E-09	2.83E-08	-	3.40E-08	1.56E-09	4.86E-07
RU 103	1.48E-06	-	4.95E-07	-	3.08E-06	-	1.80E-05
RU 105	1.36E-07	-	4.58E-08	-	1.00E-06	-	5.41E-05
RU 106	2.41E-05	-	3.01E-06	-	2.85E-05	-	1.83E-04
AG 110M	9.96E-07	7.27E-07	4.81E-07	-	1.04E-06	-	3.77E-05
TE 125M	2.33E-05	7.79E-06	3.15E-06	7.84E-06	-	-	1.11E-05
TE 127M	5.85E-05	1.94E-05	7.08E-06	1.69E-05	1.44E-04	-	2.36E-05
TE 127	1.00E-06	3.35E-07	2.15E-07	8.14E-07	2.44E-06	-	2.10E-05
TE 129M	1.00E-04	3.43E-05	1.54E-05	3.84E-05	2.50E-04	-	5.97E-05
TE 129	2.84E-07	9.79E-08	6.63E-08	2.38E-07	7.07E-07	-	2.27E-05
TE 131M	1.52E-05	6.12E-06	5.05E-06	1.24E-05	4.21E-05	-	1.03E-04
TE 131	1.76E-07	6.50E-08	4.94E-08	1.57E-07	4.50E-07	-	7.11E-06
TE 132	2.08E-05	1.03E-05	9.61E-06	1.52E-05	6.44E-05	-	3.81E-05
I 130	6.00E-06	1.32E-05	5.30E-06	1.48E-03	1.45E-05	-	2.83E-06
I 131	3.59E-05	4.23E-05	1.86E-05	1.39E-02	4.94E-05	-	1.51E-06
I 132	1.66E-06	3.37E-06	1.20E-06	1.58E-04	3.76E-06	-	2.73E-06
I 133	1.25E-05	1.82E-05	5.33E-06	3.31E-03	2.14E-05	-	3.08E-06
I 134	8.69E-07	1.78E-06	6.33E-07	4.15E-05	1.99E-06	-	1.84E-06
I 135	3.64E-06	7.24E-06	2.64E-06	6.49E-04	8.07E-06	-	2.62E-06
CS 134	3.77E-04	7.03E-04	7.10E-05	-	1.81E-04	7.42E-05	1.91E-06
CS 136	4.59E-05	1.35E-04	5.04E-05	-	5.38E-05	1.10E-05	2.05E-06
CS 137	5.22E-04	6.11E-04	4.33E-05	-	1.64E-04	6.64E-05	1.91E-06
CS 138	4.81E-07	7.82E-07	3.79E-07	-	3.90E-07	6.09E-08	1.25E-06
BA 139	8.81E-07	5.84E-10	2.55E-08	-	3.51E-10	3.54E-10	5.58E-05
BA 140	1.71E-04	1.71E-07	8.81E-06	-	4.06E-08	1.05E-07	4.20E-05
BA 141	4.25E-07	2.91E-10	1.34E-08	-	1.75E-10	1.77E-10	5.19E-06
BA 142	1.84E-07	1.53E-10	9.06E-09	-	8.81E-11	9.26E-11	7.59E-07
LA 140	2.11E-08	8.32E-09	2.14E-09	-	-	-	9.77E-05
LA 142	1.10E-09	4.04E-10	9.67E-11	-	-	-	6.86E-05
CE 141	7.87E-08	4.80E-08	5.65E-09	-	1.48E-08	-	2.48E-05
CE 143	1.48E-08	9.82E-06	1.12E-09	-	2.86E-09	-	5.73E-05
CE 144	2.98E-06	1.22E-06	1.67E-07	-	4.93E-07	-	1.71E-04
PR 143	8.13E-08	3.04E-08	4.03E-09	-	1.13E-08	-	4.29E-05
PR 144	2.74E-10	1.06E-10	1.38E-11	-	3.84E-11	-	4.93E-06
ND 147	5.53E-08	5.68E-08	3.48E-09	-	2.[illegible]08	-	3.60E-05
W 187	9.03E-07	6.28E-07	2.17E-07	-		-	3.69E-05
NP 239	1.11E-08	9.93E-10	5.61E-10	-	1.98E-09	-	2.87E-05

TABLE 15
RECOMMENDED VALUES FOR OTHER PARAMETERS
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Parameter Symbol	Definition	Values
f_g	Fraction of produce ingested grown in garden of interest.	0.76
f_l	Fraction of leafy vegetables grown in garden of interest.	1.0
P	Effective surface density of soil (assumes a 15 cm plow layer, expressed in dry weight)	240 kg/m^2
r	Fraction of deposited activity retained on crops, leafy vegetables, or pasture grass.	0.25 1.0 (for iodines) 0.2 (for other particulates)
S_p	Attenuation factor accounting for shielding provided by residential structures.	0.7 (for maximum individuals) 0.5 (for general population)
t_b	Period of long-term buildup for activity in sediment or soil (nominally 15 yr).	1.31×10^5 hr
t_e	Period of crop, leafy vegetable, or pasture grass exposure during growing season.	720 hrs (30 days, for grass-cow-milk-man pathway) 1440 hrs (60 days for crop/ vegetation-man pathway)
t_f	Transport time from animal feed-milk-man provided by residential structures.	2 days (for max. individual) 4 days (for gen. population)
t_h	Time delay between harvest of vegetation or crops and ingestion. i) For ingestion of forage by animals	Zero (for pasture grass) 2160 hr (90 days for stored feed)

RECOMMENDED VALUES FOR OTHER PARAMETERS

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Parameter Symbol	Definition	Values
	ii) For ingestion of crops by man	24 hr (1 day, for leafy vegetables & max. individual) feed) 1440 hr (60 days for produce & maximum individual) 336 hr (14 days for general population)
t_p	Environmental transit time, release to receptor (add time from release to exposure point to minimums shown for distribution)	12 hr (for max. individual) 24 hr (for gen. population)
		24 hr (for max. individual) 168 hr (7 days for population sport fish doses) 240 hr (10 days for population commercial fish doses)
t_s	Average time from slaughter of meat animal to consumption.	20 days
Y_v	Agricultural producitivity by unit area (measured in wet weight)	0.7 kg/m^2 (for grass-cow-milk man pathway) 2.0 kg/m^2 (for produce or leafy vegetables ingested by man)
λ_w	Rate constant for removal of activity on plant or leaf surfaces by weathering (corresponds to a 14-day half-life)	0.0021 hr^{-1}