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Georgia Power
the southern electric system

Nuclear Operations Department

November 8, 1985

TO: DISTRIBUTION

RE: OFFSITE DOSE CALCULATION MANUAL (ODCM)

Attached is your controlled copy of the Offsite Dose Calculation Manual (Revision 1) for Georgia Power Company Edwin I. Hatch Nuclear Plant. This copy supercedes all previous versions of the Plant Hatch ODCM.

Distribution of controlled copies of the Plant Hatch ODCM is being administered by Southern Company Services. In order to reproduce the document efficiently, it was necessary to alter slightly the format of the original version of the Plant Hatch ODCM. However, no changes were made to technical content nor methodology.

S. C. Ewald

HD/blm

Attachment

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OFFSITE DOSE CALCULATION MANUAL

FOR

GEORGIA POWER COMPANY

EDWIN I. HATCH NUCLEAR PLANT

SEPTEMBER 1984

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INTRODUCTION

The Offsite Dose Calculation Manual (ODCM) is a supporting document of the Radiological Effluent Technical Specifications (RETS). As such, the ODCM describes the methodology and parameters to be used in the calculation of offsite doses due to radioactive liquid and gaseous effluents and in the calculation of liquid and gaseous effluent monitoring instrumentation alarm/trip setpoints. The ODCM contains a list and graphical description of the specific sample locations for the radiological environmental monitoring program. Schematic configurations of liquid and gaseous radwaste effluent systems releases to unrestricted areas are also included.

The ODCM will be maintained at the plant for use as a reference guide and training document of accepted methodologies and calculations. Changes in the calculational methods or parameters will be incorporated into the ODCM in order to assure that the ODCM represents the present methodology in all applicable areas. Computer software to perform the described calculations will be maintained current with the ODCM.

1.0 LIQUID EFFLUENTS

The Edwin I. Hatch Nuclear Plant is located on the Altamaha River which supplies make-up water to the circulating water system and receives decant from the cooling tower. There are two boiling water reactors on the site; each unit is served by its own liquid radwaste system. The two units release liquid radwaste to separate discharge lines from the circulating water systems. Additional dilution flow is furnished by the cooling tower blowdown, turbine building service water, and the plant service water system, if necessary. Since each unit is served by a separate dilution stream, liquid releases may be made independently from each of the two units. Releases from the plant service water systems are to the main condenser circulating flume or to the cooling tower blowdown discharge line when needed for additional dilution. Although no significant releases of radioactivity are expected from the plant service water systems, these effluent pathways are monitored as a precautionary measure.

1.1 LIQUID EFFLUENT MONITOR SETPOINTS

Although each unit has unique liquid release sources, a separate radwaste system, independent liquid effluent radiation monitors, and separate dilution streams, the radiation monitor setpoint methodology presented below is appropriate for both units.

The calculated liquid monitor setpoint values will be regarded as upper bounds for the actual setpoint adjustments. Setpoint adjustments are not required to be performed if the existing setpoint level corresponds to a lower count rate than the calculated value. The actual monitor setpoint, which corresponds to the calculated concentration plus background for the specific monitor, is determined from calibration data or from operational data associated with liquid sample analysis data. (See Section 1.1.1.) If no release is planned for a particular pathway, or if there is no detectable activity in the planned release, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

1.1.1 Liquid Radwaste Effluent Radiation Monitors

The liquid radwaste effluent line monitors provide alarm and automatic termination of release functions prior to exceeding the concentration limits specified in 10 CFR 20, Appendix B, Table II, Column 2 at the release point to the unrestricted area. To meet this specification, the alarm/trip setpoints for the liquid effluent monitors and flow measurement devices are set to assure that the following equation is satisfied:

$$\frac{cf}{F + f} \leq C_{MPC} \qquad (1)$$

where:

C_{MPC} = the effluent concentration limit (RETS 3.15.1.1 (Unit 1) and 3.11.1.1 (Unit 2)) implementing 10 CFR 20 for the site, corresponding to the specific mix of radionuclides in the waste tank being considered for discharge, in µCi/ml.

c = the setpoint, in µCi/ml, of the radioactivity monitor which measures the radioactivity concentration in the effluent line prior to dilution and subsequent release; the setpoint, which is inversely proportional to the volumetric flow of the effluent line and proportional to the volumetric flow of the dilution stream plus the effluent stream, represents a value which, if exceeded, would result in concentrations exceeding the limits of 10 CFR 20 in the unrestricted area.

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

F = the dilution water flow setpoint as determined prior to the release point, in volume per unit time.

As stated earlier, at Plant Hatch, each of the two units is served by its own independent liquid radwaste system; the two liquid radwaste systems discharge to separate dilution streams. If additional dilution flow is needed for either dilution stream, it is available from the plant service water system. The two dilution streams release to the Altamaha River.

The sources of liquid radioactive effluents from Unit 1 are:

- Waste sample tank A.
- Waste sample tank B.
- Chemical waste sample tank A.
- Chemical waste sample tank B.

- Floor drain sample tank.
- Laundry drain tank A.
- Laundry drain tank B.
- Demineralizer feed tank.

All of these sources discharge to a common line which is served by radiation monitor 1D11-N007. These Unit 1 sources release to a dilution stream served by flow element FE N-501, which is capable of isolating liquid radwaste discharges from Unit 1 if predefined minimum dilution flow is not available in the dilution stream.

The sources of liquid radioactive effluents from Unit 2 are:

- Waste sample tank A.
- Waste sample tank B.
- Chemical waste sample tank A.
- Chemical waste sample tank B.
- Floor drain sample tank.

All of these sources discharge to a common line which is served by radiation monitor 2D11-N007. These Unit 2 sources release to a dilution stream served by flow element FE N-502, which is capable of isolating liquid radwaste discharges from Unit 2 if predefined minimum dilution flow is not available in the dilution stream.

Liquid radwaste releases from the two units may proceed independently and concurrently. Liquid radwaste releases from each unit, however, will be administratively controlled so that only one source of liquid radwaste will be released at a time from that unit.

The maximum liquid radwaste effluent flow from the source selected for release and the setpoint for the radiation monitor serving the discharge pathway are determined and set to meet the general conditions of Equation 1 for a given effluent concentration. The method by which this is accomplished is as follows:

Step 1

The radionuclide concentration for a waste tank to be released is obtained from the sum of measured concentrations as determined by the analyses required in RETS Tables 4.15.1-1 (Unit 1) and 4.11.1-1 (Unit 2):

$$\sum_i C_i = \sum_g C_g + (C_a + C_s + C_f + C_t) \qquad (2)$$

where:

C_g = the concentration of each measured gamma emitter observed by gamma-ray spectroscopy of the particular waste sample.

C_a = the concentration of alpha emitters in liquid waste as measured in the MONTHLY composite sample. (NOTE: Sample is analyzed for gross α).

C_s = the measured concentrations of Sr-89 and Sr-90 in liquid waste as observed in the QUARTERLY composite sample.

C_f = the measured concentrations of Fe-55 in liquid waste as observed in the QUARTERLY composite sample.

C_t = the measured concentration of H-3 in liquid waste as determined from analysis of the MONTHLY composite sample.

The C_g term will be included in the analysis of each batch; terms for alpha, strontiums, iron, and tritium will be included in accordance with RETS Tables 4.15.1-1 and 4.11.1-1, as appropriate.

Step 2

The measured radionuclide concentrations are used to calculate a dilution factor, DF, which is the ratio of total dilution flow rate to tank flow rate required to assure that the limiting concentrations of 10 CFR 20, Appendix B, Table II, Column 2 are met at the point of discharge.

$$DF = \left[\sum_i \frac{C_i}{MPC_i} \right] \div SF$$

$$= \left[\sum_g \frac{C_g}{MPC_g} + \frac{C_a}{MPC_a} + \frac{C_s}{MPC_s} + \frac{C_f}{MPC_f} + \frac{C_t}{MPC_t} \right] \div SF \qquad (3)$$

where:

C_i = the measured concentrations of C_g, C_a, C_s, C_f, and C_t as defined in Step 1. Terms C_a, C_s, C_f, and C_t will be included in the calculation, as appropriate.

MPC_i = MPC_g, MPC_a, MPC_s, MPC_f, and MPC_t are limiting concentrations of the appropriate radionuclide from 10 CFR 20, Appendix B, Table II, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to 2×10^{-4} µCi/ml total activity.

SF = the safety factor; a conservative factor selected to compensate for statistical fluctuations and errors of measurements. (For example, SF = 0.5 corresponds to a 100-percent variation.)

Step 3

The dilution flow monitor setpoint is determined for the minimum dilution flow rate, F_d; for Plant Hatch, F_d is normally established at 10,000 gpm.

Step 4

For the case DF < 1, the waste tank effluent concentration meets the limits of 10 CFR 20 without dilution, and the effluent discharge flow rate may be assigned any desired value. For DF > 1, the maximum permissible discharge flow rate, f_t, must be calculated:

$$f_t = \frac{F_d + f_p}{DF} \sim \frac{F_d}{DF} \quad \text{for} \quad F_d \gg f_p \tag{4}$$

where:

F_d = the minimum dilution flow rate to be used in effluent monitor setpoint calculations which is normally 10,000 gpm.

DF = the dilution factor from Step 2.

f_p = the flow rate of waste tank discharge. (This value will have an upper limit of the maximum discharge capacity of the particular waste tank pump.)

NOTE: If radioactivity from plant operations is detected in the dilution stream, the equation for calculation of f_t must include a term to account for radioactivity present in the dilution stream prior to the introduction of the waste tank effluent:

$$f_t = \frac{F_d \left[1 - \sum_i \left(\frac{C_i}{MPC_i} \right)_d \right]}{DF} \tag{5}$$

where:

$\sum_i \left(\frac{C_i}{MPC_i} \right)_d$ = the MPC fraction of the dilution stream prior to introduction of the waste tank effluent.

Step 5

The liquid radwaste effluent radiation monitor setpoint may now be determined based on the values of $\sum_i C_i$, f_t and F_d which were specified to provide compliance with the limits of 10 CFR 20, Appendix B, Table II, Column 2. The monitor response is primarily to gamma radiation; therefore, the actual setpoint is based on $\sum_g C_g$. The monitor setpoint which corresponds to the particular setpoint concentration, c, is determined based on monitor calibration data or on operational data which correlates monitor response to sample analyses associated with actual effluent releases. (Example of monitor calibration graph is shown in Figure 1.1-1.)

The setpoint concentration, c, is determined as follows:

$$c = A \sum_g C_g \quad \frac{\mu Ci}{ml} \qquad (6)$$

where:

A = adjustment factor which will allow the setpoint to be established in a practical manner for convenience and to prevent spurious alarms.

$$= \frac{f_t}{f\ (\text{actual})} \quad \text{(See Note 2 below.)} \qquad (7)$$

If $A \geq 1$, calculate c and determine the maximum value for the actual monitor setpoint ($\mu Ci/ml$).

If $A < 1$, no release may be made. Re-evaluate Steps 2, 3, and 4.

NOTE 1: The calculated setpoint concentration, c, establishes the base value for the monitor setpoint. However, in establishing the actual monitor setpoint for a particular monitor, background radiation levels must be considered. Normally, the actual monitor setpoint includes the calculated setpoint value plus background. Background levels must be controlled such that radioactivity levels in the effluent stream being monitored can be accurately assessed at or below the calculated setpoint value.

NOTE 2: If DF < 1, A = (1/DF). As stated earlier, if DF = 0, the radiation monitor setpoint should be established as close to background as practicable to prevent spurious alarms and yet alarm should an inadvertent radioactive release occur.

If calculated setpoint values are near actual concentrations planned for release, it may be impractical to set the monitor alarm based on this value. In this case a new setpoint may be calculated by decreasing the effluent flow, increasing the dilution flow, or by decreasing $\sum_i C_i$ by further processing of the liquid radwaste planned for release, and by following the methodology presented in Steps 2, 3, and 4.

Within the limits of the conditions stated above, monitor setpoints for liquid radwaste effluent radiation monitors may be determined as follows:

Liquid Radwaste Effluent Radiation Monitor 1D11-N007 (Unit 1) or 2D11-N007 (Unit 2)

Perform Step 2, solving Equation 3 for DF using the appropriate values in the concentration term from the sample analyses for the particular waste tank batch to be discharged. Then perform Steps 3, 4, and 5 to determine the monitor setpoint.

If no discharge is planned for this pathway, or if the planned release contains no measurable radioactivity, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent radioactive release occur.

1.1.2 Plant Service Water Monitors

Monitors: 1D11-N008 (Unit 1) and 2D11-N008 (Unit 2)

Concentration of radioactivity in these effluent lines normally is expected to be insignificant. Therefore, the monitor setpoints should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

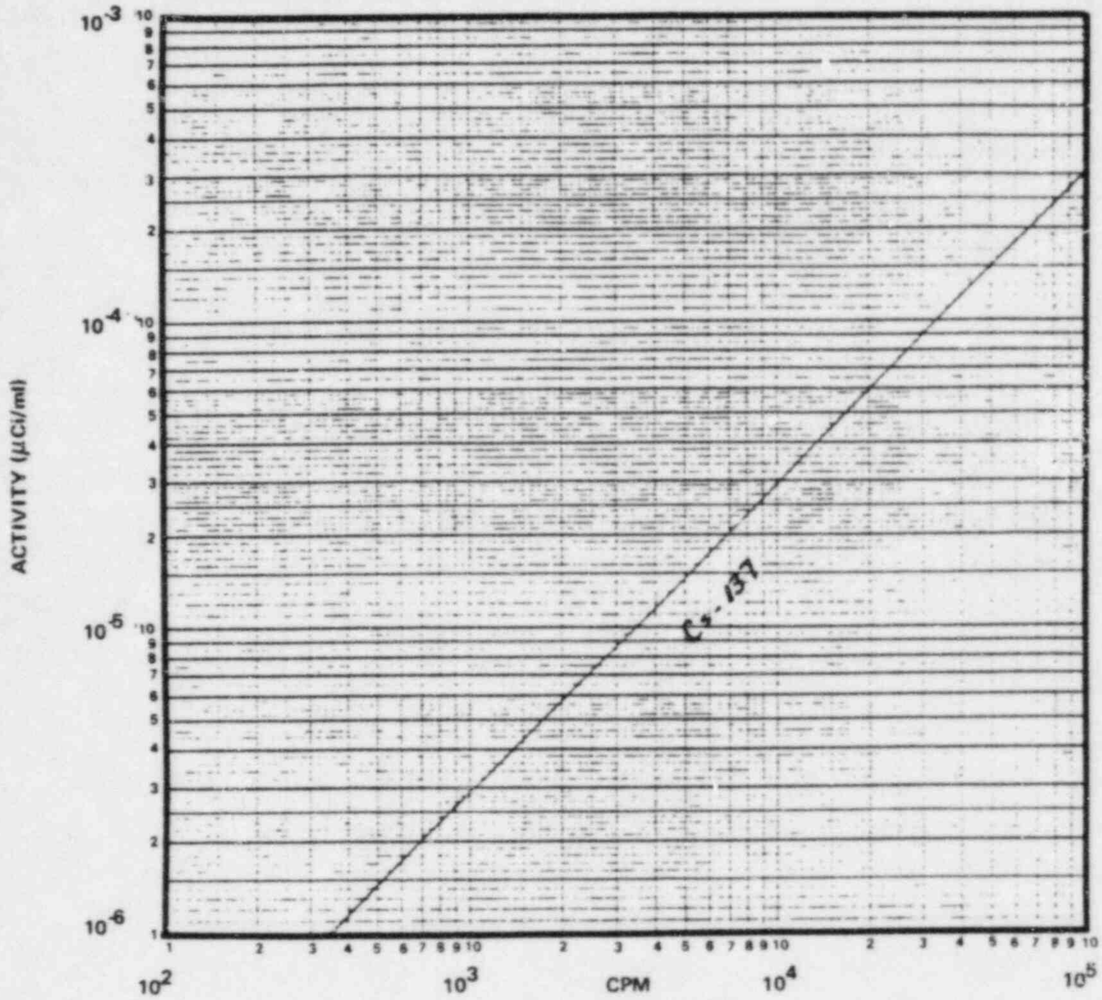
If either of these effluent streams should become contaminated with radioactivity, radionuclide concentrations must be determined and a radiation monitor setpoint determined as follows:

$$c = (\sum_g C_g) \div DF \qquad (8)$$

where:

> $\sum_g C_g$ and DF are determined using the sample analysis results for this effluent stream and applying the methodology of Section 1.1.1, Step 1 and Step 2.

For these release pathways no additional dilution is taken into account; therefore, no releases are permissible if DF > 1.



HATCH ODCM, REV 1 5/11/84

Georgia Power

EDWIN I. HATCH NUCLEAR PLANT

EXAMPLE CALIBRATION CURVE FOR LIQUID EFFLUENT MONITOR

FIGURE 1.1-1

3605-0

1.2 DOSE CALCULATION FOR LIQUID EFFLUENTS

For liquid release from Plant Hatch to the Altamaha River, the only human exposure pathway is due to consumption of fish taken from the river. No drinking water is taken from the Altamaha River downstream from Plant Hatch. The methodology for calculating doses to an individual due to fish consumption is presented in this section.

The dose contribution to the maximum exposed individual by way of fish consumption from radionuclides identified in liquid effluents released to unrestricted areas will be calculated for the purpose of implementation of RETS 3.15.1.2 (Unit 1) and 3.11.1.2 (Unit 2). In accordance with Appendix A of Reference 3, noble gases are excluded from these dose calculations. Doses to an individual are calculated as follows:

$$D_\tau = \sum_i A_{i\tau} \sum_{\ell=1}^{m} \Delta t_\ell \, C_{i\ell} \, e^{-\lambda_i t_c} F_\ell \qquad (9)$$

where:

D_τ = the cumulative dose commitment to the total body or any organ, τ, due to radioactivity in liquid effluents for the total time period

$$\sum_{\ell=1}^{m} \Delta t_\ell, \text{ in mrem, (Reference 1).}$$

Δt_ℓ = the length of the ℓth time period over which $C_{i\ell}$ and F_ℓ are averaged for all liquid releases, in hours.

$C_{i\ell}$ = the average concentration of radionuclide i, in undiluted liquid effluent during time period Δt_ℓ from any liquid release, in µCi/ml.

λ_i = the decay constant for radionuclide i (sec^{-1}).

t_c = the transit time from release to receptor (24 hours; Reference 3, Table E-15).

F_ℓ = the near-field average dilution factor in the receiving water body during any liquid effluent release. Defined as the ratio of the undiluted liquid waste flow during release to the product of the average flow from the discharge structure to unrestricted receiving water times Z.

$$= \frac{\text{(average undiluted liquid waste flow)}}{\text{(average flow from the discharge structure during periods of radioactive materials release)} \times (Z)} \qquad (10)$$

NOTE: The denominator of Equation 10 is limited to 1000 ft^3/sec or less (Reference 1, Section 4.3).

where:

Z = the applicable dilution factor for the receiving water body.

= 10 (Reference 4, Section 5.1; Reference 11, Section B; Reference 12).

$A_{i\tau}$ = the site-related fish ingestion dose commitment factor to the total body or any organ, τ, for each identified principal gamma and beta emitter listed in Table 1.2-3 in mrem-ml per hr-μCi.

$$A_{i\tau} = K_o \, (U_F \, BF_i) \, DF_{i\tau} \qquad (11)$$

where:

K_o = the units conversion factor 1.14×10^5.

$$= 10^6 \frac{pCi}{\mu Ci} \times 10^3 \frac{ml}{l} \div 8760 \frac{hr}{yr}$$

U_F = the adult fish consumption (21 kg/yr).

BF_i = the bioaccumulation factor for radionuclide i, in fish, in pCi/kg per pCi/l, from Table 1.2-1 (taken from Reference 4, Appendix A, Table 2.3-1).

$DF_{i\tau}$ = dose conversion factor for radionuclide i, for adults in preselected organ, τ, in mrem/pCi, from Table 1.2-2 (taken from Reference 3, Table E-11).

At Plant Hatch no measurable radioactivity is expected to be present in the dilution stream prior to the junction with the liquid radwaste discharge line. However, if radioactivity due to plant operations should be detected in the dilution stream prior to the junction with the liquid radwaste discharge line, the concentrations of those radionuclides found to be present must be included in the dose determination. For this part of the dose calculation, Equation 9 is used with $F_\ell = 1/Z$ and Δt = the entire time period for which the dose is being calculated.

TABLE 1.2-1

BIOACCUMULATION FACTORS
(pCi/kg per pCi/l)*

Element	Freshwater Fish
H	9.0E-01
C	4.6E 03
NA	6.6E 01
P	2.5E 04
CR	1.5E 02
MN	8.9E 01
FE	6.0E 00
CO	1.7E 02
NI	1.0E 02
CU	4.4E 01
ZN	2.9E 02
BR	4.2E 02
RB	2.0E 03
SR	3.8E 00
Y	2.5E 01
ZR	1.9E 02
NB	4.1E 01
MO	1.8E 02
TC	1.5E 01
RU	4.6E 00
RH	1.0E 01
AG	3.5E 02
TE	4.0E 02
I	4.3E 01
CS	5.8E 02
BA	5.0E 00
LA	2.5E 01
CE	8.4E 01
PR	2.5E 01
ND	4.6E 01
W	1.2E 03
NP	1.0E 01

*Values in Tables 1.2-1 are taken from Reference 4, Appendix A, Table 2.3-1.

TABLE 1.2-2 (SHEET 1 OF 2)

ADULT INGESTION DOSE FACTORS*
(mrem/pCi ingested)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H 3	NO DATA	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	NO DATA	NO DATA	NO DATA	2.17E-05
CR 51	NO DATA	NO DATA	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
MN 54	NO DATA	4.57E-06	8.72E-07	NO DATA	1.36E-06	NO DATA	1.40E-05
MN 56	NO DATA	1.15E-07	2.04E-08	NO DATA	1.46E-07	NO DATA	3.67E-06
FE 55	2.75E-06	1.90E-06	4.43E-07	NO DATA	NO DATA	1.06E-06	1.09E-06
FE 59	4.34E-06	1.02E-05	3.91E-06	NO DATA	NO DATA	2.85E-06	3.40E-05
CO 58	NO DATA	7.45E-07	1.67E-06	NO DATA	NO DATA	NO DATA	1.51E-05
CO 60	NO DATA	2.14E-06	4.72E-06	NO DATA	NO DATA	NO DATA	4.02E-05
NI 63	1.30E-04	9.01E-06	4.36E-06	NO DATA	NO DATA	NO DATA	1.88E-06
NI 65	5.28E-07	6.86E-08	3.13E-08	NO DATA	NO DATA	NO DATA	1.74E-06
CU 64	NO DATA	8.33E-08	3.91E-08	NO DATA	2.10E-07	NO DATA	7.10E-06
ZN 65	4.84E-06	1.54E-05	6.96E-06	NO DATA	1.03E-05	NO DATA	9.70E-06
ZN 69	1.03E-08	1.97E-08	1.37E-09	NO DATA	1.28E-08	NO DATA	2.96E-09
BR 83	NO DATA	NO DATA	4.02E-08	NO DATA	NO DATA	NO DATA	5.79E-08
BR 84	NO DATA	NO DATA	5.21E-08	NO DATA	NO DATA	NO DATA	4.09E-13
BR 85	NO DATA	NO DATA	2.14E-09	NO DATA	NO DATA	NO DATA	LT E-24
RB 86	NO DATA	2.11E-05	9.83E-06	NO DATA	NO DATA	NO DATA	4.16E-06
RB 88	NO DATA	6.05E-08	3.21E-08	NO DATA	NO DATA	NO DATA	8.36E-19
RB 89	NO DATA	4.01E-08	2.82E-08	NO DATA	NO DATA	NO DATA	2.33E-21
SR 89	3.08E-04	NO DATA	8.84E-06	NO DATA	NO DATA	NO DATA	4.94E-05
SR 90	7.58E-03	NO DATA	1.86E-03	NO DATA	NO DATA	NO DATA	2.19E-04
SR 91	5.67E-06	NO DATA	2.29E-07	NO DATA	NO DATA	NO DATA	2.70E-05
SR 92	2.15E-06	NO DATA	9.30E-08	NO DATA	NO DATA	NO DATA	4.26E-05
Y 90	9.62E-09	NO DATA	2.58E-10	NO DATA	NO DATA	NO DATA	1.02E-04
Y 91M	9.09E-11	NO DATA	3.52E-12	NO DATA	NO DATA	NO DATA	2.67E-10
Y 91	1.41E-07	NO DATA	3.77E-09	NO DATA	NO DATA	NO DATA	7.76E-05
Y 92	8.45E-10	NO DATA	2.47E-11	NO DATA	NO DATA	NO DATA	1.48E-05
Y 93	2.68E-09	NO DATA	7.40E-11	NO DATA	NO DATA	NO DATA	8.50E-05
ZR 95	3.04E-08	9.75E-09	6.60E-09	NO DATA	1.53E-08	NO DATA	3.09E-05
ZR 97	1.68E-09	3.39E-10	1.55E-10	NO DATA	5.12E-10	NO DATA	1.05E-04
NB 95	6.22E-09	3.46E-09	1.86E-09	NO DATA	3.42E-09	NO DATA	2.10E-05
MO 99	NO DATA	4.31E-06	8.20E-07	NO DATA	9.76E-06	NO DATA	9.99E-06
TC 99M	2.47E-10	6.98E-10	8.89E-09	NO DATA	1.06E-08	3.42E-10	4.13E-07
TC101	2.54E-10	3.66E-10	3.59E-09	NO DATA	6.59E-09	1.87E-10	1.10E-21
RU103	1.85E-07	NO DATA	7.97E-08	NO DATA	7.06E-07	NO DATA	2.16E-05
RU105	1.54E-08	NO DATA	6.08E-09	NO DATA	1.99E-07	NO DATA	9.42E-06

*Values in Table 1.2-2 are taken from Reference 3, Table E-11.

TABLE 1.2-2 (SHEET 2 OF 2)

ADULT INGESTION DOSE FACTORS*
(mrem/pCi ingested)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
RU106	2.75E-06	NO DATA	3.48E-07	NO DATA	5.31E-06	NO DATA	1.78E-04
AG110M	1.60E-07	1.48E-07	8.79E-08	NO DATA	2.91E-07	NO DATA	6.04E-05
TE125M	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	NO DATA	1.07E-05
TE127M	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	NO DATA	2.27E-05
TE127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	NO DATA	8.68E-06
TE129M	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	NO DATA	5.79E-05
TE129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	NO DATA	2.37E-08
TE131M	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	NO DATA	8.40E-05
TE131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	NO DATA	2.79E-09
TE132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	NO DATA	7.71E-05
I 130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	NO DATA	1.92E-06
I 131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	NO DATA	1.57E-06
I 132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	NO DATA	1.02E-07
I 133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	NO DATA	2.22E-06
I 134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	NO DATA	2.51E-10
I 135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	NO DATA	1.31E-06
CS134	6.22E-05	1.48E-04	1.21E-04	NO DATA	4.79E-05	1.59E-05	2.59E-06
CS136	6.51E-06	2.57E-05	1.85E-05	NO DATA	1.43E-05	1.96E-06	2.92E-06
CS137	7.97E-05	1.09E-04	7.14E-05	NO DATA	3.70E-05	1.23E-05	2.11E-06
CS138	5.52E-08	1.09E-07	5.40E-08	NO DATA	8.01E-08	7.91E-09	4.65E-13
BA139	9.70E-08	6.91E-11	2.84E-09	NO DATA	6.46E-11	3.92E-11	1.72E-07
BA140	2.03E-05	2.55E-08	1.33E-06	NO DATA	8.67E-09	1.46E-08	4.18E-05
BA141	4.71E-08	3.56E-11	1.59E-09	NO DATA	3.31E-11	2.02E-11	2.22E-17
BA142	2.13E-08	2.19E-11	1.34E-09	NO DATA	1.85E-11	1.24E-11	3.00E-26
LA140	2.50E-09	1.26E-09	3.33E-10	NO DATA	NO DATA	NO DATA	9.25E-05
LA142	1.28E-10	5.82E-11	1.45E-11	NO DATA	NO DATA	NO DATA	4.25E-07
CE141	9.36E-09	6.33E-09	7.18E-10	NO DATA	2.94E-09	NO DATA	2.42E-05
CE143	1.65E-09	1.22E-06	1.35E-10	NO DATA	5.37E-10	NO DATA	4.56E-05
CE144	4.88E-07	2.04E-07	2.62E-08	NO DATA	1.21E-07	NO DATA	1.65E-04
PR143	9.20E-09	3.69E-09	4.56E-10	NO DATA	2.13E-09	NO DATA	4.03E-05
PR144	3.01E-11	1.25E-11	1.53E-12	NO DATA	7.05E-12	NO DATA	4.33E-18
ND147	6.29E-09	7.27E-09	4.35E-10	NO DATA	4.25E-09	NO DATA	3.49E-05
W 137	1.03E-07	8.61E-08	3.01E-08	NO DATA	NO DATA	NO DATA	2.82E-05
NP239	1.19E-09	1.17E-10	6.45E-11	NO DATA	3.65E-10	NO DATA	2.40E-05

*Values in Table 1.2-2 are taken from Reference 3, Table E-11.

TABLE 1.2-3 (SHEET 1 OF 2)

SITE-RELATED INGESTION DOSE COMMITMENT FACTOR, $A_{i\tau}$
(FISH CONSUMPTION)*
(mrem/hr per μCi/ml)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01
C-14	3.13E+04	6.26E+03	6.26E+03	6.26E+03	6.26E+03	6.26E+03	6.26E+03
Na-24	2.69E+02	2.69E+02	2.69E+02	2.69E+02	2.69E+02	2.69E+02	2.69E+02
P-32	1.16E+07	7.18E+05	4.46E+05	0.00E+00	0.00E+00	0.00E+00	1.30E+06
Cr-51	0.00E+00	0.00E+00	9.55E-01	5.71E-01	2.10E-01	1.27E+00	2.40E+02
Mn-54	0.00E+00	9.74E+02	1.86E+02	0.00E+00	2.90E+02	0.00E+00	2.98E+03
Mn-56	0.00E+00	2.45E+01	4.35E+00	0.00E+00	3.11E+01	0.00E+00	7.82E+02
Fe-55	3.95E+01	2.73E+01	6.36E+00	0.00E+00	0.00E+00	1.52E+01	1.57E+01
Fe-59	6.23E+01	1.47E+02	5.62E+01	0.00E+00	0.00E+00	4.09E+01	4.88E+02
Co-58	0.00E+00	3.03E+02	6.80E+02	0.00E+00	0.00E+00	0.00E+00	6.15E+03
Co-60	0.00E+00	8.71E+02	1.92E+03	0.00E+00	0.00E+00	0.00E+00	1.64E+04
Ni-63	3.11E+04	2.16E+03	1.04E+03	0.00E+00	0.00E+00	0.00E+00	4.50E+02
Ni-65	1.26E+02	1.64E+01	7.49E+00	0.00E+00	0.00E+00	0.00E+00	4.17E+02
Cu-64	0.00E+00	8.77E+00	4.12E+00	0.00E+00	2.21E+01	0.00E+00	7.48E+02
Zn-65	3.36E+03	1.07E+04	4.83E+03	0.00E+00	7.15E+03	0.00E+00	6.73E+03
Zn-69	7.15E+00	1.37E+01	9.51E-01	0.00E+00	8.89E+00	0.00E+00	2.06E+00
Br-83	0.00E+00	0.00E+00	4.04E+01	0.00E+00	0.00E+00	0.00E+00	5.82E+01
Br-84	0.00E+00	0.00E+00	5.24E+01	0.00E+00	0.00E+00	0.00E+00	4.11E-04
Br-85	0.00E+00	0.00E+00	2.15E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-15
Rb-86	0.00E+00	1.01E+05	4.71E+04	0.00E+00	0.00E+00	0.00E+00	1.99E+04
Rb-88	0.00E+00	2.90E+02	1.54E+02	0.00E+00	0.00E+00	0.00E+00	4.00E-09
Rb-89	0.00E+00	1.92E+02	1.35E+02	0.00E+00	0.00E+00	0.00E+00	1.12E-11
Sr-89	2.80E+03	0.00E+00	8.04E+01	0.00E+00	0.00E+00	0.00E+00	4.49E+02
Sr-90	6.90E+04	0.00E+00	1.69E+04	0.00E+00	0.00E+00	0.00E+00	1.99E+03
Sr-91	5.16E+01	0.00E+00	2.08E+00	0.00E+00	0.00E+00	0.00E+00	2.46E+02
Sr-92	1.96E+01	0.00E+00	8.46E-01	0.00E+00	0.00E+00	0.00E+00	3.88E+02
Y-90	5.76E-01	0.00E+00	1.54E-02	0.00E+00	0.00E+00	0.00E+00	6.10E+03
Y-91m	5.44E-03	0.00E+00	2.11E-04	0.00E+00	0.00E+00	0.00E+00	1.60E-02
Y-91	8.44E+00	0.00E+00	2.26E-01	0.00E+00	0.00E+00	0.00E+00	4.64E+03
Y-92	5.06E-02	0.00E+00	1.48E-03	0.00E+00	0.00E+00	0.00E+00	8.86E+02
Y-93	1.60E-01	0.00E+00	4.43E-03	0.00E+00	0.00E+00	0.00E+00	5.09E+03
Zr-95	1.38E+01	4.43E+00	3.00E+00	0.00E+00	6.96E+00	0.00E+00	1.41E+04
Zr-97	7.64E-01	1.54E-01	7.05E-02	0.00E+00	2.33E-01	0.00E+00	4.78E+04
Nb-95	6.11E-01	3.40E-01	1.83E-01	0.00E+00	3.36E-01	0.00E+00	2.06E+03
Mo-99	0.00E+00	1.86E+03	3.53E+02	0.00E+00	4.21E+03	0.00E+00	4.30E+03
Tc-99m	8.87E-03	2.51E-02	3.19E-01	0.00E+00	3.81E-01	1.23E-02	1.48E+01
Tc-101	9.12E-03	1.31E-02	1.29E-01	0.00E+00	2.37E-01	6.72E-03	3.95E-14
Ru-103	2.04E+00	0.00E+00	8.78E-01	0.00E+00	7.77E+00	0.00E+00	2.38E+02
Ru-105	1.70E-01	0.00E+00	6.70E-02	0.00E+00	2.19E+00	0.00E+00	1.04E+02

*Calculated using Equation 11.

TABLE 1.2-3 (SHEET 2 OF 2)

SITE-RELATED INGESTION DOSE COMMITMENT FACTOR, $A_{i\tau}$
(FISH CONSUMPTION)*
(mrem/hr per μCi/ml)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	3.03E+01	0.00E+00	3.83E+00	0.00E+00	5.85E+01	0.00E+00	1.96E+03
Ag-110m	1.34E+02	1.24E+02	7.37E+01	0.00E+00	2.44E+02	0.00E+00	5.06E+04
Te-125m	2.57E+03	9.30E+02	3.44E+02	7.72E+02	1.04E+04	0.00E+00	1.02E+04
Te-127m	6.48E+03	2.32E+03	7.90E+02	1.66E+03	2.63E+04	0.00E+00	2.17E+04
Te-127	1.05E+02	3.78E+01	2.28E+01	7.80E+01	4.29E+02	0.00E+00	8.31E+03
Te-129m	1.10E+04	4.11E+03	1.74E+03	3.78E+03	4.60E+04	0.00E+00	5.54E+04
Te-129	3.01E+01	1.13E+01	7.33E+00	2.31E+01	1.26E+02	0.00E+00	2.27E+01
Te-131m	1.66E+03	8.10E+02	6.75E+02	1.28E+03	8.21E+03	0.00E+00	8.04E+04
Te-131	1.89E+01	7.88E+00	5.96E+00	1.55E+01	8.26E+01	0.00E+00	2.67E+00
Te-132	2.41E+03	1.56E+03	1.47E+03	1.72E+03	1.50E+04	0.00E+00	7.38E+04
I-130	7.78E+01	2.30E+02	9.06E+01	1.95E+04	3.58E+02	0.00E+00	1.98E+02
I-131	4.28E+02	6.13E+02	3.51E+02	2.01E+05	1.05E+03	0.00E+00	1.62E+02
I-132	2.09E+01	5.59E+01	1.96E+01	1.96E+03	8.90E+01	0.00E+00	1.05E+01
I-133	1.46E+02	2.54E+02	7.75E+01	3.74E+04	4.44E+02	0.00E+00	2.29E+02
I-134	1.09E+01	2.96E+01	1.06E+01	5.14E+02	4.71E+01	0.00E+00	2.58E-02
I-135	4.56E+01	1.19E+02	4.41E+01	7.88E+03	1.91E+02	0.00E+00	1.35E+02
Cs-134	8.64E+04	2.06E+05	1.68E+05	0.00E+00	6.65E+04	2.21E+04	3.60E+03
Cs-136	9.04E+03	3.57E+04	2.57E+04	0.00E+00	1.99E+04	2.72E+03	4.05E+03
Cs-137	1.11E+05	1.51E+05	9.91E+04	0.00E+00	5.14E+04	1.71E+04	2.93E+03
Cs-138	7.66E+01	1.51E+02	7.50E+01	0.00E+00	1.11E+02	1.10E+01	6.46E-04
Ba-139	1.16E+00	8.27E-04	3.40E-02	0.00E+00	7.73E-04	4.69E-04	2.06E+00
Ba-140	2.43E+02	3.05E-01	1.59E+01	0.00E+00	1.04E-01	1.75E-01	5.00E+02
Ba-141	5.64E-01	4.26E-04	1.90E-02	0.00E+00	3.96E-04	2.42E-04	2.66E-10
Ba-142	2.55E-01	2.62E-04	1.60E-02	0.00E+00	2.21E-04	1.48E-04	3.59E-19
La-140	1.50E-01	7.54E-02	1.99E-02	0.00E+00	0.00E+00	0.00E+00	5.54E+03
La-142	7.66E-03	3.48E-03	8.68E-04	0.00E+00	0.00E+00	0.00E+00	2.54E+01
Ce-141	1.88E+00	1.27E+00	1.44E-01	0.00E+00	5.91E-01	0.00E+00	4.87E+03
Ce-143	3.32E-01	2.45E+02	2.71E-02	0.00E+00	1.08E-01	0.00E+00	9.17E+03
Ce-144	9.81E+01	4.10E+01	5.27E+00	0.00E+00	2.43E+01	0.00E+00	3.32E+04
Pr-143	5.51E-01	2.21E-01	2.73E-02	0.00E+00	1.27E-01	0.00E+00	2.41E+03
Pr-144	1.80E-03	7.48E-04	9.16E-05	0.00E+00	4.22E-04	0.00E+00	2.59E-10
Nd-147	6.93E-01	8.01E-01	4.79E-02	0.00E+00	4.68E-01	0.00E+00	3.84E+03
W-187	2.96E+02	2.47E+02	8.65E+01	0.00E+00	0.00E+00	0.00E+00	8.10E+04
Np-239	2.85E-02	2.80E-03	1.54E-03	0.00E+00	8.74E-03	0.00E+00	5.75E+02

*Calculated using Equation 11.

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1.3 DOSE PROJECTIONS FOR LIQUID EFFLUENTS

1.3.1 Monthly Dose Projections

In order to meet the requirements of RETS 3.15.1.3 (Unit 1) and 3.11.1.3 (Unit 2) which pertain to operation of the liquid radwaste treatment systems, dose projections must be made at least monthly during periods in which discharge of untreated liquid effluents containing radioactive materials to unrestricted areas occurs or is expected.

Projected quarterly doses to individuals due to liquid effluents may be determined as follows:

$$D_{tb(prj)} = \left(\frac{D_{tb(c)}}{t}\right) \times 91$$

$$D_{o(prj)} = \left(\frac{D_{o(c)}}{t}\right) \times 91$$

where:

$D_{tb(c)}$ = the cumulative total-body dose for the elapsed portion of the current quarter plus the release under consideration.

t = the number of days into the current quarter.

$D_{o(c)}$ = the cumulative organ doses for the elapsed portion of the current quarter plus the release under consideration.

If activities planned during the remainder of the quarter are expected to contribute a significant dose and the determination can be reasonably made, this contribution should be included in the equations:

$$D_{tb(prj)} = \left[\left(\frac{D_{tb(c)}}{t}\right) \times 91\right] + D_{PA}$$

$$D_{o(prj)} = \left[\left(\frac{D_{o(c)}}{t} \right) x\ 91 \right] + D_{PA}$$

where:

D_{PA} = the expected dose due to the particular planned activity.

1.3.2 Dose Projections for Specific Releases

Dose projections may be performed for a particular release by performing a prerelease dose calculation, assuming that the planned release will proceed as anticipated. For individual dose projections due to liquid releases, follow the methodology presented in Section 1.2, using sample analysis values for the source to be released and parametric values expected to exist for the release period.

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1.4 DEFINITIONS OF LIQUID EFFLUENT TERMS

Term		Definition	Section of Initial Use
A	=	adjustment factor applied to facilitate setting actual monitor setpoints.	1.1.1
$A_{i\tau}$	=	the site-related ingestion dose commitment factor due to fish consumption to the total body or any organ, τ, for each identified principal gamma and beta emitter listed in Table 1.2-3 in mrem-ml per hr-μCi.	1.2
BF_i	=	the bioaccumulation factor for nuclide i, in fish, in pCi/kg per pCi/l, from Table 1.2-1.	1.2.1
c	=	the setpoint of the radioactivity monitor which measures the radioactivity concentration in the effluent line prior to dilution and subsequent release.	1.1.1
C_a	=	the effluent concentration of alpha-emitting nuclides observed by gross alpha analysis of the MONTHLY composite sample.	1.1.1
C_f	=	the concentration of Fe-55 in liquid wastes as observed in the QUARTERLY composite sample.	1.1.1
C_g	=	the effluent concentration of a gamma-emitting nuclide, g, observed by gamma-ray spectroscopy of the waste sample.	1.1.1
C_i	=	the concentration of nuclide i as determined by the analysis of the waste sample.	1.1.1

Term	Definition	Section of Initial Use
$C_{i\ell}$	= the average concentration of radionuclide i, in undiluted liquid effluent during time period Δt_ℓ, in μCi/ml.	1.2.1
C_{MPC}	= the effluent concentration limit (RETS 3.15.1.1 for Unit 1 and 3.11.1.1 for Unit 2) implementing 10 CFR 20 for the site in μCi/ml.	1.1.1
C_s	= the concentration of Sr-89 or Sr-90 in liquid wastes as determined by analysis of the QUARTERLY composite sample.	1.1.1
C_t	= the measured concentration of H-3 in liquid waste as determined by analysis of the MONTHLY composite.	1.1.1
D_τ	= the cumulative dose commitment to the total body or any organ, τ, from the liquid effluents for the total time period.	1.2.1
DF	= the dilution factor, which is the ratio of the total dilution flow rate to the effluent stream flow rate(s) required to assure that the limiting concentration of 10 CFR, Part 20, Appendix B, Table II, Column 2 are met at the point of discharge to the unrestricted area.	1.1.1
$DF_{i\tau}$	= a dose conversion factor for nuclide i, for adults in preselected organ, τ, in mrem/pCi, from Table 1.2-2.	1.2.1
f	= the flow setpoint as determined for the radiation monitor location. (General expression for Equation 1.)	1.1.1

Term		Definition	Section of Initial Use
F	=	the dilution water flow monitor setpoint as determined prior to the release point, in volume per unit time. (General expression for Equation 1.)	1.1.1
F_d	=	the minimum flow rate of the dilution stream used for setpoint calculations during the time of release.	1.1.1
F_ℓ	=	the near-field average dilution factor for $C_{i\ell}$ during any liquid effluent release.	1.2.1
f_p	=	the effluent flow rate (actual pump value).	1.1.1
f_t	=	the maximum permissible effluent flow rate.	1.1.1
K_o	=	1.14×10^5, units conversion factor.	1.2.1
m	=	the number of liquid releases.	1.2.1
MPC_i	=	MPC_g, MPC_a, MPC_s, MPC_f, and MPC_t which are the limiting concentrations of the appropriate gamma-emitting radionuclides, alpha-emitting radionuclides, strontium, iron, and tritium, respectively, from 10 CFR, Part 20, Appendix B, Table II, Column 2.	1.1.1
SF	=	the safety factor; a conservative factor used to compensate for statistical fluctuations and errors of measurements.	1.1.1
t_c	=	transit time from release to receptor.	1.2.1
Δt	=	the duration of release under consideration.	1.2.1

Term	Definition	Section of Initial Use
U_F	= 21 kg/yr, fish consumption (adult).	1.2.1
Z	= the applicable factor when additional receiving water body dilution is considered; Z = 10.	1.2.1
λ_i	= the decay constant for radionuclide i (sec^{-1}).	1.2.1

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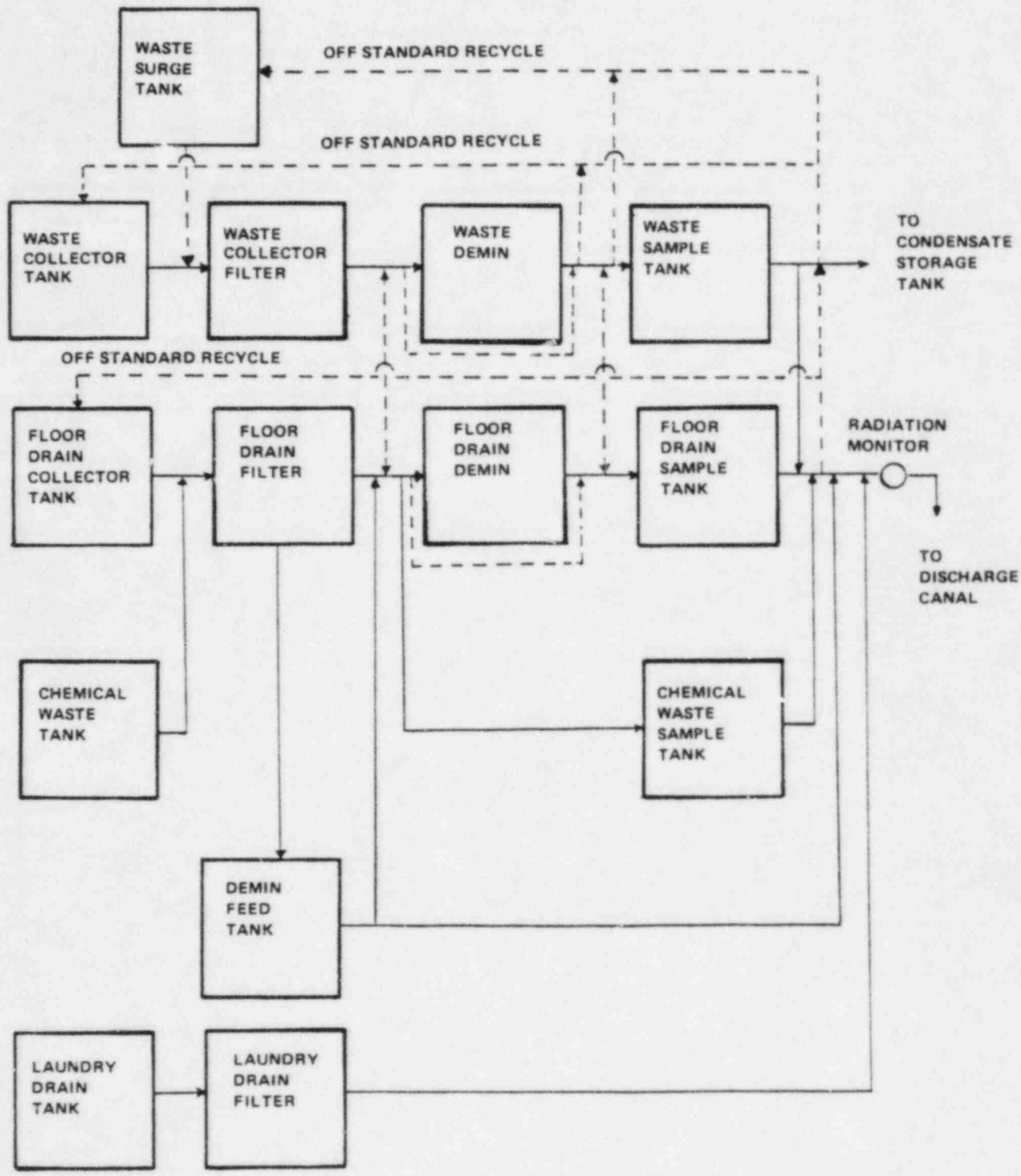
1.5 LIQUID RADWASTE TREATMENT SYSTEMS

Figures 1.5-1 and 1.5-2 are schematics of the liquid radwaste treatment systems for Unit 1 and Unit 2, respectively. The dotted lines indicate alternate pathways through which liquid radwaste may be routed. These alternate routes increase the operational flexibility of the liquid radwaste treatment systems.



HATCH ODCM, REV 1 5/11/84

Georgia Power EDWIN I. HATCH NUCLEAR PLANT

LIQUID RADWASTE TREATMENT SYSTEM (UNIT 1)

FIGURE 1.5-1

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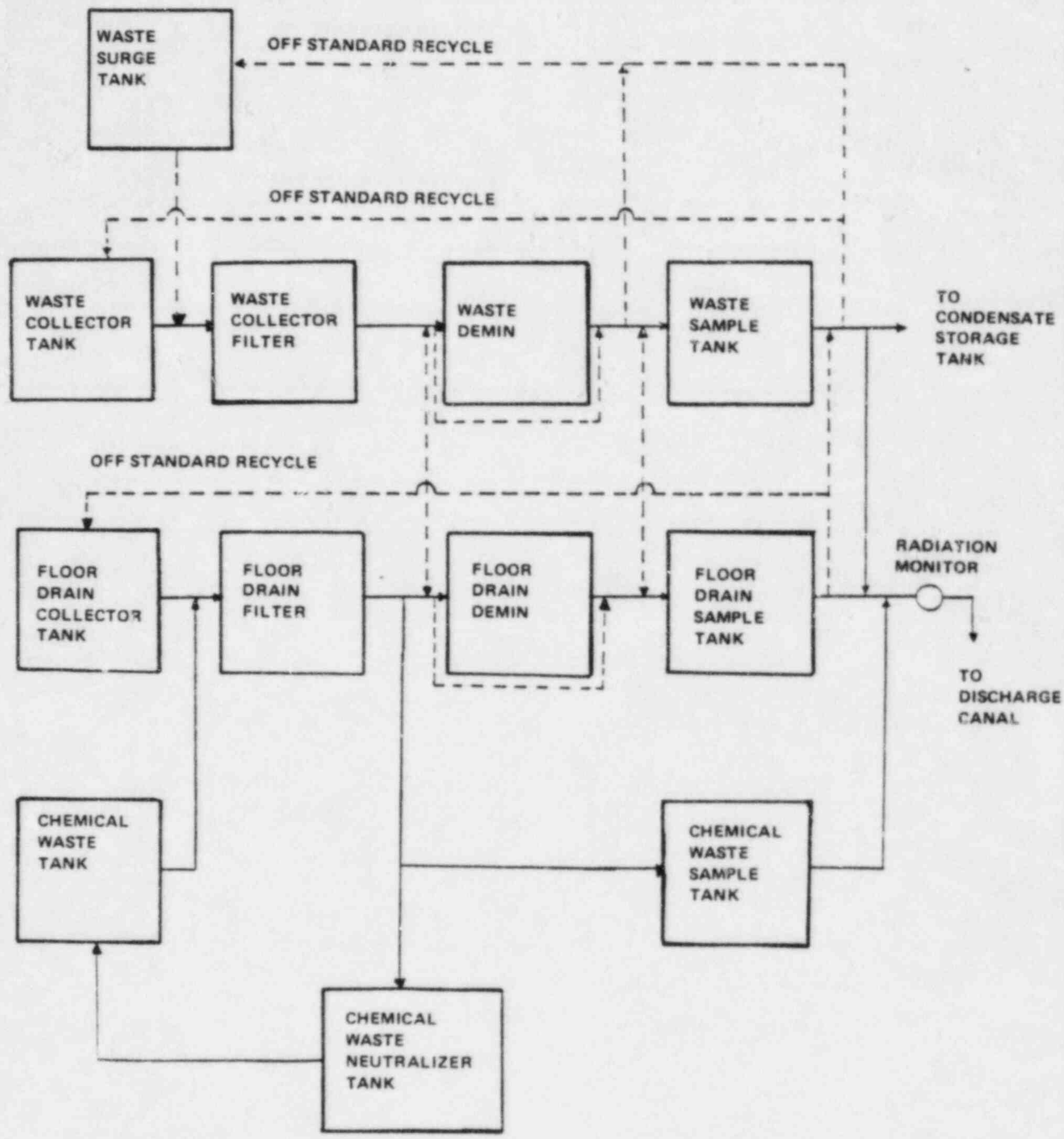

HATCH ODCM, REV 1 5/11/84

Georgia Power EDWIN I. HATCH NUCLEAR PLANT	LIQUID RADWASTE TREATMENT SYSTEM (UNIT 2)
	FIGURE 1.5-2

1.6 MIXING OF LIQUID WASTE TANKS

In order to assure that samples taken from liquid waste tanks planned for release are representative, the contents of the tank to be sampled will be recirculated for a minimum time period to allow adequate mixing of the tank contents. Recirculation times are as follows (Reference 13):

Tank(s)	Recirculation Times (minutes)	
	Unit 1	Unit 2
Waste sample tanks	40	40
Floor drain sample tanks	70	105
Chemical waste sample tanks	65	65
Demin feed tank	115	NA
Laundry drain tanks	50	NA

2.0 GASEOUS EFFLUENTS

At Plant Hatch there are four points where radioactivity is released to the atmosphere in gaseous discharges. These four release points are:

- The main stack which serves both units.
- Unit 1 reactor building vent stack.
- Unit 2 reactor building vent stack.
- Unit 1 recombiner building vent.

The main stack serves as the discharge point for the following release sources from each unit:

- Mechanical vacuum pumps.
- Off-gas system.
- Gland seal exhaust.
- Standby gas treatment system through which drywell purges are discharged.

The waste gas treatment building ventilation also discharges through the main stack.

Each reactor building vent stack serves as the discharge point for the following (of each respective unit):

- Reactor building.
- Refueling floor ventilation.
- Turbine building.
- Radwaste building.

The Unit 1 recombiner building vent discharges directly to the atmosphere.

Gaseous effluent monitor setpoints are required only for noble gas monitors serving the four release points; the methodology for calculating noble gas monitor setpoints is presented in Section 2.1. Although setpoint calculations are not required for radioiodine and particulate monitors, the methodology for assuring that the potential organ dose rates due to radioiodines, tritium, and particulates in gaseous releases from the site do not exceed the limits of RETS 3.15.2.1(b) fc· Unit 1 and 3.11.2.1(b) for Unit 2 is presented in the note following Section 2.2.1.b.

2.1 GASEOUS EFFLUENT MONITOR SETPOINTS

The gaseous monitor setpoint values determined in the following sections will be regarded as upper bounds for the actual setpoint adjustments. That is, setpoint adjustments are not required to be performed if the existing setpoint level corresponds to a lower count rate than the calculated value. Setpoints may be established at values lower than the calculated values, if desired.

If no release is planned for a particular pathway, or if there is no detectable activity in the planned release, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

If a calculated setpoint is less than the monitor reading associated with the particular release pathway, no release may be made under current conditions. Under such circumstances, the number of simultaneous release pathways may be reduced or contributing source terms may be reduced and the setpoint recalculated.

2.1.1 Unit 1 Reactor Building Vent Stack, Unit 2 Reactor Building Vent Stack, and Unit 1 Recombiner Building Vent

Monitors: D11-K619 A and B, 2D11-K636 A and B, D11-P003 A and B

For the purpose of implementation of RETS 3.14.2 (Unit 1) and 3.3.6.10 (Unit 2), the alarm setpoint level for these noble gas monitors will be calculated as follows:

C_S = the monitor reading of the noble gas monitor at the alarm setpoint concentration.

$$C_S = \text{the lesser of} \begin{cases} (AG \times SF) \times R_{tv} \times D_{TB} & (1) \\ \text{or} \\ (AG \times SF) \times R_{sv} \times D_{ss} & (2) \end{cases}$$

SF = the safety factor; a conservative factor applied to each noble gas monitor to compensate for statistical fluctuations and errors of measurement. (For example, SF = 0.5 corresponds to a 100-percent variation.)

AG = an administrative allocation factor applied to apportion the release setpoints among all gaseous release discharge pathways (normally four) to assure that release limits will not be exceeded by simultaneous releases. The allocation factor for a particular discharge pathway may be assigned any desired value between 0 and 1 under the condition that the sum of the allocation factors for all simultaneous release pathways does not exceed 1. For ease of implementation, AG may be set equal to 1/n, where: n = the number of simultaneous final gaseous release points. For a more exact determination of allocation factors, see Section 2.1.3.

D_{TB} = the dose rate limit to the total body of an individual which is 500 mrem/yr.

R_{tv} = the monitor reading per mrem/yr to the total body for vent releases.

$$= C \div ((\overline{X/Q})_G \sum_i K_i Q_{iv}). \quad (3)$$

where:

C = the monitor reading of a noble gas monitor corresponding to the grab sample radionuclide concentrations taken in accordance with RETS Tables 4.15.2-1 (Unit 1) and 4.11.2-1 (Unit 2). The monitor response corresponding to the measured concentration is determined from the monitor calibration curve for the particular monitor.

$(\overline{X/Q})_G$ = the highest annual average relative concentration at the site boundary. (If desired, the annual average relative concentration at the site boundary for the particular release point may be used.) The release points addressed in this section are ground-level releases.

$(\overline{X/Q})_G$ = 6.8×10^{-6} sec/m^3 in the W sector.

K_i = the total-body dose factor due to gamma emissions from radionuclide i (mrem/yr per μCi/m^3) from Table 2.1-1.

Q_{iv} = the rate of release of noble gas radionuclide i (μCi/sec) from the vent release pathway under consideration, which is the product of X_{iv} and F_v, where: X_{iv} = the concentration of radionuclide i for the particular release, and F_v = the maximum expected release flow rate for this release point (X_{iv} in μCi/ml and F_v in ml/sec).

D_{ss} = the dose rate limit to the skin of the body of an individual in an unrestricted area which is 3000 mrem/year.

R_{sv} = the monitor reading per mrem/yr to the skin.

$$R_{sv} = C \div ((\overline{X/Q})_G \sum_i (L_i + 1.1\ M_i)\ Q_{iv}) \qquad (4)$$

where:

L_i = the skin dose factor due to beta emissions from radionuclide i (mrem/yr per μCi/m³) from Table 2.1-1.

1.1 = the mrem skin dose per mrad air dose.

M_i = the air dose factor due to gamma emissions from radionuclide i (mrad/yr per μCi/m³) from Table 2.1-1.

2.1.2 Main Stack

Monitor: D11-K600 A and B

For the purpose of implementation of RETS 3.14.2 (Unit 1) and 3.3.6.10 (Unit 2), the alarm setpoint level for the main stack noble gas monitor will be calculated as follows:

C_S = the monitor reading of the noble gas monitor at the alarm setpoint concentration.

= the lesser of

$$(AG \times SF) \times R_{ts} \times D_{TB} \qquad (5)$$

or

$$(AG \times SF) \times R_{ss} \times D_{ss} \qquad (6)$$

$$R_{ts} = C \div \sum_i V_i\ Q_{is} \qquad (7)$$

$$R_{ss} = C \div \sum_i (L_i (\overline{X/Q})_E + 1.1 B_i) Q_{is} \quad (8)$$

where:

V_i = the constant, which includes the dose factor, for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume resulting from the main stack release, in mrem/yr per μCi/sec, from Table 2.1-2.

B_i = the constant, which includes the air dose factor, for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume resulting from the main stack release, in mrad/yr per μCi/sec, from Table 2.1-2.

Q_{is} = the rate of release of noble gas radionuclide i (μCi/sec) from the main stack, which is equal to the product of X_{is} and F_s, where: X_{is} = the concentration of radionuclide i for the main stack release, and F_s = the maximum expected main stack release flow rate (X_{is} in μCi/ml and F_s in ml/sec).

$(\overline{X/Q})_E$ = the highest annual average relative concentration in the unrestricted area associated with releases from the main stack. The main stack is an elevated release.

= the 1.0×10^{-7} sec/m³ in the W sector.

All other terms were identified previously in Section 2.1.1.

2.1.3 Determination of Allocation Factor, AG

When simultaneous gaseous releases are made to the environment, an (administrative) allocation factor must be applied to each discharge pathway. This is to ensure that simultaneous gaseous releases from the site to unrestricted areas will not exceed the dose rate limits specified in RETS 3.15.2.1 (Unit 1) or 3.11.2.1 (Unit 2). For Plant Hatch, final discharge pathways which may be released simultaneously are:

- The main stack.
- Unit 1 reactor building vent stack.
- Unit 2 reactor building vent stack.
- Unit 1 recombiner building vent.

The allocation factor for each discharge pathway must be between 0 and 1, and the sum of the allocation factors for the simultaneous releases must not exceed 1.

There are three methods by which allocation factors may be determined:

1. The allocation factor for a particular release pathway may be administratively selected based on an estimate of the fraction of the total dose rate (from all simultaneous releases) which is contributed by the particular release pathway.

2. The allocation factor may be calculated using the expression:

$$AG = 1/n$$

   where: n = the number of release pathways to be released simultaneously.

3. The allocation factor may be determined for a particular discharge pathway by calculating the ratio of the total-body dose rate due to noble gases released from the particular discharge pathway under consideration to the total-body dose rate due to noble gases in all simultaneous releases.

For the main stack:

$$AG = \frac{\sum_i V_i Q_{is}}{\sum_i V_i Q_{is} + \sum_n (\overline{X/Q})_G \sum_i K_i Q_{iv}}$$

where: n = the number of simultaneous vent releases.

For vent releases:

$$AG = \frac{(\overline{X/Q})_G \sum_i K_i Q_{iv(r)}}{\sum_i V_i Q_{is} + \sum_n (\overline{X/Q})_G \sum_i K_i Q_{iv}}$$

where:

n = the number of simultaneous vent releases.

(r) = the particular discharge pathway number for which an allocation factor is being determined.

TABLE 2.1-1

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

Nuclide	γ-Body (K)***	β-Skin (L)***	γ-Air (M)**	β-Air (N)**
Kr-83m	7.56E-02****	--	1.93E+01	2.88E+02
Kr-85m	1.17E+03	1.46E+03	1.23E+03	1.97E+03
Kr-85	1.61E+01	1.34E+03	1.72E+01	1.95E+03
Kr-87	5.92E+03	9.73E+03	6.17E+03	1.03E+04
Kr-88	1.47E+04	2.37E+03	1.52E+04	2.93E+03
Kr-89	1.66E+04	1.01E+04	1.73E+04	1.06E+04
Kr-90	1.56E+04	7.29E+03	1.63E+04	7.83E+03
Xe-131m	9.15E+01	4.76E+02	1.56E+02	1.11E+03
Xe-133m	2.51E+02	9.94E+02	3.27E+02	1.48E+03
Xe-133	2.94E+02	3.06E+02	3.53E+02	1.05E+03
Xe-135m	3.12E+03	7.11E+02	3.36E+03	7.39E+02
Xe-135	1.81E+03	1.86E+03	1.92E+03	2.46E+03
Xe-137	1.42E+03	1.22E+04	1.51E+03	1.27E+04
Xe-138	8.83E+03	4.13E+03	9.21E+03	4.75E+03
Ar-41	8.84E+03	2.69E+03	9.30E+03	3.28E+03

* Values taken from Reference 3, Table B-1.

** $\frac{\text{mrad-m}^3}{\mu\text{Ci-yr}}$

*** $\frac{\text{mrem-m}^3}{\mu\text{Ci-yr}}$

**** 7.56E-02 = 7.56×10^{-2}

TABLE 2.1-2

DOSE FACTORS FOR EXPOSURE TO DIRECT RADIATION
FROM NOBLE GASES IN THE ELEVATED FINITE PLUME*
(Location: Site Boundary in West Sector at 1501 m)

Nuclide	γ-Body (V)**	γ-Air (B)***
Kr-85m	6.77E-05	7.13E-05
Kr-85	9.46E-07	1.01E-06
Kr-87	3.59E-04	3.75E-04
Kr-88	9.22E-04	9.58E-04
Kr-89	8.90E-04	9.31E-04
Kr-90	6.39E-04	6.74E-04
Xe-131m	1.41E-06	1.48E-06
Xe-133m	1.54E-05	1.79E-05
Xe-133	1.17E-05	1.21E-05
Xe-135m	1.97E-04	2.10E-04
Xe-135	1.10E-04	1.17E-04
Xe-137	9.11E-05	9.71E-05
Xe-138	5.14E-04	5.37E-04
Ar-41	5.94E-04	6.25E-04

* Values calculated in accordance with methodologies presented in Section 5.2.1 of Reference 1 and Appendix F of Reference 3, with meteorological joint frequency distributions presented in Reference 5, Appendix E, Table E.4-7.

** $\frac{\text{mrem-sec}}{\mu\text{Ci-yr}}$

*** $\frac{\text{mrad-sec}}{\mu\text{Ci-yr}}$

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2.2 GASEOUS EFFLUENT DOSE RATE AND DOSE CALCULATIONS

2.2.1 Unrestricted Area Boundary Dose Rates

2.2.1.a Dose Rates Due To Noble Gases

For the purpose of implementation of RETS 3.15.2.1.a (Unit 1) and 3.11.2.1.a (Unit 2), the dose rate in the unrestricted area due to noble gases shall be calculated as follows:

D_t = the total body dose rate at time of release (mrem/yr).

$$= \left[\sum_v (\overline{X/Q})_G \sum_i K_i \, Q_{iv} \right] + \left[\sum_i V_i \, Q_{is} \right] \quad (9)$$

D_s = the skin dose rate at time of release (mrem/yr).

$$= \left[\sum_v (\overline{X/Q})_G \sum_i (L_i + 1.1 \, M_i) \, Q_{iv} \right] + \left[\sum_i (L_i (\overline{X/Q})_E + 1.1 \, B_i) \, Q_{is} \right] \quad (10)$$

Terms were defined previously in Section 2.1.1 and 2.1.2.

The dose rate limits are site limits at any point in time; therefore, dose rates are summed over all releases occurring simultaneously. For Plant Hatch the three vent releases are:

- Unit 1 reactor building vent stack.
- Unit 2 reactor building vent stack.
- Unit 1 recombiner building vent.

The only elevated release is the main stack which serves both units. Simultaneous releases may include any combination of these four release points.

2.2.1.b Dose Rates Due to Radioiodines, Tritium, and Particulates

For the purpose of implementing RETS 3.15.2.1.b (Unit 1) and 3.11.2.1.b (Unit 2), organ dose rates due to radioiodines, tritium, and all radioactive materials in particulate form with half-lives greater than 8 days are required to be calculated for the inhalation pathway for the child age group. The child age group would experience the highest potential dose rate via the inhalation pathway. In accordance with Appendix C to Reference 3, noble gases are excluded from these calculations. These dose rates are calculated as follows:

D_o = the organ dose rate at time of release (mrem/yr).

$$= \left[\sum_{v} (\overline{X/Q})_G \sum_{i} P_{io} Q'_{iv}\right] + \left[(\overline{X/Q})_E \sum_{i} P_{io} Q'_{is}\right] \quad (11)$$

where:

$(\overline{X/Q})_G$ = defined in Section 2.1.1.

$(\overline{X/Q})_E$ = defined in Section 2.1.2.

Q'_{iv} = the release rate (μCi/sec) of radioiodines, tritium, and particulates (required by RETS 3.15.2.1 (Unit 1) and 3.11.2.1 (Unit 2) from the Unit 1 reactor building vent stack, the Unit 2 reactor building vent stack, and the Unit 1 recombiner building vent.

Q'_{is} = the release rate (μCi/sec) of radioiodines, tritium, and particulates (required by RETS 3.15.2.1 (Unit 1) and 3.11.2.1 (Unit 2) from the main stack.

P_{io} = the organ dose parameter for organ o and radionuclide i (mrem/yr per $\mu Ci/m^3$) for inhalation determined as follows:

$$P_{io} = K\ (BR)\ DF_{io} \qquad (12)$$

and where:

K = the constant of unit conversion, 10^6 pCi/μCi.

BR = the breathing rate for child age group ($3700\ m^3$/year), Table 2.2-10, from Reference 3.

DF_{io} = the inhalation pathway dose factor for child age group for organ o and radionuclide i, Table 2.2-2, from Reference 3.

NOTE: In order to assure that potential dose rates (prerelease) to an organ due to radioiodine, tritium, and particulates in simultaneous gaseous releases from the site do not exceed 1500 mrem/yr as specified in RETS 3.15.2.1(b) (Unit 1) and 3.11.2.1(b) (Unit 2), the potential organ dose rate D_o must be limited as follows:

$$D_o \div (AG \times SF) \leq 1500 \text{ mrem/yr} \qquad (13)$$

where: AG and SF are assigned the same values as were used in Section 2.1 for the release source pathway under consideration. To further ensure that dose rate limits were not exceeded, (post-release) dose rates from simultaneous releases shall be summed, as shown above.

2.2.2 Unrestricted Area Air Dose and Dose to Individual

2.2.2.a Air Dose in Unrestricted Area

For the purpose of implementation of RETS 3.15.2.2 (Unit 1) and 3.11.2.2 (Unit 2), and 3.15.2.4 (Unit 1) and 3.11.2.4 (Unit 2), the air dose in unrestricted areas shall be determined as follows:

D_γ = the air dose due to gamma emissions from noble gas radionuclides (mrad).

$$= 3.17 \times 10^{-8} \left[\left[\sum_v (\overline{X/Q})_G \sum_i M_i \tilde{Q}_{iv} \right] + \left[\sum_i B_i \tilde{Q}_{is} \right] \right] \quad (14)$$

where:

3.17×10^{-8} = the fraction of 1 yr per 1 sec.

$\tilde{Q}_{iv}$ = the cumulative release of noble gas radionuclide i over the period of interest (μCi) from the vent release under consideration.

$\tilde{Q}_{is}$ = the cumulative release of noble gas radionuclide i over the period of interest (μCi) from the main stack.

M_i = defined previously in Section 2.1.1.

B_i = defined previously in Section 2.1.2.

$(\overline{X/Q})_G$ = defined previously in Section 2.1.1.

D_β = the air dose due to beta emissions from noble gas radionuclides (mrad).

$$= 3.17 \times 10^{-8} \left[\left[\sum_v (\overline{X/Q})_G \sum_i N_i \tilde{Q}_{iv} \right] + \left[(\overline{X/Q})_E \sum_i N_i \tilde{Q}_{is} \right] \right] \quad (15)$$

where:

N_i = the air dose factor due to beta emissions from noble gas radionuclide i (mrad/yr per $\mu Ci/m^3$) from Table 2.1-1.

$(\overline{X/Q})_E$ = defined previously in Section 2.1.2.

2.2.2.b Dose to An Individual In Unrestricted Area

Dose to an individual from radioiodines, tritium, and radioactive materials in particulate form will be calculated for the purpose of implementation of RETS 3.15.2.3 and 3.15.2.4 (Unit 1), and 3.11.2.3 and 3.11.2.4 (Unit 2). In accordance with Appendix C of Reference 3, noble gases are excluded from these dose calculations. Doses to an individual are calculated as follows:

NOTE: At Plant Hatch the controlling receptor is an individual in the infant age group, located in the NNE sector at a distance of 3.2 miles, exposed to inhalation, ground-plane, and grass-cow-milk pathways.

D_j = dose to an organ j of an individual in age group a from radioiodines, tritium, and radionuclides in particulate f[illegible] with half-lives greater than 8 days (mrem).

$$= 3.17 \times 10^{-8} \sum_{pi} R_{aipj} [W'_{vp} \tilde{Q}'_{iv} + W'_{sp} \tilde{Q}'_{is}] \quad (16)$$

where:

3.17×10^{-8} = the fraction of 1 yr per 1 sec.

W_{vp}' = the pathway-dependent relative dispersion or deposition in the unrestricted area at the location of the controlling receptor, associated with plant vent releases.

W_{vp}' =

$(\overline{X/Q'})_{vp}$ = the annual average relative dispersion parameter for location of controlling (critical) receptor for plant vent releases. $(\overline{X/Q'})_{vp}$ applies only to inhalation and all tritium pathways. (For all tritium pathways, the $\tilde{Q}_i'$ source term is limited to tritium.)

= 6.1×10^{-7} sec/m^3 in the NNE sector for inhalation and all tritium pathways.

$(\overline{D/Q'})_{vp}$ = the annual average deposition parameter for the location of controlling (critical) receptor for plant vent releases. $(\overline{D/Q'})_{vp}$ applies to all other pathways.

= 1.9×10^{-9} m^{-2} in NNE sector for all other pathways.

W_{sp}' = the pathway-dependent relative dispersion or deposition in the unrestricted area at the location of the controlling receptor, associated with main stack releases.

W_{sp}' =

$(\overline{X/Q'})_{sp}$ = the annual average relative dispersion parameter for location of controlling (critical) receptor for main stack releases. $(\overline{X/Q'})_{sp}$ applies only to inhalation and all tritium pathways. (For all tritium pathways, the $\tilde{Q}_i'$ source term is limited to tritium.)

= 4.2×10^{-8} sec/m^3 in the NNE sector for inhalation and all tritium pathways.

$(\overline{D/Q'})_{sp}$ = the annual average deposition parameter for the location of controlling (critical) receptor for main stack releases. $(\overline{D/Q'})_{sp}$ applies to all other pathways.

= 6.9×10^{-10} m^{-2} in NNE sector for all other pathways.

The selection of the dispersion or deposition parameter, X/Q or D/Q, is dependent upon the pathway being considered. The dispersion parameter, X/Q, is required for the inhalation pathway. The deposition parameter, D/Q, is required for the ground-plane pathway and the grass-cow-milk pathway. However, since tritium is taken up by vegetation directly from surrounding air, X/Q is required for tritium contributions from the grass-cow-milk pathway.

$\tilde{Q}_{iv}'$ = the cumulative release (μCi), from plant vent releases, of radionuclide i as required by RETS 3.15.2.3 (Unit 1) and 3.11.2.3 (Unit 2) over the period of interest. Dose determinations required by RETS 3.15.2.3 and 3.11.2.3 are on a per reactor basis; therefore, cumulative release quantities must also be reactor-specific. (For dose contributions due to tritium from the grass-cow-milk pathway, the Q_{iv}' term is limited to tritium.)

$\tilde{Q}_{is}'$ = the cumulative release (μCi), from the main stack releases, of radionuclide i as required by RETS 3.15.2.3 (Unit 1) and 3.11.2.3 (Unit 2) over the period of interest. Dose determinations required by RETS 3.15.2.3 and 3.11.2.3 are on a per reactor basis; therefore, cumulative release quantities must also be reactor-specific. Since the main stack serves both reactors, release quantities must be apportioned between the two units. In absence of evidence that one reactor contributes a greater quantity of radioactivity than the other over the period of interest, release quantities may be apportioned equally between the two units.

R_{aipj} = the pathway-specific, individual age-specific organ dose factor for radionuclide i, pathway p, organ j, and individual age group a. Routine individual dose calculations address the inhalation, ground-plane, grass-cow (or goat)-milk, grass-cow-meat, and garden vegetation pathways. However, the dose pathways actually present at the controlling location, as well as the controlling individual age group, are determined through the Land Use Census for the site. Pathway factors Raipj are determined as shown in the following subsections.

As stated earlier, the controlling receptor for Plant Hatch is an infant exposed to inhalation, ground-plane, and grass-cow-milk pathways.

Plant Hatch site-specific values, or appropriate default values, required in the pathway factor determinations for the critical receptor are presented in Table 2.2-12.

Inhalation Pathway Factor

$R_{aipj} = K'(BR)_a (DFA_{ij})_a$ (mrem/yr per μCi/m³)

where:

K' = the constant of unit conversion, 10^6 pCi/μCi.

$(BR)_a$ = the breathing rate for a particular age group, in m³/yr, from Table 2.2-10.

DFA_{ija} = the inhalation dose factor for receptor age group a, organ j, and for radionuclide i, in mrem/pCi, from Tables 2.2-1 through 2.2-4.

Ground-Plane Pathway Factor

$R_{aipj} = K'K'' (SF')(DFG_{ij}) \left((1-e^{-\lambda_i t})/\lambda_i\right)$ (m²mrem/yr per μCi/sec)

where:

K' = the constant of unit conversion, 10^6 pCi/μCi.

K'' = the constant of unit conversion, 8760 hr/yr.

SF' = the shielding factor, 0.7 (dimensionless).

DFG_{ij} = the ground-plane dose conversion factor for radionuclide i (same for all age groups and specific organs are assumed to receive the same dose as the total body), in mrem/hr per pCi/m², from Table 2.2-9.

λ_i = the decay constant for radionuclide i.

t = the exposure time, 4.73 x 10^8 sec (15 yr).

<u>Grass-Cow-Milk Pathway Factor</u>

$$R_{aipj} = K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_m(r)(DFL_{ij})_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f} \qquad (17)$$

(m^2mrem/yr per µCi/sec)

where:

K' = a constant of unit conversion, 10^6 pCi/µCi.

Q_F = the cow's consumption rate, in kg/day (wet weight).

U_{ap} = the receptor's milk consumption rate for age group a, in liters/yr, from Table 2.2-10.

Y_p = the agricultural productivity by unit area of pasture grass, in kg/m².

Y_s = the agricultural productivity by unit area of stored feed, in kg/m².

F_m = the stable element transfer coefficients, in days/liter. (See Table 2.2-11.)

r = fraction of deposited activity retained on feed grass (1.0 for radioiodines; 0.2 for particulates).

$(DFL_{ij})_a$ = the organ ingestion dose factor for the ith radionuclide for the receptor in age group a, in mrem/pCi, from Tables 2.2-5 through 2.2-8.

λ_i = the decay constant for the ith radionuclide, in sec^{-1}.

λ_w = the decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73×10^{-7} sec^{-1} (corresponding to a 14-day half-life).

t_f = the transport time from pasture to cow, to milk, to receptor, in sec, (1.73×10^5).

t_h = the transport time from pasture, to harvest, to cow, to milk, to receptor, in sec, (7.78×10^6).

f_p = fraction of the year that the cow is on pasture (dimensionless).

f_s = fraction of the cow feed that is pasture grass while the cow is on pasture (dimensionless).

For tritium in milk, the grass-cow-milk pathway factor is a special case due to the fact that the concentration of tritium in milk is based on airborne concentration rather than deposition:

$$R_{aipj} = K'K'''F_m Q_F U_{ap}(DFL_{ij})_a \, [0.75(0.5/H)] \text{ (mrem/yr per } \mu Ci/m^3) \quad (18)$$

where:

K''' = a constant of unit conversion, 10^3 gm/kg.

H = the absolute humidity of the atmosphere, in gm/m^3.

0.75 = the fraction of total feed that is water.

0.5 = the ratio of the specific activity of the feed grass water to the atmospheric water.

Other parameters and values as previously defined.

2.2.2.c Dose Calculations To Support Other Specific Technical Specifications

In the event radiological impact assessment becomes necessary to implement RETS 6.9.1.12 or 6.9.1.13, dose calculations will be performed using the equations in Section 2.2.2.c, with the substitution of average meteorological parameters for the period of the report and the appropriate pathway receptor dose factors (R_{aipj}).

For the purpose of implementing RETS 3.16.2, dose calculations may be performed using the equations in Section 2.2.2.c, substituting the appropriate pathway receptor dose factor (R_{aipj}) and the appropriate dispersion parameters for the location(s) of interest. Annual average dispersion parameters may be used for these calculations.

The receptor for which dose calculations may be required in order to implement RETS 6.9.1.12, 6.9.1.13, or 3.16.2 may not be the previously identified critical receptor. The receptor age group and exposure pathways present (and applicable) at the location of interest must be determined. In addition to the inhalation, ground-plane, and grass-cow-milk pathways presented in Section 2.2.2.b, it may be necessary to consider the grass-cow-meat and/or the garden vegetation pathways. The equations for calculating the pathway factors R_{aipj} for these two additional pathways are presented below. Historically, milk goats have not been present within 5 miles of Plant Hatch. However, in order to facilitate implementation of RETS 3.16.2 in the event milk goats are located within 5 miles of Plant Hatch, the equation for calculating the grass-goat-milk pathway factor is also presented. Plant Hatch site-specific values, or appropriate default values, required in the pathway factor determinations are presented in Table 2.2-13.

Grass-Cow-Meat Pathway Factor

$$R_{aipj} = K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_f(r)(DFL_{ij})_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f} \quad (19)$$

(m^2mrem/yr per μCi/sec)

where:

K' = a constant of unit conversion, 10^6 pCi/μCi.

Q_F = the cow's consumption rate, in kg/day (wet weight).

U_{ap} = the receptor's meat consumption rate for age group a, in kg/yr, from Table 2.2-10.

Y_p = the agricultural productivity by unit area of pasture feed grass, in kg/m^2.

Y_s = the agricultural productivity by unit area of stored feed, in kg/m^2.

F_f = the stable element transfer coefficients, in days/kg. (See Table 2.2-11.)

r = the fraction of deposited activity retained on feed grass (1.0 for radioiodines; 0.2 for particulates).

$(DFL_{ij})_a$ = the organ ingestion dose factor for the ith radionuclide for the receptor in age group a, in mrem/pCi, from Tables 2.2-5 through 2.2-8.

λ_i = the decay constant for the ith radionuclide, in sec^{-1}.

λ_w = the decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73×10^{-7} sec^{-1} (corresponding to a 14-day half-life).

t_f = the transport time from pasture to cow, to meat, to receptor, in sec, (1.73×10^6).

t_h = the transport time from pasture to harvest, to cow, to meat, to receptor, in sec, (7.78×10^6).

f_p = fraction of the year that the cow is on pasture (dimensionless).

f_s = fraction of the cow feed that is pasture grass while the cow is on pasture (dimensionless).

For tritium in meat, the grass-cow-meat pathway factor is a special case due to the fact that the concentration of tritium in meat is based on airborne concentration rather than deposition:

$$R_{aipj} = K'K'''F_f Q_F U_{ap}(DFL_{ij})_a\ [0.75(0.5/H)]\ \text{(mrem/yr per } \mu Ci/m^3) \quad (20)$$

where:

K''' = a constant of unit conversion, 10^3 gm/kg.

H = absolute humidity of the atmosphere, in gm/m^3.

0.75 = the fraction of total feed that is water.

0.5 = the ratio of the specific activity of the feed grass water to the atmospheric water.

Other parameters and values are given above.

Vegetation Pathway Factor

$$R_{aipj} = K' \frac{r}{Y_v(\lambda_i + \lambda_w)} (DFL_{ij})_a \left[U_{a\ell} f_\ell e^{-\lambda_i t_\ell} + U_{as} f_g e^{-\lambda_i t_h} \right] \qquad (21)$$

where:

K' = a constant of unit conversion, 10^6 pCi/μCi.

$U_{a\ell}$ = the consumption rate of fresh leafy vegetation by the receptor in age group a, in kg/yr. (See Table 2.2-10.)

U_{as} = the consumption rate of stored vegetation by the receptor in age group a, in kg/yr. (See Table 2.2-10.)

f_ℓ = the fraction of the annual intake of fresh leafy vegetation grown locally.

f_g = the fraction of the annual intake of stored vegetation grown locally.

t_ℓ = the average time between harvest of leafy vegetation and its consumption, in sec, (8.6×10^4).

t_h = the average time between harvest of stored vegetation and its consumption, in sec, (5.18×10^6).

Y_v = the vegetation areal density, in kg/m².

$(DFL_{ij})_a$ = the organ ingestion dose factor for the ith radionuclide for the receptor in age group a, in mrem/pCi, from Tables 2.2-5 through 2.2-8.

λ_i = the decay constant for the ith radionuclide, in sec^{-1}.

λ_w = the decay constant for removal of activity on leaf and plant surfaces by weathering, 5.7J x 10^{-7}, in sec^{-1} (corresponding to a 14-day half-life).

For tritium in vegetation, the vegetation pathway factor is a special case due to the fact that the concentration of tritium in vegetation is based on airborne concentration rather than deposition:

$$R_{aipj} = K'K'''(U_{a\ell}f_\ell + U_{as}f_g)\,(DFL_{ij})_a\,[0.75(0.5/H)] \text{ (mrem/yr per } \mu Ci/m^3) \quad (22)$$

where:

K''' = a constant of unit conversion, 10^3 gm/kg.

H = absolute humidity of the atmosphere, in gm/m^3.

0.75 = the fraction of total vegetation that is water.

0.5 = the ratio of the specific activity of the vegetation water to the atmospheric water.

Other parameters and values are given above.

Grass-Goat-Milk Pathway Factor

$$R_{aipj} = K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_m(r)(DFL_{ij})_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f} \quad (19)$$

(m^2mrem/yr per μCi/sec)

where:

K' = a constant of unit conversion, 10^6 pCi/μCi.

Q_F = the goat's consumption rate, in kg/day (wet weight).

U_{ap} = the receptor's milk consumption rate for age group a, in liters/yr, from Table 2.2-10.

Y_p = the agricultural productivity by unit area of pasture feed grass, in kg/m^2.

Y_s = the agricultural productivity by unit area of stored feed, in kg/m^2.

F_m = the stable element transfer coefficients, in days/liter. (See Table 2.2-11.)

r = fraction of deposited activity retained on feed grass (1.0 for radioiodines; 0.2 for particulates).

$(DFL_{ij})_a$ = the organ ingestion dose factor for the ith radionuclide for the receptor in age group a, in mrem/pCi, from Tables 2.2-5 through 2.2-8.

λ_i the decay constant for the ith radionuclide, in sec^{-1}.

λ_w = the decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73×10^{-7}, in sec^{-1} (corresponding to a 14-day half-life).

t_f = the transport time from pasture to goat, to milk, to receptor, in sec (1.73×10^5).

t_h = the transport time from pasture, to harvest, to goat, to milk, to receptor, in sec (7.78×10^6).

f_p = the fraction of the year that the goat is on pasture (dimensionless).

f_s = the fraction of the goat feed that is pasture grass while the goat is on pasture (dimensionless).

For tritium in milk, the grass-goat-milk pathway factor is a special case due to the fact that the concentration of tritium in milk is based on airborne concentration rather than deposition:

$$R_{aipj} = K'K'''F_m Q_F U_{ap}(DFL_{ij})_a \, [0.75(0.5/H)] \text{ (mrem/yr per } \mu Ci/m^3) \quad (24)$$

where:

K''' = a constant of unit conversion, 10^3 gm/kg.

H = absolute humidity of the atmosphere, in gm/m^3.

0.75 = the fraction of total feed that is water.

0.5 = the ratio of the specific activity of the feed grass water to the atmospheric water.

Other parameters and values are given above.

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TABLE 2.2-1 (SHEET 1 OF 3)

INHALATION DOSE FACTORS FOR INFANT*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	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	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06
P-32	1.45E-03	8.03E-05	5.53E-05	No Data	No Data	No Data	1.15E-05
Cr-51	No Data	No Data	6.39E-08	4.11E-08	9.45E-09	9.17E-06	2.55E-07
Mn-54	No Data	1.81E-05	3.56E-06	No Data	3.56E-06	7.14E-04	5.04E-06
Mn-56	No Data	1.10E-09	1.58E-10	No Data	7.86E-10	8.95E-06	5.12E-05
Fe-55	1.41E-05	8.39E-06	2.38E-06	No Data	No Data	6.21E-05	7.82E-07
Fe-59	9.69E-06	1.68E-05	6.77E-06	No Data	No Data	7.25E-04	1.77E-05
Co-58	No Data	8.71E-07	1.30E-06	No Data	No Data	5.55E-04	7.95E-06
Co-60	No Data	5.73E-06	8.41E-06	No Data	No Data	3.22E-03	2.28E-05
Ni-63	2.42E-04	1.46E-05	8.29E-06	No Data	No Data	1.49E-04	1.73E-06
Ni-65	1.71E-09	2.03E-10	8.79E-11	No Data	No Data	5.80E-06	3.58E-05
Cu-64	No Data	1.34E-09	5.53E-10	No Data	2.84E-09	6.64E-06	1.07E-0[illegible]
Zn-65	1.38E-05	4.47E-05	2.22E-05	No Data	2.32E-05	4.62E-04	3.67E-05
Zn-69	3.85E-11	6.91E-11	5.13E-12	No Data	2.87E-11	1.05E-06	9.44E-06
Br-83	No Data	No Data	2.72E-07	No Data	No Data	No Data	LT E-24
Br-84	No Data	No Data	2.86E-07	No Data	No Data	No Data	LT E-24
Br-85	No Data	No Data	1.46E-08	No Data	No Data	No Data	LT E-24
Rb-86	No Data	1.36E-04	6.30E-05	No Data	No Data	No Data	2.17E-06
Rb-88	No Data	3.98E-07	2.05E-07	No Data	No Data	No Data	2.42E-07
Rb-89	No Data	2.29E-07	1.47E-07	No Data	No Data	No Data	4.87E-08
Sr-89	2.84E-04	No Data	8.15E-06	No Data	No Data	1.45E-03	4.57E-05
Sr-90	2.92E-02	No Data	1.85E-03	No Data	No Data	8.03E-03	9.36E-05
Sr-91	6.83E-08	No Data	2.47E-09	No Data	No Data	3.76E-05	5.24E-05
Sr-92	7.50E-09	No Data	2.79E-10	No Data	No Data	1.70E-05	1.00E-04
Y-90	2.35E-06	No Data	6.30E-08	No Data	No Data	1.92E-04	7.43E-05
Y-91M	2.91E-10	No Data	9.90E-12	No Data	No Data	1.99E-06	1.68E-06
Y-91	4.20E-04	No Data	1.12E-05	No Data	No Data	1.75E-03	5.02E-05
Y-92	1.17E-08	No Data	3.29E-10	No Data	No Data	1.75E-05	9.04E-05

*Reference 3, Table E-10.

TABLE 2.2-1 (SHEET 2 OF 3)

INHALATION DOSE FACTORS FOR INFANT*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Y-93	1.07E-07	No Data	2.91E-09	No Data	No Data	5.46E-05	1.19E-04
Zr-95	8.24E-05	1.99E-05	1.45E-05	No Data	2.22E-05	1.25E-03	1.55E-05
Zr-97	1.07E-07	1.83E-08	8.36E-09	No Data	1.85E-08	7.88E-05	1.00E-04
Nb-95	1.12E-05	4.59E-06	2.70E-06	No Data	3.37E-06	3.42E-04	9.05E-06
Mo-99	No Data	1.18E-07	2.31E-08	No Data	1.89E-07	9.63E-05	3.48E-05
Tc-99M	9.98E-13	2.06E-12	2.66E-11	No Data	2.22E-11	5.79E-07	1.45E-06
Tc-101	4.65E-14	5.88E-14	5.80E-13	No Data	6.99E-13	4.17E-07	6.03E-07
Ru-103	1.44E-06	No Data	4.85E-07	No Data	3.03E-06	3.94E-04	1.15E-05
Ru-105	8.74E-10	No Data	2.93E-10	No Data	6.42E-10	1.12E-05	3.46E-05
Ru-106	6.20E-05	No Data	7.77E-06	No Data	7.61E-05	8.26E-03	1.17E-04
Ag-110M	7.13E-06	5.16E-06	3.57E-06	No Data	7.80E-06	2.62E-03	2.36E-05
Te-125M	3.40E-06	1.42E-06	4.70E-07	1.16E-06	No Data	3.19E-04	9.22E-06
Te-127M	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.68E-05	9.37E-04	1.95E-05
Te-127	1.59E-09	6.81E-10	3.49E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
Te-129M	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
Te-129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
Te-131M	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
Te-131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-06
Te-132	2.66E-07	1.69E-07	1.26E-07	1.99E-07	7.39E-07	2.43E-04	3.15E-05
I-130	4.54E-06	9.91E-06	3.[illegible]E-06	1.14E-03	1.09E-05	No Data	1.42E-06
I-131	2.71E-05	3.17E-05	1.40E-05	1.06E-02	3.70E-05	No Data	7.56E-07
I-132	1.21E-06	2.53E-06	8.99E-07	1.21E-04	2.82E-06	No Data	1.36E-06
I-133	9.46E-06	1.37E-05	4.00E-06	2.54E-03	1.60E-05	No Data	1.54E-06
I-134	6.58E-07	1.34E-06	4.75E-07	3.18E-05	1.49E-06	No Data	9.21E-07
I-135	2.76E-06	5.43E-06	1.98E-06	4.97E-04	6.05E-06	No Data	1.31E-06
Cs-134	2.83E-04	5.02E-04	5.32E-05	No Data	1.36E-04	5.69E-05	9.53E-07
Cs-136	3.45E-05	9.61E-05	3.78E-05	No Data	4.03E-05	8.40E-06	1.02E-06
Cs-137	3.92E-04	4.37E-04	3.25E-05	No Data	1.23E-04	5.09E-05	9.53E-07
Cs-138	3.61E-07	5.58E-07	2.84E-07	No Data	2.93E-07	4.67E-08	6.26E-07
Ba-139	1.06E-09	7.03E-13	3.07E-11	No Data	4.23E-13	4.25E-06	3.64E-05
Ba-140	4.00E-05	4.00E-08	2.07E-06	No Data	9.59E-09	1.14E-03	2.74E-05
Ba-141	1.12E-10	7.70E-14	3.55E-12	No Data	4.64E-14	2.12E-06	3.39E-06
Ba-142	2.84E-11	2.36E-14	1.40E-12	No Data	1.36E-14	1.11E-06	4.95E-07
La-140	3.61E-07	1.43E-07	3.68E-08	No Data	No Data	1.20E-04	5.06E-05

*Reference 3, Table E-10.

TABLE 2.2-1 (SHEET 3 OF 3)

INHALATION DOSE FACTORS FOR INFANT*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
La-142	7.36E-10	2.63E-10	6.46E-11	No Data	No Data	5.87E-06	4.25E-05
Ce-141	1.98E-05	1.19E-05	1.42E-06	No Data	3.75E-06	3.69E-04	1.54E-05
Ce-143	2.09E-07	1.38E-07	1.58E-08	No Data	4.03E-08	8.30E-05	3.55E-05
Ce-144	2.28E-03	8.65E-04	1.26E-04	No Data	3.84E-04	7.03E-03	1.06E-04
Pr-143	1.00E-05	3.74E-06	4.99E-07	No Data	1.41E-06	3.09E-04	2.66E-05
Pr-144	3.42E-11	1.32E-11	1.72E-12	No Data	4.80E-12	1.15E-06	3.06E-06
Nd-147	5.67E-06	5.81E-06	3.57E-07	No Data	2.25E-06	2.30E-04	2.23E-05
W-187	9.26E-09	6.44E-09	2.23E-09	No Data	No Data	2.83E-05	2.54E-05
Np-239	2.65E-07	2.37E-08	1.34E-08	No Data	4.73E-08	4.25E-05	1.78E-05

*Reference 3, Table E-10.

TABLE 2.2-2 (SHEET 1 OF 3)

INHALATION DOSE FACTORS FOR CHILD*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	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	No Data	No Data	No Data	1.14E-05
Cr-51	No Data	No Data	4.17E-08	2.31E-08	6.57E-09	4.59E-06	2.93E-07
Mn-54	No Data	1.16E-05	2.57E-06	No Data	2.71E-06	4.26E-04	6.19E-06
Mn-56	No Data	4.48E-10	8.43E-11	No Data	4.52E-10	3.55E-06	3.33E-05
Fe-55	1.28E-05	6.80E-06	2.10E-06	No Data	No Data	3.00E-05	7.75E-07
Fe-59	5.59E-06	9.04E-06	4.51E-06	No Data	No Data	3.43E-04	1.91E-05
Co-58	No Data	4.79E-07	8.55E-07	No Data	No Data	2.99E-04	9.29E-06
Co-60	No Data	3.55E-06	6.12E-06	No Data	No Data	1.91E-03	2.60E-05
Ni-63	2.22E-04	1.25E-05	7.56E-06	No Data	No Data	7.43E-05	1.71E-06
Ni-65	8.08E-10	7.99E-11	4.44E-11	No Data	No Data	2.21E-06	2.27E-05
Cu-64	No Data	5.39E-10	2.90E-10	No Data	1.63E-09	2.59E-06	9.92E-06
Zn-65	1.15E-05	3.06E-05	1.90E-05	No Data	1.93E-05	2.69E-04	4.41E-06
Zn-69	1.81E-11	2.61E-11	2.41E-12	No Data	1.58E-11	3.84E-07	2.75E-06
Br-83	No Data	No Data	1.28E-07	No Data	No Data	No Data	LT E-24
Br-84	No Data	No Data	1.48E-07	No Data	No Data	No Data	LT E-24
Br-85	No Data	No Data	6.84E-09	No Data	No Data	No Data	LT E-24
Rb-86	No Data	5.36E-05	3.09E-05	No Data	No Data	No Data	2.16E-06
Rb-88	No Data	1.52E-07	9.90E-08	No Data	No Data	No Data	4.66E-09
Rb-89	No Data	9.33E-08	7.83E-08	No Data	No Data	No Data	5.11E-10
Sr-89	1.62E-04	No Data	4.66E-06	No Data	No Data	5.83E-04	4.52E-05
Sr-90	2.73E-02	No Data	1.74E-03	No Data	No Data	3.99E-03	9.28E-05
Sr-91	3.28E-08	No Data	1.24E-09	No Data	No Data	1.44E-05	4.70E-05
Sr-92	3.54E-09	No Data	1.42E-10	No Data	No Data	6.49E-06	6.55E-05
Y-90	1.11E-06	No Data	2.99E-08	No Data	No Data	7.07E-05	7.24E-05
Y-91M	1.37E-10	No Data	4.98E-12	No Data	No Data	7.60E-07	4.64E-07
Y-91	2.47E-04	No Data	6.59E-06	No Data	No Data	7.10E-04	4.97E-05
Y-92	5.50E-09	No Data	1.57E-10	No Data	No Data	6.46E-06	6.46E-05

*Reference 3, Table E-9.

TABLE 2.2-2 (SHEET 2 OF 3)

INHALATION DOSE FACTORS FOR CHILD*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Y-93	5.04E-08	No Data	1.38E-09	No Data	No Data	2.01E-05	1.05E-04
Zr-95	5.13E-05	1.13E-05	1.00E-05	No Data	1.61E-05	6.03E-04	1.65E-05
Zr-97	5.07E-08	7.34E-09	4.32E-09	No Data	1.05E-08	3.06E-05	9.49E-05
Nb-95	6.35E-06	2.48E-06	1.77E-06	No Data	2.33E-06	1.66E-04	1.00E-05
Mo-99	No Data	4.66E-08	1.15E-08	No Data	1.06E-07	3.66E-05	3.42E-05
Tc-99M	4.81E-13	9.41E-13	1.56E-11	No Data	1.37E-11	2.57E-07	1.30E-06
Tc-101	2.19E-14	2.30E-14	2.91E-13	No Data	3.92E-13	1.58E-07	4.41E-09
Ru-103	7.55E-07	No Data	2.90E-07	No Data	1.90E-06	1.79E-04	1.21E-05
Ru-105	4.13E-10	No Data	1.50E-10	No Data	3.63E-10	4.30E-06	2.69E-05
Ru-106	3.68E-05	No Data	4.57E-06	No Data	4.97E-05	3.87E-03	1.16E-04
Ag-110M	4.56E-06	3.08E-06	2.47E-06	No Data	5.74E-06	1.48E-03	2.71E-05
Te-125M	1.82E-06	6.29E-07	2.47E-07	5.20E-07	No Data	1.29E-04	9.13E-06
Te-127M	6.72E-06	2.31E-06	8.16E-07	1.64E-06	1.72E-05	4.00E-04	1.93E-05
Te-127	7.49E-10	2.57E-10	1.65E-10	5.30E-10	1.91E-09	2.71E-06	1.52E-05
Te-129M	5.19E-06	1.85E-06	8.22E-07	1.71E-06	1.36E-05	4.76E-04	4.91E-05
Te-129	2.64E-11	9.45E-12	6.44E-12	1.93E-11	6.94E-11	7.93E-07	6.89E-06
Te-131M	3.63E-08	1.60E-08	1.37E-08	2.64E-08	1.08E-07	5.56E-05	8.32E-05
Te-131	5.87E-12	2.28E-12	1.78E-12	4.59E-12	1.59E-11	5.55E-07	3.60E-07
Te-132	1.30E-07	7.36E-08	7.12E-08	8.58E-08	4.79E-07	1.02E-04	3.72E-05
I-130	2.21E-06	4.43E-06	2.28E-06	4.99E-04	6.61E-06	No Data	1.38E-06
I-131	1.30E-05	1.30E-05	7.37E-06	4.39E-03	2.13E-05	No Data	7.68E-07
I-132	5.72E-07	1.10E-06	5.07E-07	5.23E-05	1.69E-06	No Data	8.65E-07
I-133	4.48E-06	5.49E-06	2.08E-06	1.04E-03	9.13E-06	No Data	1.48E-06
I-134	3.17E-07	5.84E-07	2.69E-07	1.37E-05	8.92E-07	No Data	2.58E-07
I-135	1.33E-06	2.36E-06	1.12E-06	2.14E-04	3.62E-06	No Data	1.20E-06
Cs-134	1.76E-04	2.74E-04	6.07E-05	No Data	8.93E-05	3.27E-05	1.04E-06
Cs-136	1.76E-05	4.62E-05	3.14E-05	No Data	2.58E-05	3.93E-06	1.13E-06
Cs-137	2.45E-04	2.23E-04	3.47E-05	No Data	7.63E-05	2.81E-05	9.78E-07
Cs-138	1.71E-07	2.27E-07	1.50E-07	No Data	1.68E-07	1.84E-08	7.29E-08
Ba-139	4.98E-10	2.66E-13	1.45E-11	No Data	2.33E-13	1.56E-06	1.56E-05
Ba-140	2.00E-05	1.75E-08	1.17E-06	No Data	5.71E-09	4.71E-04	2.75E-05
Ba-141	5.29E-11	2.95E-14	1.72E-12	No Data	2.56E-14	7.89E-07	7.44E-08
Ba-142	1.35E-11	9.73E-15	7.54E-13	No Data	7.87E-15	4.44E-07	7.41E-10
La-140	1.74E-07	6.08E-08	2.04E-08	No Data	No Data	4.94E-05	6.10E-05

*Reference 3, Table E-9.

TABLE 2.2-2 (SHEET 3 OF 3)

INHALATION DOSE FACTORS FOR CHILD*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
La-142	3.50E-10	1.11E-10	3.49E-11	No Data	No Data	2.35E-06	2.05E-05
Ce-141	1.06E-05	5.28E-06	7.83E-07	No Data	2.31E-06	1.47E-04	1.53E-05
Ce-143	9.89E-08	5.37E-08	7.77E-09	No Data	2.26E-08	3.12E-05	3.44E-05
Ce-144	1.83E-03	5.72E-04	9.77E-05	No Data	3.17E-04	3.23E-03	1.05E-04
Pr-143	4.99E-06	1.50E-06	2.47E-07	No Data	8.11E-07	1.17E-04	2.63E-05
Pr-144	1.61E-11	4.99E-12	8.10E-13	No Data	2.64E-12	4.23E-07	5.32E-08
Nd-147	2.92E-06	2.36E-06	1.84E-07	No Data	1.30E-06	8.87E-05	2.22E-05
W-187	4.41E-09	2.61E-09	1.17E-09	No Data	No Data	1.11E-05	2.46E-05
Np-239	1.26E-07	9.04E-09	6.35E-09	No Data	2.63E-08	1.57E-05	1.73E-05

*Reference 3, Table E-9.

TABLE 2.2-3 (SHEET 1 OF 3)

INHALATION DOSE FACTORS FOR TEENAGER*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	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-06	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	No Data	No Data	No Data	1.16E-05
Cr-51	No Data	No Data	1.69E-08	9.37E-09	3.84E-09	2.62E-06	3.75E-07
Mn-54	No Data	6.39E-06	1.05E-06	No Data	1.59E-06	2.48E-04	8.35E-06
Mn-56	No Data	2.12E-10	3.15E-11	No Data	2.24E-10	1.90E-06	7.18E-06
Fe-55	4.18E-06	2.98E-06	6.93E-07	No Data	No Data	1.55E-05	7.99E-07
Fe-59	1.99E-06	4.62E-06	1.79E-06	No Data	No Data	1.91E-04	2.23E-05
Co-58	No Data	2.59E-07	3.47E-07	No Data	No Data	1.68E-04	1.19E-05
Co-60	No Data	1.89E-06	2.48E-06	No Data	No Data	1.09E-03	3.24E-05
Ni-63	7.25E-05	5.43E-06	2.47E-06	No Data	No Data	3.84E-05	1.77E-06
Ni-65	2.73E-10	3.66E-11	1.59E-11	No Data	No Data	1.17E-06	4.59E-06
Cu-64	No Data	2.54E-10	1.06E-10	No Data	8.01E-10	1.39E-06	7.68E-06
Zn-65	4.82E-06	1.67E-05	7.80E-06	No Data	1.08E-05	1.55E-04	5.83E-06
Zn-69	6.04E-12	1.15E-11	8.07E-13	No Data	7.53E-12	1.98E-07	3.56E-08
Br-83	No Data	No Data	4.30E-08	No Data	No Data	No Data	LT E-24
Br-84	No Data	No Data	5.41E-08	No Data	No Data	No Data	LT E-24
Br-85	No Data	No Data	2.29E-09	No Data	No Data	No Data	LT E-24
Rb-86	No Data	2.38E-05	1.05E-05	No Data	No Data	No Data	2.21E-06
Rb-88	No Data	6.82E-08	3.40E-08	No Data	No Data	No Data	3.65E-15
Rb-89	No Data	4.40E-08	2.91E-08	No Data	No Data	No Data	4.22E-17
Sr-89	5.43E-05	No Data	1.56E-06	No Data	No Data	3.02E-04	4.64E-05
Sr-90	1.35E-02	No Data	8.35E-04	No Data	No Data	2.06E-03	9.56E-05
Sr-91	1.10E-08	No Data	4.39E-10	No Data	No Data	7.59E-06	3.24E-05
Sr-92	1.19E-09	No Data	5.08E-11	No Data	No Data	3.43E-06	1.49E-05
Y-90	3.73E-07	No Data	1.00E-08	No Data	No Data	3.66E-05	6.99E-05
Y-91M	4.63E-11	No Data	1.77E-12	No Data	No Data	4.00E-07	3.77E-09
Y-91	8.26E-05	No Data	2.21E-06	No Data	No Data	3.67E-04	5.11E-05
Y-92	1.84E-09	No Data	5.36E-11	No Data	No Data	3.35E-06	2.06E-05

*Reference 3, Table E-8.

TABLE 2.2-3 (SHEET 2 OF 3)

INHALATION DOSE FACTORS FOR TEENAGER*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Y-93	1.69E-08	No Data	4.65E-10	No Data	No Data	1.04E-05	7.24E-05
Zr-95	1.82E-05	5.73E-06	3.94E-06	No Data	8.42E-06	3.36E-04	1.86E-05
Zr-97	1.72E-08	3.40E-09	1.57E-09	No Data	5.15E-09	1.62E-05	7.88E-05
Nb-95	2.32E-06	1.29E-06	7.08E-07	No Data	1.25E-06	9.39E-05	1.21E-05
Mo-99	No Data	2.11E-08	4.03E-09	No Data	5.14E-08	1.92E-05	3.36E-05
Tc-99M	1.73E-13	4.83E-13	6.24E-12	No Data	7.20E-12	1.44E-07	7.66E-07
Tc-101	7.40E-15	1.05E-14	1.03E-13	No Data	1.90E-13	8.34E-08	1.09E-16
Ru-103	2.63E-07	No Data	1.12E-07	No Data	9.29E-07	9.79E-05	1.36E-05
Ru-105	1.40E-10	No Data	5.42E-11	No Data	1.76E-10	2.27E-06	1.13E-05
Ru-106	1.23E-05	No Data	1.55E-06	No Data	2.38E-05	2.01E-03	1.20E-04
Ag-110M	1.73E-06	1.64E-06	9.99E-07	No Data	3.13E-06	8.44E-04	3.41E-05
Te-125M	6.10E-07	2.80E-07	8.34E-08	1.75E-07	No Data	6.70E-05	9.38E-06
Te-127M	2.25E-06	1.02E-06	2.73E-07	5.48E-07	8.17E-06	2.07E-04	1.99E-05
Te-127	2.51E-10	1.14E-10	5.52E-11	1.77E-10	9.10E-10	1.40E-06	1.01E-05
Te-129M	1.74E-06	8.23E-07	2.81E-07	5.72E-07	6.49E-06	2.47E-04	5.06E-05
Te-129	8.87E-12	4.22E-12	2.20E-12	6.48E-12	3.32E-11	4.12E-07	2.02E-07
Te-131M	1.23E-08	7.51E-09	5.03E-09	9.06E-09	5.49E-08	2.97E-05	7.76E-05
Te-131	1.97E-12	1.04E-12	6.30E-13	1.55E-12	7.72E-12	2.92E-07	1.89E-09
Te-132	4.50E-08	3.63E-08	2.74E-08	3.07E-08	2.44E-07	5.61E-05	5.79E-05
I-130	7.80E-07	2.24E-06	8.96E-07	1.86E-04	3.44E-06	No Data	1.14E-06
I-131	4.43E-06	6.14E-06	3.30E-06	1.83E-03	1.05E-05	No Data	8.11E-07
I-132	1.99E-07	5.47E-07	1.97E-07	1.89E-05	8.65E-07	No Data	1.59E-07
I-133	1.52E-06	2.56E-06	7.78E-07	3.65E-04	4.49E-06	No Data	1.29E-06
I-134	1.11E-07	2.90E-07	1.05E-07	4.94E-06	4.58E-07	No Data	2.55E-09
I-135	4.62E-07	1.18E-06	4.36E-07	7.76E-05	1.86E-06	No Data	8.69E-07
Cs-134	6.28E-05	1.41E-04	6.86E-05	No Data	4.69E-05	1.83E-05	1.22E-06
Cs-136	6.44E-06	2.42E-05	1.71E-05	No Data	1.38E-05	2.22E-06	1.36E-06
Cs-137	8.38E-05	1.06E-04	3.89E-05	No Data	3.80E-05	1.51E-05	1.06E-06
Cs-138	5.82E-08	1.07E-07	5.58E-08	No Data	8.28E-08	9.84E-09	3.38E-11
Ba-139	1.67E-10	1.18E-13	4.87E-12	No Data	1.11E-13	8.08E-07	8.06E-07
Ba-140	6.84E-06	8.38E-09	4.40E-07	No Data	2.85E-09	2.54E-04	2.86E-05
Ba-141	1.78E-11	1.32E-14	5.93E-13	No Data	1.23E-14	4.11E-07	9.33E-14
Ba-142	4.62E-12	4.63E-15	2.84E-13	No Data	3.92E-15	2.39E-07	5.99E-20
La-140	5.99E-08	2.95E-08	7.82E-09	No Data	No Data	2.68E-05	6.09E-05

*Reference 3, Table E-8.

TABLE 2.2-3 (SHEET 3 OF 3)

INHALATION DOSE FACTORS FOR TEENAGER*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
La-142	1.20E-10	5.31E-11	1.32E-11	No Data	No Data	1.27E-06	1.50E-06
Ce-141	3.55E-06	2.37E-06	2.71E-07	No Data	1.11E-06	7.67E-05	1.58E-05
Ce-143	3.32E-08	2.42E-08	2.70E-09	No Data	1.08E-08	1.63E-05	3.19E-05
Ce-144	6.11E-04	2.53E-04	3.28E-05	No Data	1.51E-04	1.67E-03	1.08E-04
Pr-143	1.67E-06	6.64E-07	8.28E-08	No Data	3.86E-07	6.04E-05	2.67E-05
Pr-144	5.37E-12	2.20E-12	2.72E-13	No Data	1.26E-12	2.19E-07	2.94E-14
Nd-147	9.83E-07	1.07E-06	6.41E-08	No Data	6.28E-07	4.65E-05	2.28E-05
W-187	1.50E-09	1.22E-09	4.29E-10	No Data	No Data	5.92E-06	2.21E-05
Np-239	4.23E-08	3.99E-09	2.21E-09	No Data	1.25E-08	8.11E-06	1.65E-05

*Reference 3, Table E-8.

TABLE 2.2-4 (SHEET 1 OF 3)

INHALATION DOSE FACTORS FOR ADULT*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	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	No Data	No Data	No Data	1.08E-05
Cr-51	No Data	No Data	1.25E-08	7.44E-09	2.85E-09	1.80E-06	4.15E-07
Mn-54	No Data	4.95E-06	7.87E-07	No Data	1.23E-06	1.75E-04	9.67E-06
Mn-56	No Data	1.55E-10	2.29E-11	No Data	1.63E-10	1.18E-06	2.53E-06
Fe-55	3.07E-06	2.12E-06	4.93E-07	No Data	No Data	9.01E-06	7.54E-07
Fe-59	1.47E-06	3.47E-06	1.32E-06	No Data	No Data	1.27E-04	2.35E-05
Co-58	No Data	1.98E-07	2.59E-07	No Data	No Data	1.16E-04	1.33E-05
Co-60	No Data	1.44E-06	1.85E-06	No Data	No Data	7.46E-04	3.56E-05
Ni-63	5.40E-05	3.93E-06	1.81E-06	No Data	No Data	2.23E-05	1.67E-06
Ni-65	1.92E-10	2.62E-11	1.14E-11	No Data	No Data	7.00E-07	1.54E-06
Cu-64	No Data	1.83E-10	7.69E-11	No Data	5.78E-10	8.48E-07	6.12E-06
Zn-65	4.05E-06	1.29E-05	5.82E-06	No Data	8.62E-06	1.08E-04	6.68E-06
Zn-69	4.23E-12	8.14E-12	5.65E-13	No Data	5.27E-12	1.15E-07	2.04E-09
Br-83	No Data	No Data	3.01E-08	No Data	No Data	No Data	2.90E-08
Br-84	No Data	No Data	3.91E-08	No Data	No Data	No Data	2.05E-13
Br-85	No Data	No Data	1.60E-09	No Data	No Data	No Data	LT E-24
Rb-86	No Data	1.69E-05	7.37E-06	No Data	No Data	No Data	2.08E-06
Rb-88	No Data	4.84E-08	2.41E-08	No Data	No Data	No Data	4.18E-19
Rb-89	No Data	3.20E-08	2.12E-08	No Data	No Data	No Data	1.16E-21
Sr-89	3.80E-05	No Data	1.09E-06	No Data	No Data	1.75E-04	4.37E-05
Sr-90	1.24E-02	No Data	7.62E-04	No Data	No Data	1.20E-03	9.02E-05
Sr-91	7.74E-09	No Data	3.13E-10	No Data	No Data	4.56E-06	2.39E-05
Sr-92	8.43E-10	No Data	3.64E-11	No Data	No Data	2.06E-06	5.38E-06
Y-90	2.61E-07	No Data	7.01E-09	No Data	No Data	2.12E-05	6.32E-05
Y-91M	3.26E-11	No Data	1.27E-12	No Data	No Data	2.40E-07	1.66E-10
Y-91	5.78E-05	No Data	1.55E-06	No Data	No Data	2.13E-04	4.81E-05
Y-92	1.29E-09	No Data	3.77E-11	No Data	No Data	1.96E-06	9.19E-06

*Reference 3, Table E-7.

TABLE 2.2-4 (SHEET 2 OF 3)

INHALATION DOSE FACTORS FOR ADULT*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Y-93	1.18E-08	No Data	3.26E-10	No Data	No Data	6.06E-06	5.27E-05
Zr-95	1.34E-05	4.30E-06	2.91E-06	No Data	6.77E-06	2.21E-04	1.88E-05
Zr-97	1.21E-08	2.45E-09	1.13E-09	No Data	3.71E-09	9.84E-06	6.54E-05
Nb-95	1.76E-06	9.77E-07	5.26E-07	No Data	9.67E-07	6.31E-05	1.30E-05
Mo-99	No Data	1.51E-08	2.87E-09	No Data	3.64E-08	1.14E-05	3.10E-05
Tc-99M	1.29E-13	3.64E-13	4.63E-12	No Data	5.52E-12	9.55E-08	5.20E-07
Tc-101	5.22E-15	7.52E-15	7.38E-14	No Data	1.35E-13	4.99E-08	1.36E-21
Ru-103	1.91E-07	No Data	8.23E-08	No Data	7.29E-07	6.31E-05	1.38E-05
Ru-105	9.88E-11	No Data	3.89E-11	No Data	1.27E-10	1.37E-06	6.02E-06
Ru-106	8.64E-06	No Data	1.09E-06	No Data	1.67E-05	1.17E-03	1.14E-04
Ag-110M	1.35E-06	1.25E-06	7.43E-07	No Data	2.46E-06	5.79E-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	No Data	9.61E-07
I-131	3.15E-06	4.47E-06	2.56E-06	1.49E-03	7.66E-06	No Data	7.85E-07
I-132	1.45E-07	4.07E-07	1.45E-07	1.43E-05	6.48E-07	No Data	5.08E-08
I-133	1.08E-06	1.85E-06	5.65E-07	2.69E-04	3.23E-06	No Data	1.11E-06
I-134	8.05E-08	2.16E-07	7.69E-08	3.73E-06	3.44E-07	No Data	1.26E-10
I-135	3.35E-07	8.73E-07	3.21E-07	5.60E-05	1.39E-06	No Data	6.56E-07
Cs-134	4.66E-05	1.06E-04	9.10E-05	No Data	3.59E-05	1.22E-05	1.30E-06
Cs-136	4.88E-06	1.83E-05	1.38E-05	No Data	1.07E-05	1.50E-06	1.46E-06
Cs-137	5.98E-05	7.76E-05	5.35E-05	No Data	2.78E-05	9.40E-06	1.05E-06
Cs-138	4.14E-08	7.76E-08	4.05E-08	No Data	6.00E-08	6.07E-09	2.33E-13
Ba-139	1.17E-10	8.32E-14	3.42E-12	No Data	7.78E-14	4.70E-07	1.12E-07
Ba-140	4.88E-06	6.13E-09	3.21E-07	No Data	2.09E-09	1.59E-04	2.73E-05
Ba-141	1.25E-11	9.41E-15	4.20E-13	No Data	8.75E-15	2.42E-07	1.45E-17
Ba-142	3.29E-12	3.38E-15	2.07E-13	No Data	2.86E-15	1.49E-07	1.96E-26
La-140	4.30E-08	2.17E-08	5.73E-09	No Data	No Data	1.70E-05	5.73E-05

*Reference 3, Table E-7.

TABLE 2.2-4 (SHEET 3 OF 3)

INHALATION DOSE FACTORS FOR ADULT*
(mrem per pCi inhaled)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
La-142	8.54E-11	3.88E-11	9.65E-12	No Data	No Data	7.91E-07	2.64E-07
Ce-141	2.49E-06	1.69E-06	1.91E-07	No Data	7.83E-07	4.52E-05	1.50E-05
Ce-143	2.33E-08	1.72E-08	1.91E-09	No Data	7.60E-09	9.97E-06	2.83E-05
Ce-144	4.29E-04	1.79E-04	2.30E-05	No Data	1.06E-04	9.72E-04	1.02E-04
Pr-143	1.17E-06	4.69E-07	5.80E-08	No Data	2.70E-07	3.51E-05	2.50E-05
Pr-144	3.76E-12	1.56E-12	1.91E-13	No Data	8.81E-13	1.27E-07	2.69E-18
Nd-147	6.59E-07	7.62E-07	4.56E-08	No Data	4.45E-07	2.76E-05	2.16E-05
W-187	1.06E-09	8.85E-10	3.10E-10	No Data	No Data	3.63E-06	1.94E-05
Np-239	2.87E-08	2.82E-09	1.55E-09	No Data	8.75E-09	4.70E-06	1.49E-05

*Reference 3, Table E-7.

TABLE 2.2-5 (SHEET 1 OF 3)

INGESTION DOSE FACTORS FOR INFANT*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	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	No Data	No Data	No Data	2.30E-05
Cr-51	No Data	No Data	1.41E-08	9.20E-09	2.01E-09	1.79E-08	4.11E-07
Mn-54	No Data	1.99E-05	4.51E-06	No Data	4.41E-06	No Data	7.31E-06
Mn-56	No Data	8.18E-07	1.41E-07	No Data	7.03E-07	No Data	7.43E-05
Fe-55	1.39E-05	8.98E-06	2.40E-06	No Data	No Data	4.39E-06	1.14E-06
Fe-59	3.08E-05	5.38E-05	2.12E-05	No Data	No Data	1.59E-05	2.57E-05
Co-58	No Data	3.60E-06	8.98E-06	No Data	No Data	No Data	8.97E-06
Co-60	No Data	1.08E-05	2.55E-05	No Data	No Data	No Data	2.57E-05
Ni-63	6.34E-04	3.92E-05	2.20E-05	No Data	No Data	No Data	1.95E-06
Ni-65	4.70E-06	5.32E-07	2.42E-07	No Data	No Data	No Data	4.05E-05
Cu-64	No Data	6.09E-07	2.82E-07	No Data	1.03E-06	No Data	1.25E-05
Zn-65	1.84E-05	6.31E-05	2.91E-05	No Data	3.06E-05	No Data	5.33E-05
Zn-69	9.33E-08	1.68E-07	1.25E-08	No Data	6.98E-08	No Data	1.37E-05
Br-83	No Data	No Data	3.63E-07	No Data	No Data	No Data	LT E-24
Br-84	No Data	No Data	3.82E-07	No Data	No Data	No Data	LT E-24
Br-85	No Data	No Data	1.94E-08	No Data	No Data	No Data	LT E-24
Rb-86	No Data	1.70E-04	8.40E-05	No Data	No Data	No Data	4.35E-06
Rb-88	No Data	4.98E-07	2.73E-07	No Data	No Data	No Data	4.85E-07
Rb-89	No Data	2.86E-07	1.97E-07	No Data	No Data	No Data	9.74E-08
Sr-89	2.51E-03	No Data	7.20E-05	No Data	No Data	No Data	5.16E-05
Sr-90	1.85E-02	No Data	4.71E-03	No Data	No Data	No Data	2.31E-04
Sr-91	5.00E-05	No Data	1.81E-06	No Data	No Data	No Data	5.92E-05
Sr-92	1.92E-05	No Data	7.13E-07	No Data	No Data	No Data	2.07E-04
Y-90	8.69E-08	No Data	2.33E-09	No Data	No Data	No Data	1.20E-04
Y-91M	8.10E-10	No Data	2.76E-11	No Data	No Data	No Data	2.70E-06
Y-91	1.13E-06	No Data	3.01E-08	No Data	No Data	No Data	8.10E-05
Y-92	7.65E-09	No Data	2.15E-10	No Data	No Data	No Data	1.46E-04

*Reference 3, Table E-14.

TABLE 2.2-5 (SHEET 2 OF 3)

INGESTION DOSE FACTORS FOR INFANT*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Y-93	2.43E-08	No Data	6.62E-10	No Data	No Data	No Data	1.92E-04
Zr-95	2.06E-07	5.02E-08	3.56E-08	No Data	5.41E-08	No Data	2.50E-05
Zr-97	1.48E-08	2.54E-09	1.16E-09	No Data	2.56E-09	No Data	1.62E-04
Nb-95	4.20E-08	1.73E-08	1.00E-08	No Data	1.24E-08	No Data	1.46E-05
Mo-99	No Data	3.40E-05	6.63E-06	No Data	5.08E-05	No Data	1.12E-05
Tc-99M	1.92E-09	3.96E-09	5.10E-08	No Data	4.26E-08	2.07E-09	1.15E-06
Tc-101	2.27E-09	2.86E-09	2.83E-08	No Data	3.40E-08	1.56E-09	4.86E-07
Ru-103	1.48E-06	No Data	4.95E-07	No Data	3.08E-06	No Data	1.80E-05
Ru-105	1.36E-07	No Data	4.58E-08	No Data	1.00E-06	No Data	5.41E-05
Ru-106	2.41E-05	No Data	3.01E-06	No Data	2.85E-05	No Data	1.83E-04
Ag-110M	9.96E-07	7.27E-07	4.81E-07	No Data	1.04E-06	No Data	3.77E-05
Te-125M	2.33E-05	7.79E-06	3.15E-06	7.84E-06	No Data	No Data	1.11E-05
Te-127M	5.85E-05	1.94E-05	7.08E-06	1.69E-05	1.44E-04	No Data	2.36E-05
Te-127	1.00E-06	3.35E-07	2.15E-07	8.14E-07	2.44E-06	No Data	2.10E-05
Te-129M	1.00E-04	3.43E-05	1.54E-05	3.84E-05	2.50E-04	No Data	5.97E-05
Te-129	2.84E-07	9.79E-08	6.63E-08	2.38E-07	7.07E-07	No Data	2.27E-05
Te-131M	1.52E-05	6.12E-06	5.05E-06	1.24E-05	4.21E-05	No Data	1.03E-04
Te-131	1.76E-07	6.50E-08	4.94E-08	1.57E-07	4.50E-07	No Data	7.11E-06
Te-132	2.08E-05	1.03E-05	9.61E-06	1.52E-05	6.44E-05	No Data	3.81E-05
I-130	6.00E-06	1.32E-05	5.30E-06	1.48E-03	1.45E-05	No Data	2.83E-06
I-131	3.59E-05	4.23E-05	1.86E-05	1.39E-02	4.94E-05	No Data	1.51E-06
I-132	1.66E-06	3.37E-06	1.20E-06	1.58E-04	3.76E-06	No Data	2.73E-06
I-133	1.25E-05	1.82E-05	5.33E-06	3.31E-03	2.14E-05	No Data	3.08E-06
I-134	8.69E-07	1.78E-06	6.33E-07	4.15E-05	1.99E-06	No Data	1.84E-06
I-135	3.64E-06	7.24E-06	2.64E-06	6.49E-04	8.07E-06	No Data	2.62E-06
Cs-134	3.77E-04	7.03E-04	7.10E-05	No Data	1.81E-04	7.42E-05	1.91E-06
Cs-136	4.59E-05	1.35E-04	5.04E-05	No Data	5.38E-05	1.10E-05	2.05E-06
Cs-137	5.22E-04	6.11E-04	4.33E-05	No Data	1.64E-04	6.64E-05	1.91E-06
Cs-138	4.81E-07	7.82E-07	3.79E-07	No Data	3.90E-07	6.09E-08	1.25E-06
Ba-139	8.81E-07	5.84E-10	2.55E-08	No Data	3.51E-10	3.54E-10	5.58E-05

*Reference 3, Table E-14.

TABLE 2.2-5 (SHEET 3 OF 3)

INGESTION DOSE FACTORS FOR INFANT*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Ba-140	1.71E-04	1.71E-07	8.81E-06	No Data	4.06E-08	1.05E-07	4.20E-05
Ba-141	4.25E-07	2.91E-10	1.34E-08	No Data	1.75E-10	1.77E-10	5.19E-06
Ba-142	1.84E-07	1.53E-10	9.06E-09	No Data	8.81E-11	9.26E-11	7.59E-07
La-140	2.11E-08	8.32E-09	2.14E-09	No Data	No Data	No Data	9.77E-05
La-142	1.10E-09	4.04E-10	9.67E-11	No Data	No Data	No Data	6.86E-05
Ce-141	7.87E-08	4.80E-08	5.65E-09	No Data	1.48E-08	No Data	2.48E-05
Ce-143	1.48E-08	9.82E-06	1.12E-09	No Data	2.86E-09	No Data	5.73E-05
Ce-144	2.98E-06	1.22E-06	1.67E-07	No Data	4.93E-07	No Data	1.71E-04
Pr-143	8.13E-08	3.04E-08	4.03E-09	No Data	1.13E-08	No Data	4.29E-05
Pr-144	2.74E-10	1.06E-10	1.38E-11	No Data	3.84E-11	No Data	4.93E-06
Nd-147	5.53E-08	5.68E-08	3.48E-09	No Data	2.19E-08	No Data	3.60E-05
W-187	9.03E-07	6.28E-07	2.17E-07	No Data	No Data	No Data	3.69E-05
Np-239	1.11E-08	9.93E-10	5.61E-10	No Data	1.98E-09	No Data	2.87E-05

*Reference 3, Table E-14.

TABLE 2.2-6 (SHEET 1 OF 3)

INGESTION DOSE FACTORS FOR CHILD*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	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	No Data	No Data	No Data	2.28E-05
Cr-51	No Data	No Data	8.90E-09	4.94E-09	1.35E-09	9.02E-09	4.72E-07
Mn-54	No Data	1.07E-05	2.85E-06	No Data	3.00E-06	No Data	8.98E-06
Mn-56	No Data	3.34E-07	7.54E-08	No Data	4.04E-07	No Data	4.84E-05
Fe-55	1.15E-05	6.10E-06	1.89E-06	No Data	No Data	3.45E-06	1.13E-06
Fe-59	1.65E-05	2.67E-05	1.33E-05	No Data	No Data	7.74E-06	2.78E-05
Co-58	No Data	1.80E-06	5.51E-06	No Data	No Data	No Data	1.05E-05
Co-60	No Data	5.29E-06	1.56E-05	No Data	No Data	No Data	2.93E-05
Ni-63	5.38E-04	2.88E-05	1.83E-05	No Data	No Data	No Data	1.94E-06
Ni-65	2.22E-06	2.09E-07	1.22E-07	No Data	No Data	No Data	2.56E-05
Cu-64	No Data	2.45E-07	1.48E-07	No Data	5.92E-07	No Data	1.15E-05
Zn-65	1.37E-05	3.65E-05	2.27E-05	No Data	2.30E-05	No Data	6.41E-06
Zn-69	4.38E-08	6.33E-08	5.85E-09	No Data	3.84E-08	No Data	3.99E-06
Br-83	No Data	No Data	1.71E-07	No Data	No Data	No Data	LT E-24
Br-84	No Data	No Data	1.98E-07	No Data	No Data	No Data	LT E-24
Br-85	No Data	No Data	9.12E-09	No Data	No Data	No Data	LT E-24
Rb-86	No Data	6.70E-05	4.12E-05	No Data	No Data	No Data	4.31E-06
Rb-88	No Data	1.90E-07	1.32E-07	No Data	No Data	No Data	9.32E-09
Rb-89	No Data	1.17E-07	1.04E-07	No Data	No Data	No Data	1.02E-09
Sr-89	1.32E-03	No Data	3.77E-05	No Data	No Data	No Data	5.11E-05
Sr-90	1.70E-02	No Data	4.31E-03	No Data	No Data	No Data	2.29E-04
Sr-91	2.40E-05	No Data	9.06E-07	No Data	No Data	No Data	5.30E-05
Sr-92	9.03E-06	No Data	3.62E-07	No Data	No Data	No Data	1.71E-04
Y-90	4.11E-08	No Data	1.10E-09	No Data	No Data	No Data	1.17E-04
Y-91M	3.82E-10	No Data	1.39E-11	No Data	No Data	No Data	7.48E-07
Y-91	6.02E-07	No Data	1.61E-08	No Data	No Data	No Data	8.02E-05
Y-92	3.60E-09	No Data	1.03E-10	No Data	No Data	No Data	1.04E-04

*Reference 3, Table E-13.

TABLE 2.2-6 (SHEET 2 OF 3)

INGESTION DOSE FACTORS FOR CHILD*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Y-93	1.14E-08	No Data	3.13E-10	No Data	No Data	No Data	1.70E-04
Zr-95	1.16E-07	2.55E-08	2.27E-08	No Data	3.65E-08	No Data	2.66E-05
Zr-97	6.99E-09	1.01E-09	5.96E-10	No Data	1.45E-09	No Data	1.53E-04
Nb-95	2.25E-08	8.76E-09	6.26E-09	No Data	8.23E-09	No Data	1.62E-05
Mo-99	No Data	1.33E-05	3.29E-06	No Data	2.84E-05	No Data	1.10E-05
Tc-99M	9.23E-10	1.81E-09	3.00E-08	No Data	2.63E-08	9.19E-10	1.03E-06
Tc-101	1.07E-09	1.12E-09	1.42E-08	No Data	1.91E-08	5.92E-10	3.56E-09
Ru-103	7.31E-07	No Data	2.81E-07	No Data	1.84E-06	No Data	1.89E-05
Ru-105	6.45E-08	No Data	2.34E-08	No Data	5.67E-07	No Data	4.21E-05
Ru-106	1.17E-05	No Data	1.46E-06	No Data	1.58E-05	No Data	1.82E-04
Ag-110M	5.39E-07	3.64E-07	2.91E-07	No Data	6.78E-07	No Data	4.33E-05
Te-125M	1.14E-05	3.09E-06	1.52E-06	3.20E-06	No Data	No Data	1.10E-05
Te-127M	2.89E-05	7.78E-06	3.43E-06	6.91E-06	8.24E-05	No Data	2.34E-05
Te-127	4.71E-07	1.27E-07	1.01E-07	3.26E-07	1.34E-06	No Data	1.84E-05
Te-129M	4.87E-05	1.36E-05	7.56E-06	1.57E-05	1.43E-04	No Data	5.94E-05
Te-129	1.34E-07	3.74E-08	3.18E-08	9.56E-08	3.92E-07	No Data	8.34E-06
Te-131M	7.20E-06	2.49E-06	2.65E-06	5.12E-06	2.41E-05	No Data	1.01E-04
Te-131	8.30E-08	2.53E-08	2.47E-08	6.35E-08	2.51E-07	No Data	4.36E-07
Te-132	1.01E-05	4.47E-06	5.40E-06	6.51E-06	4.15E-05	No Data	4.50E-05
I-130	2.92E-06	5.90E-06	3.04E-06	6.50E-04	8.82E-06	No Data	2.76E-06
I-131	1.72E-05	1.73E-05	9.83E-06	5.72E-03	2.84E-05	No Data	1.54E-06
I-132	8.00E-07	1.47E-06	6.76E-07	6.82E-05	2.25E-06	No Data	1.73E-06
I-133	5.92E-06	7.32E-06	2.77E-06	1.36E-03	1.22E-05	No Data	2.95E-06
I-134	4.19E-07	7.78E-07	3.58E-07	1.79E-05	1.19E-06	No Data	5.16E-07
I-135	1.75E-06	3.15E-06	1.49E-06	2.79E-04	4.83E-06	No Data	2.40E-06
Cs-134	2.34E-04	3.84E-04	8.10E-05	No Data	1.19E-04	4.27E-05	2.07E-06
Cs-136	2.35E-05	6.46E-05	4.18E-05	No Data	3.44E-05	5.13E-06	2.27E-06
Cs-137	3.27E-04	3.13E-04	4.62E-05	No Data	1.02E-04	3.67E-05	1.96E-06
Cs-138	2.28E-07	3.17E-07	2.01E-07	No Data	2.23E-07	2.40E-08	1.46E-07
Ba-139	4.14E-07	2.21E-10	1.20E-08	No Data	1.93E-10	1.30E-10	2.39E-05
Ba-140	8.31E-05	7.28E-08	4.85E-06	No Data	2.37E-08	4.34E-08	4.21E-05
Ba-141	2.00E-07	1.12E-10	6.51E-09	No Data	9.69E-11	6.58E-10	1.14E-07
Ba-142	8.74E-08	6.29E-11	4.88E-09	No Data	5.09E-11	3.70E-11	1.14E-09

*Reference 3, Table E-13.

TABLE 2.2-6 (SHEET 3 OF 3)

INGESTION DOSE FACTORS FOR CHILD*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
La-140	1.01E-08	3.53E-09	1.19E-09	No Data	No Data	No Data	9.84E-05
La-142	5.24E-10	1.67E-10	5.23E-11	No Data	No Data	No Data	3.31E-05
Ce-141	3.97E-08	1.98E-08	2.94E-09	No Data	8.68E-09	No Data	2.47E-05
Ce-143	6.99E-09	3.79E-06	5.49E-10	No Data	1.59E-09	No Data	5.55E-05
Ce-144	2.08E-06	6.52E-07	1.11E-07	No Data	3.61E-07	No Data	1.70E-04
Pr-143	3.93E-08	1.18E-08	1.95E-09	No Data	6.39E-09	No Data	4.24E-05
Pr-144	1.29E-10	3.99E-11	6.49E-12	No Data	2.11E-11	No Data	8.59E-08
Nd-147	2.79E-08	2.26E-08	1.75E-09	No Data	1.24E-08	No Data	3.58E-05
W-187	4.29E-07	2.54E-07	1.14E-07	No Data	No Data	No Data	3.57E-05
Np-239	5.25E-09	3.77E-10	2.65E-10	No Data	1.09E-09	No Data	2.79E-05

*Reference 3, Table E-13.

TABLE 2.2-7 (SHEET 1 OF 3)

INGESTION DOSE FACTORS FOR TEENAGER*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	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	No Data	No Data	No Data	2.32E-05
Cr-51	No Data	No Data	3.60E-09	2.00E-09	7.89E-10	5.14E-09	6.05E-07
Mn-54	No Data	5.90E-06	1.17E-06	No Data	1.76E-06	No Data	1.21E-05
Mn-56	No Data	1.58E-07	2.81E-08	No Data	2.00E-07	No Data	1.04E-05
Fe-55	3.78E-06	2.68E-06	6.25E-07	No Data	No Data	1.70E-06	1.16E-06
Fe-59	5.87E-06	1.37E-05	5.29E-06	No Data	No Data	4.32E-06	3.24E-05
Co-58	No Data	9.72E-07	2.24E-06	No Data	No Data	No Data	1.34E-05
Co-60	No Data	2.81E-06	6.33E-06	No Data	No Data	No Data	3.66E-05
Ni-63	1.77E-04	1.25E-05	6.00E-06	No Data	No Data	No Data	1.99E-06
Ni-65	7.49E-07	9.57E-08	4.36E-08	No Data	No Data	No Data	5.19E-06
Cu-64	No Data	1.15E-07	5.41E-08	No Data	2.91E-07	No Data	8.92E-06
Zn-65	5.76E-06	2.00E-05	9.33E-06	No Data	1.28E-05	No Data	8.47E-06
Zn-69	1.47E-08	2.80E-08	1.96E-09	No Data	1.83E-08	No Data	5.16E-08
Br-83	No Data	No Data	5.74E-08	No Data	No Data	No Data	LT E-24
Br-84	No Data	No Data	7.22E-08	No Data	No Data	No Data	LT E-24
Br-85	No Data	No Data	3.05E-09	No Data	No Data	No Data	LT E-24
Rb-86	No Data	2.98E-05	1.40E-05	No Data	No Data	No Data	4.41E-06
Rb-88	No Data	8.52E-08	4.54E-08	No Data	No Data	No Data	7.30E-15
Rb-89	No Data	5.50E-08	3.89E-08	No Data	No Data	No Data	8.43E-17
Sr-89	4.40E-04	No Data	1.26E-05	No Data	No Data	No Data	5.24E-05
Sr-90	8.30E-03	No Data	2.05E-03	No Data	No Data	No Data	2.33E-04
Sr-91	8.07E-06	No Data	3.21E-07	No Data	No Data	No Data	3.66E-05
Sr-92	3.05E-06	No Data	1.30E-07	No Data	No Data	No Data	7.77E-05
Y-90	1.37E-08	No Data	3.69E-10	No Data	No Data	No Data	1.13E-04
Y-91M	1.29E-10	No Data	4.93E-12	No Data	No Data	No Data	6.09E-09
Y-91	2.01E-07	No Data	5.39E-09	No Data	No Data	No Data	8.24E-05
Y-92	1.21E-09	No Data	3.50E-11	No Data	No Data	No Data	3.32E-05

*Reference 3, Table E-12.

TABLE 2.2-7 (SHEET 2 OF 3)

INGESTION DOSE FACTORS FOR TEENAGER*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Y-93	3.83E-09	No Data	1.05E-10	No Data	No Data	No Data	1.17E-04
Zr-95	4.12E-08	1.30E-08	8.94E-09	No Data	1.91E-08	No Data	3.00E-05
Zr-97	2.37E-09	4.69E-10	2.16E-10	No Data	7.11E-10	No Data	1.27E-04
Nb-95	8.22E-09	4.56E-09	2.51E-09	No Data	4.42E-09	No Data	1.95E-05
Mo-99	No Data	6.03E-06	1.15E-06	No Data	1.38E-05	No Data	1.08E-05
Tc-99M	3.32E-10	9.26E-10	1.20E-08	No Data	1.38E-08	5.14E-10	6.08E-07
Tc-101	3.60E-10	5.12E-10	5.03E-09	No Data	9.26E-09	3.12E-10	8.75E-17
Ru-103	2.55E-07	No Data	1.09E-07	No Data	8.99E-07	No Data	2.13E-05
Ru-105	2.18E-08	No Data	8.46E-09	No Data	2.75E-07	No Data	1.76E-05
Ru-106	3.92E-06	No Data	4.94E-07	No Data	7.56E-06	No Data	1.88E-04
Ag-110M	2.05E-07	1.94E-07	1.18E-07	No Data	3.70E-07	No Data	5.45E-05
Te-125M	3.83E-06	1.38E-06	5.12E-07	1.07E-06	No Data	No Data	1.13E-05
Te-127M	9.67E-06	3.43E-06	1.15E-06	2.30E-06	3.92E-05	No Data	2.41E-05
Te-127	1.58E-07	5.60E-08	3.40E-08	1.09E-07	6.40E-07	No Data	1.22E-05
Te-129M	1.63E-05	6.05E-06	2.58E-06	5.26E-06	6.82E-05	No Data	6.12E-05
Te-129	4.48E-08	1.67E-08	1.09E-08	3.20E-08	1.88E-07	No Data	2.45E-07
Te-131M	2.44E-06	1.17E-06	9.76E-07	1.76E-06	1.22E-05	No Data	9.39E-05
Te-131	2.79E-08	1.15E-08	8.72E-09	2.15E-08	1.22E-07	No Data	2.29E-09
Te-132	3.49E-06	2.21E-06	2.08E-06	2.33E-06	2.12E-05	No Data	7.00E-05
I-130	1.03E-06	2.98E-06	1.19E-06	2.43E-04	4.59E-06	No Data	2.29E-06
I-131	5.85E-06	8.19E-06	4.40E-06	2.39E-03	1.41E-05	No Data	1.62E-06
I-132	2.79E-07	7.30E-07	2.62E-07	2.46E-05	1.15E-06	No Data	3.18E-07
I-133	2.01E-06	3.41E-06	1.04E-06	4.76E-04	5.98E-06	No Data	2.58E-06
I-134	1.46E-07	3.87E-07	1.39E-07	6.45E-06	6.10E-07	No Data	5.10E-09
I-135	6.10E-07	1.57E-06	5.82E-07	1.01E-04	2.48E-06	No Data	1.74E-06
Cs-134	8.37E-05	1.97E-04	9.14E-05	No Data	6.26E-05	2.39E-05	2.45E-06
Cs-136	8.59E-06	3.38E-05	2.27E-05	No Data	1.84E-05	2.90E-06	2.72E-06
Cs-137	1.12E-04	1.49E-04	5.19E-05	No Data	5.07E-05	1.97E-05	2.12E-06
Cs-138	7.76E-08	1.49E-07	7.45E-08	No Data	1.10E-07	1.28E-08	6.76E-11
Ba-139	1.39E-07	9.78E-11	4.05E-09	No Data	9.22E-11	6.74E-11	1.24E-06

*Reference 3, Table E-12.

TABLE 2.2-7 (SHEET 3 OF 3)

INGESTION DOSE FACTORS FOR TEENAGER*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Ba-140	2.84E-05	3.48E-08	1.83E-06	No Data	1.18E-08	2.34E-08	4.38E-05
Ba-141	6.71E-08	5.01E-11	2.24E-09	No Data	4.65E-11	3.43E-11	1.43E-13
Ba-142	2.99E-08	2.99E-11	1.84E-09	No Data	2.53E-11	1.99E-11	9.18E-20
La-140	3.48E-09	1.71E-09	4.55E-10	No Data	No Data	No Data	9.82E-05
La-142	1.79E-10	7.95E-11	1.98E-11	No Data	No Data	No Data	2.42E-06
Ce-141	1.33E-08	8.88E-09	1.02E-09	No Data	4.18E-09	No Data	2.54E-05
Ce-143	2.35E-09	1.71E-06	1.91E-10	No Data	7.67E-10	No Data	5.14E-05
Ce-144	6.96E-07	2.88E-07	3.74E-08	No Data	1.72E-07	No Data	1.75E-04
Pr-143	1.[illegible]1E-08	5.23E-09	6.52E-10	No Data	3.04E-09	No Data	4.31E-05
Pr-144	4.30E-11	1.76E-11	2.18E-12	No Data	1.01E-11	No Data	4.74E-14
Nd-147	9.38E-09	1.02E-08	6.11E-10	No Data	5.99E-09	No Data	3.68E-05
W-187	1.46E-07	1.19E-07	4.17E-08	No Data	No Data	No Data	3.22E-05
Np-239	1.76E-09	1.66E-10	9.22E-11	No Data	5.21E-10	No Data	2.67E-05

*Reference 3, Table E-12.

TABLE 2.2-8 (SHEET 1 OF 3)

INGESTION DOSE FACTORS FOR ADULT*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	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	No Data	No Data	No Data	2.17E-05
Cr-51	No Data	No Data	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
Mn-54	No Data	4.57E-06	8.72E-07	No Data	1.36E-06	No Data	1.40E-05
Mn-56	No Data	1.15E-07	2.04E-08	No Data	1.46E-07	No Data	3.67E-06
Fe-55	2.75E-06	1.90E-06	4.43E-07	No Data	No Data	1.06E-06	1.09E-06
Fe-59	4.34E-06	1.02E-05	3.91E-06	No Data	No Data	2.85E-06	3.40E-05
Co-58	No Data	7.45E-07	1.67E-06	No Data	No Data	No Data	1.51E-05
Co-60	No Data	2.14E-06	4.72E-06	No Data	No Data	No Data	4.02E-05
Ni-63	1.30E-04	9.01E-06	4.36E-06	No Data	No Data	No Data	1.88E-06
Ni-65	5.28E-07	6.86E-08	3.13E-08	No Data	No Data	No Data	1.74E-06
Cu-64	No Data	8.33E-08	3.91E-08	No Data	2.10E-07	No Data	7.10E-06
Zn-65	4.84E-06	1.54E-05	6.96E-06	No Data	1.03E-05	No Data	9.70E-06
Zn-69	1.03E-08	1.97E-08	1.37E-09	No Data	1.28E-08	No Data	2.96E-09
Br-83	No Data	No Data	4.02E-08	No Data	No Data	No Data	5.79E-08
Br-84	No Data	No Data	5.21E-08	No Data	No Data	No Data	4.09E-13
Br-85	No Data	No Data	2.14E-09	No Data	No Data	No Data	LT E-24
Rb-86	No Data	2.11E-05	9.83E-06	No Data	No Data	No Data	4.16E-06
Rb-88	No Data	6.05E-08	3.21E-08	No Data	No Data	No Data	8.36E-19
Rb-89	No Data	4.01E-08	2.82E-08	No Data	No Data	No Data	2.33E-21
Sr-89	3.08E-04	No Data	8.84E-06	No Data	No Data	No Data	4.94E-05
Sr-90	7.58E-03	No Data	1.86E-03	No Data	No Data	No Data	2.19E-04
Sr-91	5.67E-06	No Data	2.29E-07	No Data	No Data	No Data	2.70E-05
Sr-92	2.15E-06	No Data	9.30E-08	No Data	No Data	No Data	4.26E-05
Y-90	9.62E-09	No Data	2.58E-10	No Data	No Data	No Data	1.02E-04
Y-91M	9.09E-11	No Data	3.52E-12	No Data	No Data	No Data	2.67E-10
Y-91	1.41E-07	No Data	3.77E-09	No Data	No Data	No Data	7.76E-05
Y-92	8.45E-10	No Data	2.47E-11	No Data	No Data	No Data	1.48E-05

*Reference 3, Table E-11.

TABLE 2.2-8 (SHEET 2 OF 3)

INGESTION DOSE FACTORS FOR ADULT*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Y-93	2.68E-09	No Data	7.40E-11	No Data	No Data	No Data	8.50E-05
Zr-95	3.04E-08	9.75E-09	6.60E-09	No Data	1.53E-08	No Data	3.09E-05
Zr-97	1.68E-09	3.39E-10	1.55E-10	No Data	5.12E-10	No Data	1.05E-04
Nb-95	6.22E-09	3.46E-09	1.86E-09	No Data	3.42E-09	No Data	2.10E-05
Mo-99	No Data	4.31E-06	8.20E-07	No Data	9.76E-06	No Data	9.99E-06
Tc-99M	2.47E-10	6.98E-10	8.89E-09	No Data	1.06E-08	3.42E-10	4.13E-07
Tc-101	2.54E-10	3.66E-10	3.59E-09	No Data	6.59E-09	1.87E-10	1.10E-21
Ru-103	1.85E-07	No Data	7.97E-08	No Data	7.06E-07	No Data	2.16E-05
Ru-105	1.54E-08	No Data	6.08E-09	No Data	1.99E-07	No Data	9.42E-06
Ru-106	2.75E-06	No Data	3.48E-07	No Data	5.31E-06	No Data	1.78E-04
Ag-110M	1.60E-07	1.48E-07	8.79E-08	No Data	2.91E-07	No Data	6.04E-05
Te-125M	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	No Data	1.07E-05
Te-127M	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	No Data	2.27E-05
Te-127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	No Data	8.68E-06
Te-129M	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	No Data	5.79E-05
Te-129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	No Data	2.37E-08
Te-131M	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	No Data	8.40E-05
Te-131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	No Data	2.79E-09
Te-132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	No Data	7.71E-05
I-130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	No Data	1.92E-06
I-131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	No Data	1.57E-06
I-132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	No Data	1.02E-07
I-133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	No Data	2.22E-06
I-134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	No Data	2.51E-10
I-135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	No Data	1.31E-06
Cs-134	6.22E-05	1.48E-04	1.21E-04	No Data	4.79E-05	1.59E-05	2.59E-06
Cs-136	6.51E-06	2.57E-05	1.85E-05	No Data	1.43E-05	1.96E-06	2.92E-06
Cs-137	7.97E-05	1.09E-04	7.14E-05	No Data	3.70E-05	1.23E-05	2.11E-06
Cs-138	5.52E-08	1.09E-07	5.40E-08	No Data	8.01E-08	7.91E-09	4.65E-13
Ba-139	9.70E-08	6.91E-11	2.84E-09	No Data	6.46E-11	3.92E-11	1.72E-07
Ba-140	2.03E-05	2.55E-08	1.33E-06	No Data	8.67E-09	1.46E-08	4.18E-05
Ba-141	4.71E-08	3.56E-11	1.59E-09	No Data	3.31E-11	2.02E-11	2.22E-17
Ba-142	2.13E-08	2.19E-11	1.34E-09	No Data	1.85E-11	1.24E-11	3.00E-26

*Reference 3, Table E-11.

TABLE 2.2-8 (SHEET 3 OF 3)

INGESTION DOSE FACTORS FOR ADULT*
(mrem per pCi ingested)

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
La-140	2.50E-09	1.26E-09	3.33E-10	No Data	No Data	No Data	9.25E-05
La-142	1.28E-10	5.82E-11	1.45E-11	No Data	No Data	No Data	4.25E-07
Ce-141	9.36E-09	6.33E-09	7.18E-10	No Data	2.94E-09	No Data	2.42E-05
Ce-143	1.65E-09	1.22E-06	1.35E-10	No Data	5.37E-10	No Data	4.56E-05
Ce-144	4.88E-07	2.04E-07	2.62E-08	No Data	1.21E-07	No Data	1.65E-04
Pr-143	9.20E-09	3.69E-09	4.56E-10	No Data	2.13E-09	No Data	4.03E-05
Pr-144	3.01E-11	1.25E-11	1.53E-12	No Data	7.05E-12	No Data	4.33E-18
Nd-147	6.29E-09	7.27E-09	4.35E-10	No Data	4.25E-09	No Data	3.49E-05
W-187	1.03E-07	8.61E-08	3.01E-08	No Data	No Data	No Data	2.82E-05
Np-239	1.19E-09	1.17E-10	6.45E-11	No Data	3.65E-10	No Data	2.40E-05

*Reference 3, Table E-11.

TABLE 2.2-9 (SHEET 1 OF 2)

EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND*

(mrem/hr per pCi/m²)

Element	Total Body	Skin
H-3	0.0	0.0
C-14	0.0	0.0
NA-24	2.50E-08	2.90E-08
P-32	0.0	0.0
Cr-51	2.20E-10	2.60E-10
Mn-54	5.80E-09	6.80E-09
Mn-56	1.10E-08	1.30E-08
Fe-55	0.0	0.0
Fe-59	8.00E-09	9.40E-09
Co-58	7.00E-09	8.20E-09
Co-60	1.70E-08	2.00E-08
Ni-63	0.0	0.0
Ni-65	3.70E-09	4.30E-09
Cu-64	1.50E-09	1.70E-09
Zn-65	4.00E-09	4.60E-09
Zn-69	0.0	0.0
Br-83	6.40E-11	9.30E-11
Br-84	1.20E-08	1.40E-08
Br-85	0.0	0.0
Rb-86	6.30E-10	7.20E-10
Rb-88	3.50E-09	4.00E-09
Rb-89	1.50E-08	1.80E-08
Sr-89	5.60E-13	6.50E-13
Sr-91	7.10E-09	8.30E-09
Sr-92	9.00E-09	1.00E-08
Y-90	2.20E-12	2.60E-12
Y-91M	3.80E-09	4.40E-09
Y-91	2.40E-11	2.70E-11
Y-92	1.60E-09	1.90E-09
Y-93	5.70E-10	7.80E-10
Zr-95	5.00E-09	5.80E-09
Zr-97	5.50E-09	6.40E-09
Nb-95	5.10E-09	6.00E-09
Mo-99	1.90E-09	2.20E-09
Tc-99M	9.60E-10	1.10E-09
Tc-101	2.70E-09	3.00E-09
Ru-103	3.60E-09	4.20E-09
Ru-105	4.50E-09	5.10E-09

*Reference 3, Table E-6.

TABLE 2.2-9 (SHEET 2 OF 2)

EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND*

(mrem/hr per pCi/m²)

Element	Total Body	Skin
Ru-106	1.50E-09	1.80E-09
Ag-110M	1.80E-08	2.10E-08
Te-125M	3.50E-11	4.80E-11
Te-127M	1.10E-12	1.30E-12
Te-127	1.00E-11	1.10E-11
Te-129M	7.70E-10	9.00E-10
Te-129	7.10E-10	8.40E-10
Te-131M	8.40E-09	9.90E-09
Te-131	2.20E-09	2.60E-06
Te-132	1.70E-09	2.00E-09
I-130	1.40E-08	1.70E-08
I-131	2.80E-09	3.40E-09
I-132	1.70E-08	2.00E-08
I-133	3.70E-09	4.50E-09
I-134	1.60E-08	1.90E-08
I-135	1.20E-08	1.40E-08
Cs-134	1.20E-08	1.40E-08
Cs-136	1.50E-08	1.70E-08
Cs-137	4.20E-09	4.90E-09
Cs-138	2.10E-08	2.40E-08
Ba-139	2.40E-09	2.70E-09
Ba-140	2.10E-09	2.40E-09
Ba-141	4.30E-09	4.90E-09
Ba-142	7.90E-09	9.00E-09
La-140	1.50E-08	1.70E-08
La-142	1.50E-08	1.80E-08
Ce-141	5.50E-10	6.20E-10
Ce-143	2.20E-09	2.50E-09
Ce-144	3.20E-10	3.70E-10
Pr-143	0.0	0.0
Pr-144	2.00E-10	2.30E-10
Nd-147	1.00E-09	1.20E-09
W-187	3.10E-09	3.60E-09
Np-239	9.50E-10	1.10E-09

*Reference 3, Table E-6.

TABLE 2.2-10

INDIVIDUAL USAGE FACTORS*

	Infant	Child	Teenager	Adult
Milk consumption rate U_{ap} (liters/yr)	330	330	400	310
Meat consumption rate, U_{ap} (kg/yr)	0	41	65	110
Fresh leafy vegetation consumption rate, $U_{a\ell}$ (kg/yr)	0	26	42	64
Stored vegetation consumption rate, U_{as} (kq/yr)	0	520	630	520
Breathing rate (m^3/yr)	1400	3700	8000	8000

*Reference 3, Table E-5.

TABLE 2.2-11

STABLE ELEMENT TRANSFER DATA*

Element	F_m - Milk (Cow)	F_m - Milk (Goat)	F_f - Meat
H	1.0E-02	1.7E-01	1.2E-02
C	1.2E-02	1.0E-01	3.1E-02
Na	4.0E-02	4.0E-02	3.0E-02
P	2.5E-02	2.5E-01	4.6E-02
Cr	2.2E-03	2.2E-03	2.4E-03
Mn	2.5E-04	2.5E-04	8.0E-04
Fe	1.2E-03	1.3E-04	4.0E-02
Co	1.0E-03	1.0E-03	1.3E-02
Ni	6.7E-03	6.7E-03	5.3E-02
Cu	1.4E-02	1.3E-02	8.0E-03
Zn	3.9E-02	3.9E-02	3.0E-02
Rb	3.0E-02	3.0E-02	3.1E-02
Sr	8.0E-04	1.4E-02	6.0E-04
Y	1.0E-05	1.0E-05	4.6E-03
Zr	5.0E-06	5.0E-06	3.4E-02
Nb	2.5E-03	2.5E-03	2.8E-01
Mo	7.5E-03	7.5E-03	8.0E-03
Tc	2.5E-02	2.5E-02	4.0E-01
Ru	1.0E-06	1.0E-06	4.0E-01
Rh	1.0E-02	1.0E-02	1.5E-03
Ag	5.0E-02	5.0E-02	1.7E-02
Te	1.0E-03	1.0E-03	7.7E-02
I	6.0E-03	6.0E-02	2.9E-03
Cs	1.2E-02	3.0E-01	4.0E-03
Ba	4.0E-04	4.0E-04	3.2E-03
La	5.0E-06	5.0E-06	2.0E-04
Ce	1.0E-04	1.0E-04	1.2E-03
Pr	5.0E-06	5.0E-06	4.7E-03
Nd	5.0E-06	5.0E-06	3.3E-03
W	5.0E-04	5.0E-04	1.3E-03
Np	5.0E-06	5.0E-06	2.0E-04

*Reference 3, Table E-1.

TABLE 2.2-12

SITE-SPECIFIC (OR DEFAULT) VALUES TO BE USED IN PATHWAY FACTOR CALCULATIONS*

The critical receptor is an infant exposed to the inhalation, ground-plane, and grass-cow-milk pathways.

Parameter	Description	Value
Inhalation		
$(BR)_a$	Breathing rate for infant	1400 m³/yr
$(DFA)_{ija}$	Inhalation dose factor for infant	Table 2.2-1
Ground plane		
SF'	Shielding factor due to structure	0.7
$(DFG)_{ij}$	Ground-plane dose factor (same for all age groups)	Table 2.2-9
Grass-Cow-Milk		
Q_F	Feed consumption rate for cow	50 kg/day
U_{ap}	Milk consumption rate for infant	330 liters/yr
$(DFL)_{ija}$	Ingestion dose factor for infant	Table 2.2-5
Y_p	Pasture grass areal density	0.7 kg/m²
Y_s	Stored feed areal density	2.0 kg/m²
f_p	Fraction of year that cow grazes on pasture	1.0
f_s	Fraction of total feed that is pasture grass while cow is on pasture	1.0
H	Absolute humidity of the atmosphere	8.0 gm/m³

*Supports Section 2.2.2b.

TABLE 2.2-13 (SHEET 1 OF 2)

SITE-SPECIFIC (OR DEFAULT) VALUES TO BE USED IN ADDITIONAL PATHWAY FACTOR CALCULATIONS*

Parameter	Description	Value
Inhalation		
$(BR)_a$	Breathing rate for age group	Table 2.2-10
$(DFA)_{ija}$	Inhalation dose factor for age group	Tables 2.2-1 thru 2.2-4
Grass-Cow-Meat		
Q_F	Feed consumption rate for cow	50 kg/day
U_{ap}	Meat consumption rate for age group	Table 2.2-10
$(DFL)_{ija}$	Ingestion dose factor for age group	Tables 2.2-6 thru 2.2-8
Y_p	Pasture grass areal density	0.7 kg/m²
Y_s	Stored feed areal density	2.0 kg/m²
f_p	Fraction of year that cow grazes on pasture	1.0
f_s	Fraction of total feed that is pasture grass while cow is on pasture	1.0
H	Absolute humidity of the atmosphere	8.0 gm/m³
Garden Vegetation		
Y_v	Garden vegetation areal density	2.0 kg/m²
$U_{a\ell}$	Leafy vegetation consumption rate for age group	Table 2.2-10
U_{as}	Stored vegetation consumption rate for age group	Table 2.2-10

*Supports Section 2.2.2.c.

TABLE 2.2-13 (SHEET 2 OF 2)

SITE-SPECIFIC (OR DEFAULT) VALUES TO
BE USED IN ADDITIONAL PATHWAY FACTOR CALCULATIONS*

Parameter	Description	Value
Garden Vegetation (continued)		
f_ℓ	Fraction of annual intake of leafy vegetation grown locally	1.0
f_g	Fraction of annual intake of stored vegetation grown locally	0.76
H	Absolute humidity of the atmosphere	8.0 gm/m³
Grass-Goat-Milk		
Q_F	Feed consumption rate for goat	6.0 kg/day
U_{ap}	Milk consumption rate for age group	Table 2.2-10
$(DFL)_{ija}$	Ingestion dose factor for age group	Tables 2.2-5 thru 2.2-8
Y_p	Pasture grass areal density	0.7 kg/m²
Y_s	Stored feed areal density	2.0 kg/m²
f_p	Fraction of year that goat grazes on pasture	1.0
f_s	Fraction of total feed that is pasture grass while goat is on pasture	1.0
H	Absolute humidity of the atmosphere	8.0 gm/m³

*Supports Section 2.2.2.c.

2.3 METEOROLOGICAL MODEL

2.3.1 Atmospheric Dispersion

Atmospheric dispersion may be calculated using the appropriate form of the sector-averaged Gaussian model. Gaseous releases are considered to be either elevated or at ground-level. Included in the ground-level category are releases from:

- Reactor building vent (Unit 1).
- Reactor building vent (Unit 2).
- Recombiner building vent (Unit 1).

Releases from the main stack are considered to be elevated.

2.3.1.a Ground-Level Releases

X/Q = the sector-averaged annual average relative concentration at any distance in the given sector.

$$= 2.032\ \delta\ K_r \sum_{jk} \frac{n_{jk}}{Nu_{jk}\ r\ \Sigma_{zk}} \quad (\text{sec m}^{-3})$$

where:

2.032 = $(2/\pi)^{1/2}$ divided by the number of radians in a 22.5° sector $(2\pi/16)$.

δ = the plume depletion factor for all radionuclides other than noble gases at a distance r shown in Figure 2.3-3. For noble gases the depletion factor is unity. Only depletion by deposition is considered since depletion by decay would be of little significance at the distances considered.

K_r = the terrain recirculation factor corresponding to a distance r taken from Figure 2.3-2.

n_{jk} = the number of hours the wind of wind speed class j is directed <u>into</u> the given sector during the time atmospheric stability category k existed. These values may be obtained from Table E.4-8 of Reference 5.

N = the total hours of valid meteorological data recorded for all sectors, wind speed classes, and stability categories from Table E.4-8 of Reference 5.

r = the distance from the point of release to the receptor location, in meters.

u_{jk} = the wind speed (mid-point of wind speed class j) at ground level (m sec^{-1}) during atmospheric stability k.

Σ_{zk} = the vertical standard deviation of the plume concentration distribution considering the initial dispersion within the building wake.

$$= \text{the lesser of} \begin{cases} (\sigma_z^2 + b^2/2\pi)^{1/2} \\ \text{or} \\ \sqrt{3}\,(\sigma_z) \end{cases}$$

σ_{zk} = the vertical standard deviation of the plume concentration distribution (meters) for a given distance and stability category k as shown in Figure 2.3-1. The stability category is determined by the vertical temperature gradient $\Delta T/\Delta z$ (°C/100 m).

π = 3.1416.

b = the maximum height of the adjacent plant structure (47 m).

2.3.1.b Elevated Releases

X/Q = the sector-averaged annual average relative concentration at any distance in the given sector for radionuclides other than noble gases.

$$= 2.032\ K_r \sum_{jk} \delta_k \frac{n_{jk} \exp(-h^2/2\sigma_{zk}^2)}{NU_j r\ \sigma_{zk}}$$

where:

δ_k = the plume depletion factor taken from Figure 2.3-4. For an elevated release, this factor is stability dependent.

h = the height of the main stack (120 m).

n = the number of hours the wind of wind speed class j is directed <u>into</u> the given sector during the time atmospheric stability category k existed. These values may be obtained from Table E.4-7 of Reference 5.

U_{jk} = the wind speed (mid-point of wind speed class j) at the height of release h (m sec^{-1}) during atmospheric stability k.

N = the total hours of valid meteorological data recorded for all sectors, wind speed classes, and stability categories from Table E.4-7 of Reference 5.

The remaining symbols are the same as those previously defined.

When considering the direct gamma radiation from an elevated finite plume, the constants B_i and V_i defined in Section 2.1.2 for each identified noble gas radionuclide are calculated using the following:

$$B_i = \frac{K}{r} \sum_j \sum_k \sum_\ell \left[\frac{n_{jk}\ A_{\ell i}\ \mu_a\ E_\ell\ I_{(r)k\ell}}{N\ U_j} \right] \frac{\text{mrad/yr}}{\mu\text{Ci/sec}}$$

$$V_i = 1.1 \frac{K}{r} \sum_j \sum_k \sum_\ell \left[\frac{n_{jk} A_{\ell i} \mu_a E_\ell I_{(r)k\ell}}{N U_j} \right] \exp(-\mu_T T_d) \frac{mrem/yr}{\mu Ci/sec}$$

where:

K = a numerical constant representing the aggregated numerical constants and unit conversions.

= 2.1×10^4.

$A_{\ell i}$ = the number of photons of energy corresponding to the ℓth energy group emitted per transformation of radionuclide i (number/transformation).

μ_a = the energy absorption coefficient in air for photon energy E_ℓ (m^{-1}).

E_ℓ = the energy assigned to energy group ℓ (MeV).

μ_T = the tissue energy absorbtion coefficient for photons of energy E_ℓ ($cm^2 gm^{-1}$).

T_d = the tissue density thickness taken to represent the total-body dose (5 gm cm^{-2}).

1.1 = an average ratio of the tissue-to-air absorbtion coefficients over the energy range of interest. The ratio converts dose (rad) to dose equivalent (rem).

$I_{(r)k\ell}$ = the results of numerical integration over the plume spatial distribution of airborne activity; this value is dependent on atmospheric stability, downwind distance, and gamma energy.

The aforementioned integral is used in representing the summation of the dose rates from all the points (the concentration within a differential volume element) of a distributed source (plume). For the sector-averaged Gaussian model, the integral is given by:

$$\frac{1}{2^{3/2}\sigma_z} \int_0^\infty\int_0^\infty \frac{B_g[\mu,\mu_a,(L^2 + z^2)^{1/2}]\;\; G(z)\; \exp\,[-\mu\;(L^2 + z^2)^{1/2}]\; L\; dL\; dz}{L^2 + z^2}$$

where:

B_g = the buildup factor.

= $1 - k\mu\;(L^2 + z^2)^{1/2}$.

μ = the total absorbtion coefficient for air (m^{-1}).

k = $(\mu-\mu_a)/\mu_a$.

L = the horizontal distance from the receptor to the differential volume element.

z = the vertical distance from the receptor to the differential volume element.

$G(z)$ = a function relating the variation of radionuclide concentration with the height for a given differential volume element.

= $\exp\,[-\,(z-h)^2/2\sigma_z{}^2] + \exp\,[-(z+h)^2/2\sigma_z{}^2]$

$2\pi\;L\;dL\;dz$ = the differential volume element of the integral. (The 2π is subsequently factored out of the integral, leaving the L dL dz.)

A derivation of the model describing the gamma dose rate from a finite elevated plume is found in Chapter 7 of Reference 10. Numerical methods for evaluating the dose integral are found in Appendix F of Reference 3 in the form of two computer code listings. The first listing performs the integration using a Gauss-Legendre quadrature; the other utilizes a Newton-Cotes formulation. Details of these two methods may be found in Reference 9.

2.3.2 Relative Deposition

Relative deposition per unit area is given by:

D/Q = the sector-averaged annual average deposition at any distance for a given sector.

$$= \sum_k \frac{2.55\, K_r D_g n_k}{r\, N} \quad (m^{-2})$$

where:

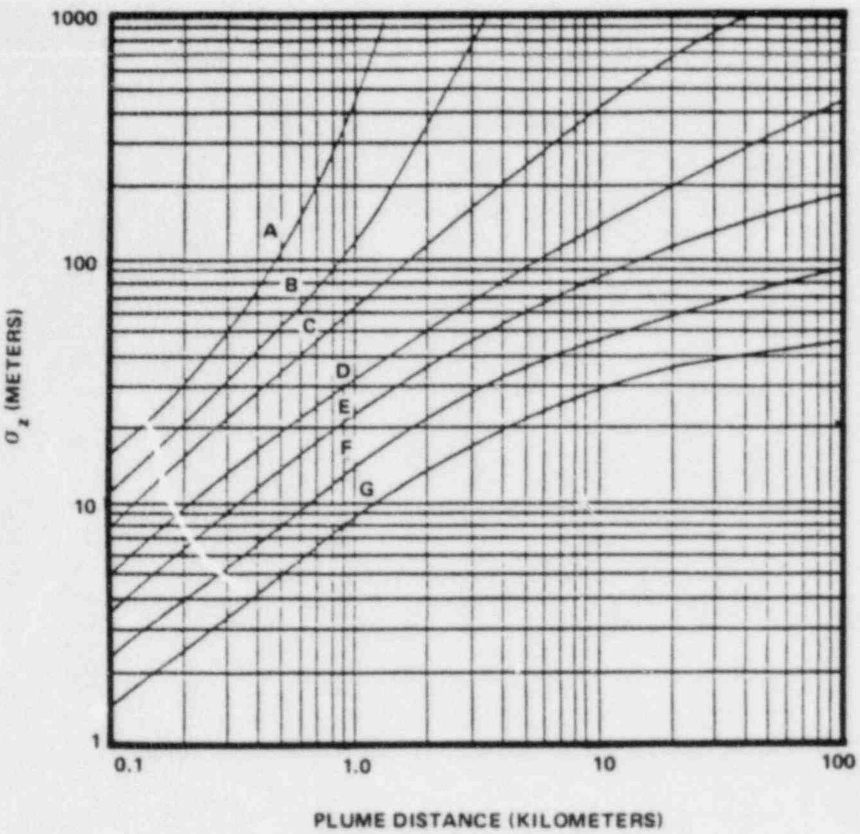
2.55 = the inverse of the number of radians in a 22.5° sector $(2\pi/16)^{-1}$.

K_r = the terrain recirculation factor described in the previous section.

D_g = the deposition rate at a given distance taken from Figure 2.3-5 for ground-level releases and Figure 2.3-6 for elevated releases.

n_k = the number of hours the wind is directed into the sector of interest for a ground-level release or for an elevated release during which time stability category k exists. These values may be found in Tables E.4-7 and E.4-8 of Reference 5.

N = the total hours of valid meteorological data.



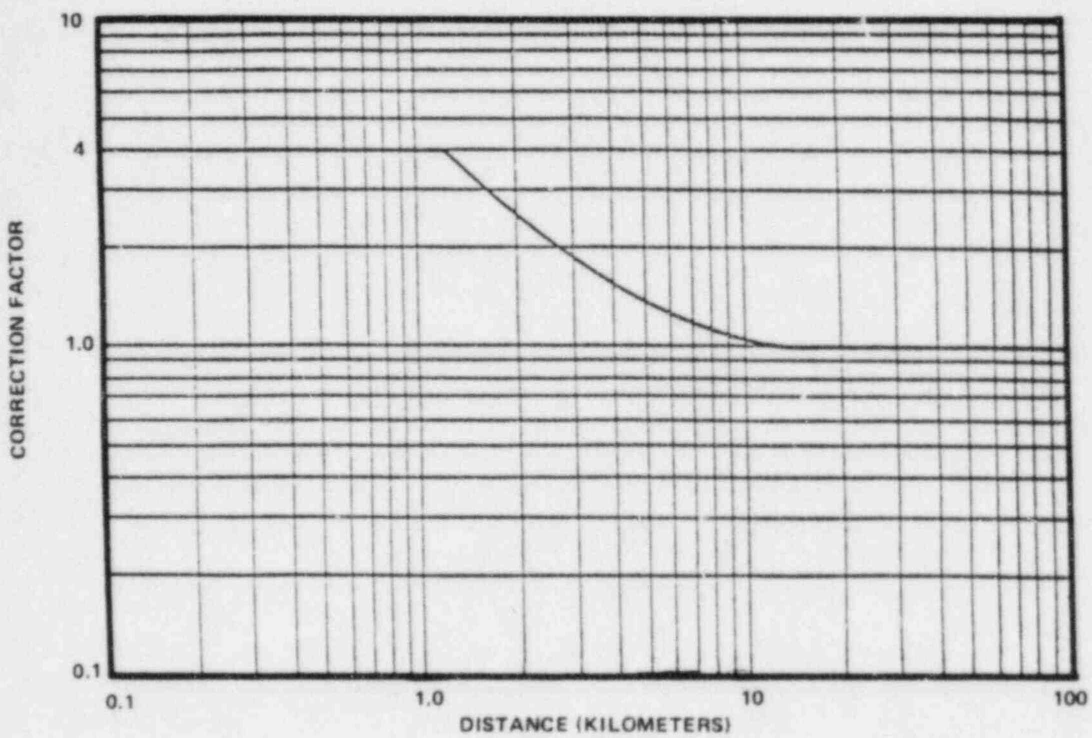
Category	Range of Vertical Temperature Gradient (°C/100 m)	Range of Vertical Temperature Gradient (°F/100 ft)
A	$\Delta T/\Delta Z < -1.9$	$\Delta T < -1.0$
B	$-1.9 \leq \Delta T/\Delta Z < -1.7$	$-1.0 \leq \Delta T < -0.9$
C	$-1.7 \leq \Delta T/\Delta Z < -1.5$	$-0.9 \leq \Delta T < -0.8$
D	$-1.5 \leq \Delta T/\Delta Z < -0.5$	$-0.8 \leq \Delta T < -0.3$
E	$-0.5 \leq \Delta T/\Delta Z < 1.5$	$-0.3 \leq \Delta T < 0.8$
F	$1.5 \leq \Delta T/\Delta Z < 4.0$	$0.8 \leq \Delta T < 2.2$
G	$4.0 \leq \Delta T/\Delta Z$	$2.2 \leq \Delta T$

*Reference 8.

Georgia Power — EDWIN I. HATCH NUCLEAR PLANT

VERTICAL STANDARD DEVIATION OF MATERIAL IN A PLUME (σ_z)* (Letters Denote Pasquill Stability Class)

FIGURE 2.3-1

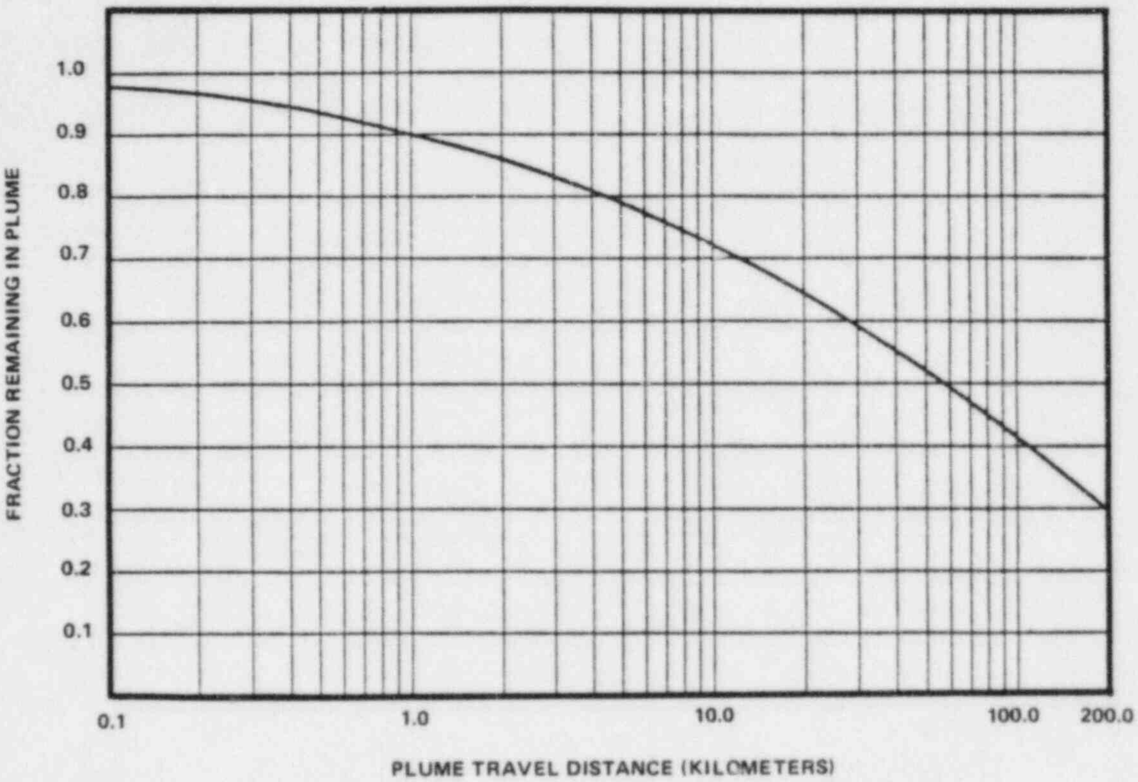


*Reference 7.

Georgia Power EDWIN I. HATCH NUCLEAR PLANT

OPEN TERRAIN RECIRCULATION FACTOR *

FIGURE 2.3-2



*Reference 8.

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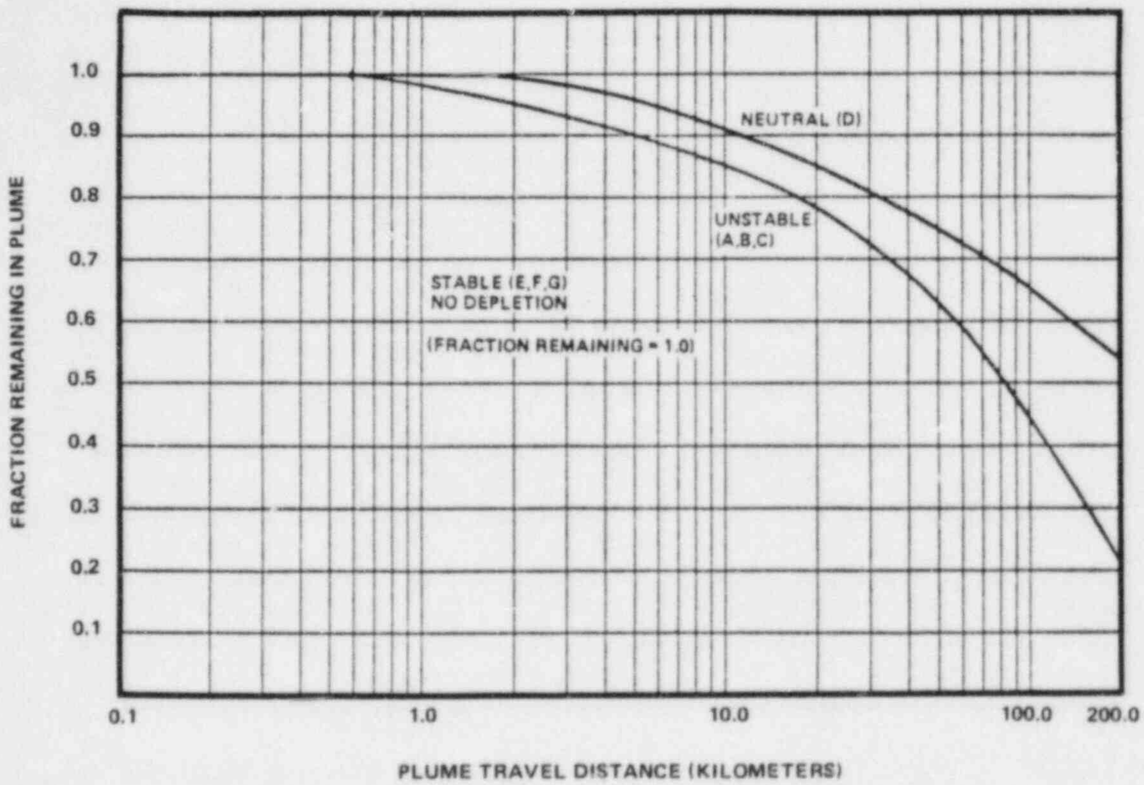
Georgia Power EDWIN I. HATCH NUCLEAR PLANT

PLUME DEPLETION EFFECT FOR GROUND-LEVEL RELEASES* (All Atmospheric Stability Classes)

FIGURE 2.3-3

3605-0



*Reference 8.

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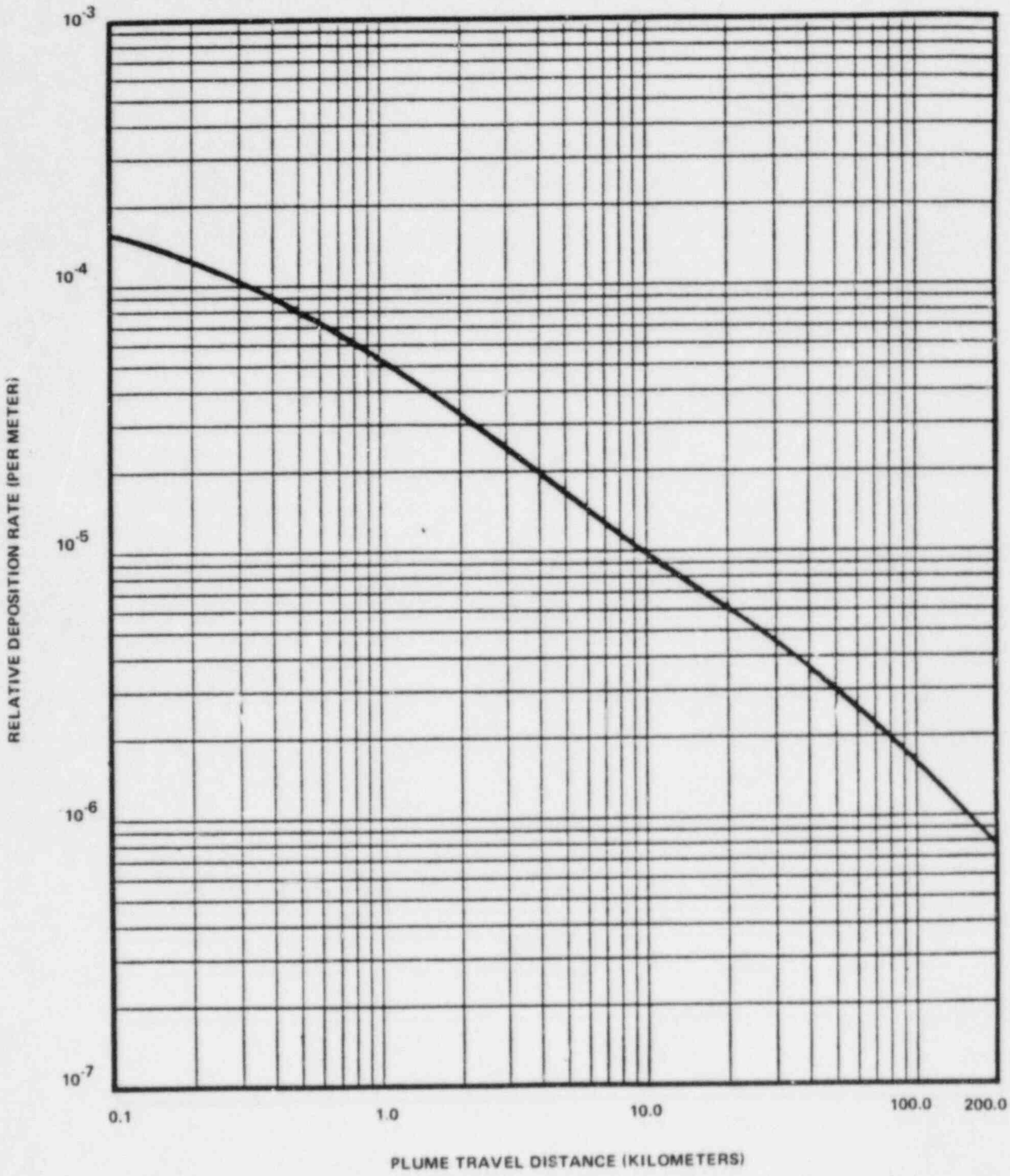
PLUME DEPLETION EFFECT FOR GREATER THAN 100-m RELEASES* (Letters Denote Pasquill Stability Class)

FIGURE 2.3-4



*Reference 8.

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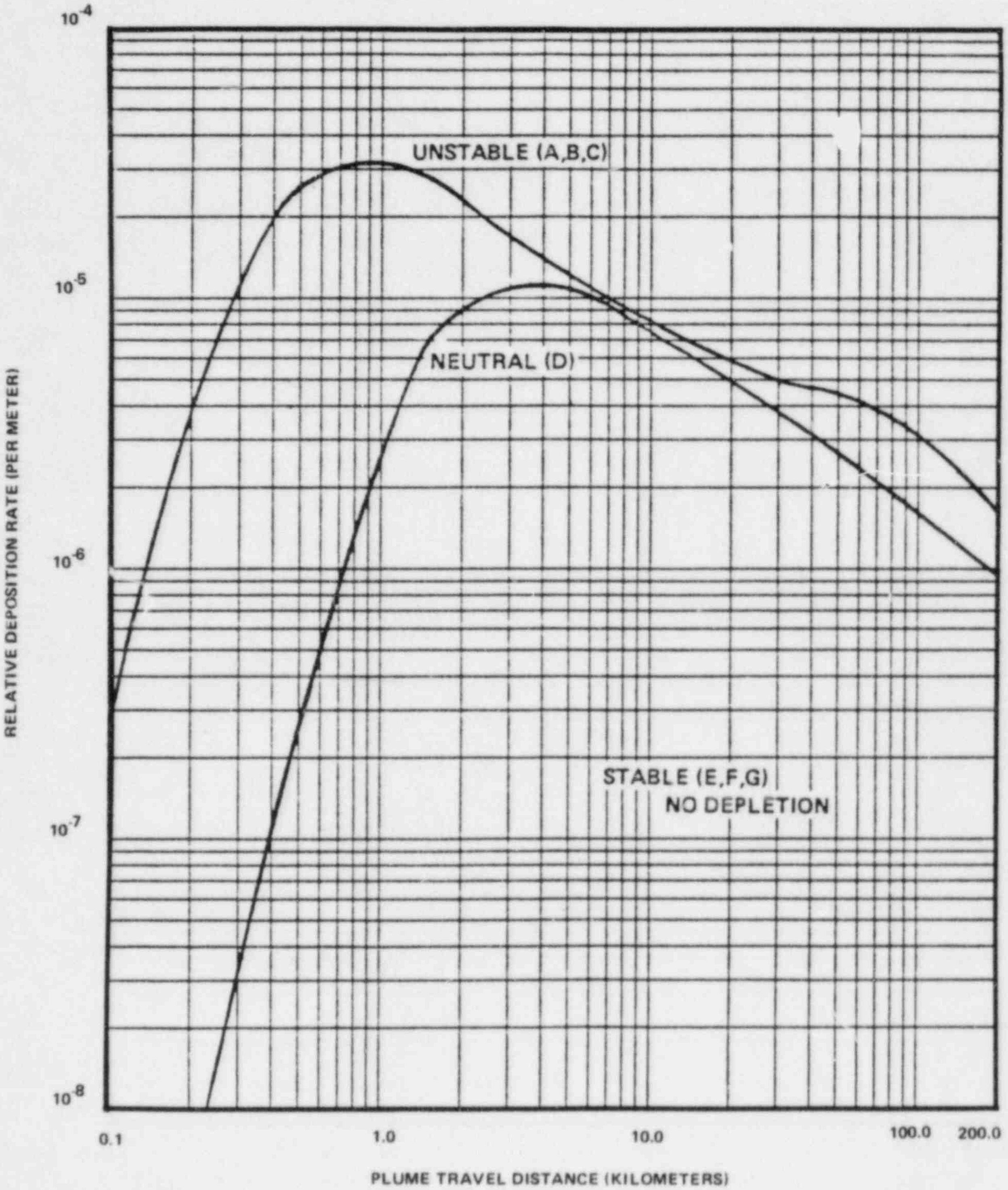
Georgia Power EDWIN I. HATCH NUCLEAR PLANT

RELATIVE DEPOSITION FOR GROUND-LEVEL RELEASES* (All Atmospheric Stability Classes)

FIGURE 2.3-5



*Reference 8.

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Georgia Power EDWIN I. HATCH NUCLEAR PLANT	RELATIVE DEPOSITION FOR GREATER THAN 100-m RELEASES* (Letters Denote Pasquill Stability Class)
	FIGURE 2.3-6

3605-0

2.4 DEFINITIONS OF GASEOUS EFFLUENT PARAMETERS

Term		Definition	Section of Initial Use
$A_{\ell i}$	=	the number of photons of energy corresponding to the ℓth energy group emitted per transformation of radionuclide i (number/transformation).	2.3.1
AG	=	the administrative allocation factor for gaseous effluent pathways.	2.1.1
b	=	the maximum height of the adjacent building.	2.3.1
B_i	=	the constant which includes the air dose factor, for each identified noble gas radionuclide, accounting for the gamma radiation from an elevated finite plume (mrad/yr per μCi/sec).	2.1.2
B_g	=	the buildup factor.	2.3.1
C	=	the monitor reading of a noble gas monitor corresponding to associated grab sample radionuclide concentrations.	2.1.1
C_s	=	the monitor reading of the noble gas monitor at the alarm setpoint concentration.	2.1.1
D_g	=	the deposition rate at a given distance taken from Figure 2.3-5 for ground-level releases and Figure 2.3-6 for elevated releases.	2.3.1

Term		Definition	Section of Initial Use
D_j	=	the dose to an organ of individual from radioiodines, tritium, and radionuclides in particulate form with half-lives greater than 8 days (mrem).	2.2.2.b
D_o	=	the organ dose rate at time of release (mrem/yr).	2.2.1.b
D_s	=	the skin dose rate at time of release (mrem/yr).	2.2.1.a
D_{ss}	=	the limiting dose rate to the skin of the body of an individual in an unrestricted area which is 3000 mrem/yr.	2.1.1
D_t	=	the total body dose rate at time of release (mrem/yr).	2.2.1.a
D_{TB}	=	the limiting dose rate to the total body of an individual which is 500 mrem/yr.	2.1.1
D_β	=	the air dose due to beta emissions from noble gases (mrad).	2.2.2.a
D_γ	=	the air dose due to gamma emissions from noble gases (mrad).	2.2.2.a
D/Q	=	the sector-averaged relative deposition for any distance in a given sector.	2.3.2
$(\overline{D/Q'})_{vp}$	=	the annual average deposition parameter for the location of controlling (critical) receptor for plant vent releases.	2.2.2.b

Term	Definition	Section of Initial Use
$(\overline{D/Q'})_{vp}$	= 1.9 x 10^{-9} m^{-2} in the NNE sector.	2.2.2.b
$(\overline{D/Q'})_{sp}$	= the annual average deposition parameter for the location of controlling (critical) receptor for main stack releases.	2.2.2.b
	= 6.9 x 10^{-10} m^{-2} in the NNE sector.	2.2.2.b
E_{ℓ}	= the energy assigned to energy group ℓ (MeV).	2.3.1
h	= the elevated release height (meters).	2.3.1
$I_{(r)k\ell}$	= the results of numerical integration over the spatial distribution of an elevated finite plume.	2.2.1
δ	= the plume depletion factor for all radionuclides other than noble gases at distance r.	2.3.1
δ_k	= the plume depletion factor for all radionuclides other than noble gases at a distance r for the appropriate stability class k (radioiodines and particulates).	2.3.1
K	= a constant associated with the K_i and V_i calculation representing a combination of constants and unit conversions.	2.3.1
K_i	= the total body dose factor due to gamma emissions from radionuclide i (mrem/yr per $\mu Ci/m^3$) from Table 2.1-1.	2.1.1

Term	Definition	Section of Initial Use
K_r	= the terrain recirculation factor.	2.3.1
L	= the horizontal distance from the ground-level receptor to the volume element considered as a point source in the evaluation of $I_{(r)k\ell}$.	2.1.1
L_i	= the skin dose factor due to beta emissions from radionuclide i (mrem/yr per μCi/m³) from Table 2.1-1.	2.1.1
M_i	= the air dose factor due to gamma emissions from radionuclide i (mrad/yr per μCi/m³) from Table 2.1-1.	2.1.1
n	= the number of hours the wind of wind speed class j is directed <u>into</u> the given sector during the existence of atmospheric stability class k.	2.3.1
N_i	= the air dose factor due to beta emissions from noble gas radionuclide i (mrad/yr per μCi/m³) from Table 2.1-1.	2.2.2.a
n_{jk}	= the number of hours meteorological conditions are observed to be in a given wind direction, windspeed class j, and atmospheric stability class k.	2.3.1
N	= the total hours of valid meteorological data.	2.3.1
P_{io}	= the dose parameter for radionuclide i (mrem/yr per μCi/m³) for the inhalation pathway.	2.2.1.b

Term		Definition	Section of Initial Use
Q_{iv}	=	the rate of release of noble gas radionuclide i (μCi/sec) from the vent release pathway under consideration.	2.1.1
Q_{is}	=	the rate of release of noble gas radionuclide i (μCi/sec) from the main stack.	2.1.2
$\tilde{Q}_{iv}$	=	the cumulative release of noble gas radionuclide i over the period of interest (μCi) from the vent release under consideration.	2.2.2.a
$\tilde{Q}_{is}$	=	the cumulative release of noble gas radionuclide i over the period of interest (μCi) from the main stack.	2.2.2.a
$\tilde{Q}_{iv}'$	=	the cumulative release of radioiodine, tritium, or material in particulate form from plant vent releases over the period of interest (μCi).	2.2.2.b
$\tilde{Q}_{is}'$	=	the cumulative release of radioiodine, tritium, or material in particulate form from the main stack over the period of interest (μCi).	2.2.2.b
r	=	the distance from the point of release to the receptor of interest for dispersion calculations (meters).	2.3.1
R_{aipj}	=	the pathway-specific, individual age-specific organ dose factor for radionuclide i, pathway p, organ j, and age group a (mrem/yr per $\mu Ci/m^3$) or (m^2-mrem/yr per μCi/sec).	2.2.2.b

Term		Definition	Section of Initial Use
R_{sv}	=	the monitor reading per mrem/yr to the skin for vent releases.	2.1.1
R_{ss}	=	the monitor reading per mrem/yr to the skin for stack releases.	2.1.1
R_{tv}	=	the monitor reading per mrem/yr to the total body for vent releases.	2.1.1
R_{ts}	=	the monitor reading per mrem/yr to the total body for stack releases.	2.1.1
Σ_j	=	the vertical standard deviation of the plume with building wake correction.	2.3.1
Σ_{zk}	=	the vertical standard deviation of the plume concentration distribution considering the initial dispersion within the building wake.	2.3.1
σ_{zk}	=	the vertical standard deviation of the plume (meters) for a given distance for ground-level releases under the stability category k indicated by $\Delta T/\Delta z$, from Figure 2.3-1.	2.3.1
$\Delta T/\Delta z$	=	the vertical temperature gradient used to determine the atmospheric stability category (°C/100 m or °F/100 ft).	2.3.1
T_d	=	the tissue density thickness taken to represent the total body dose (5 gm cm^{-2}).	2.1.1

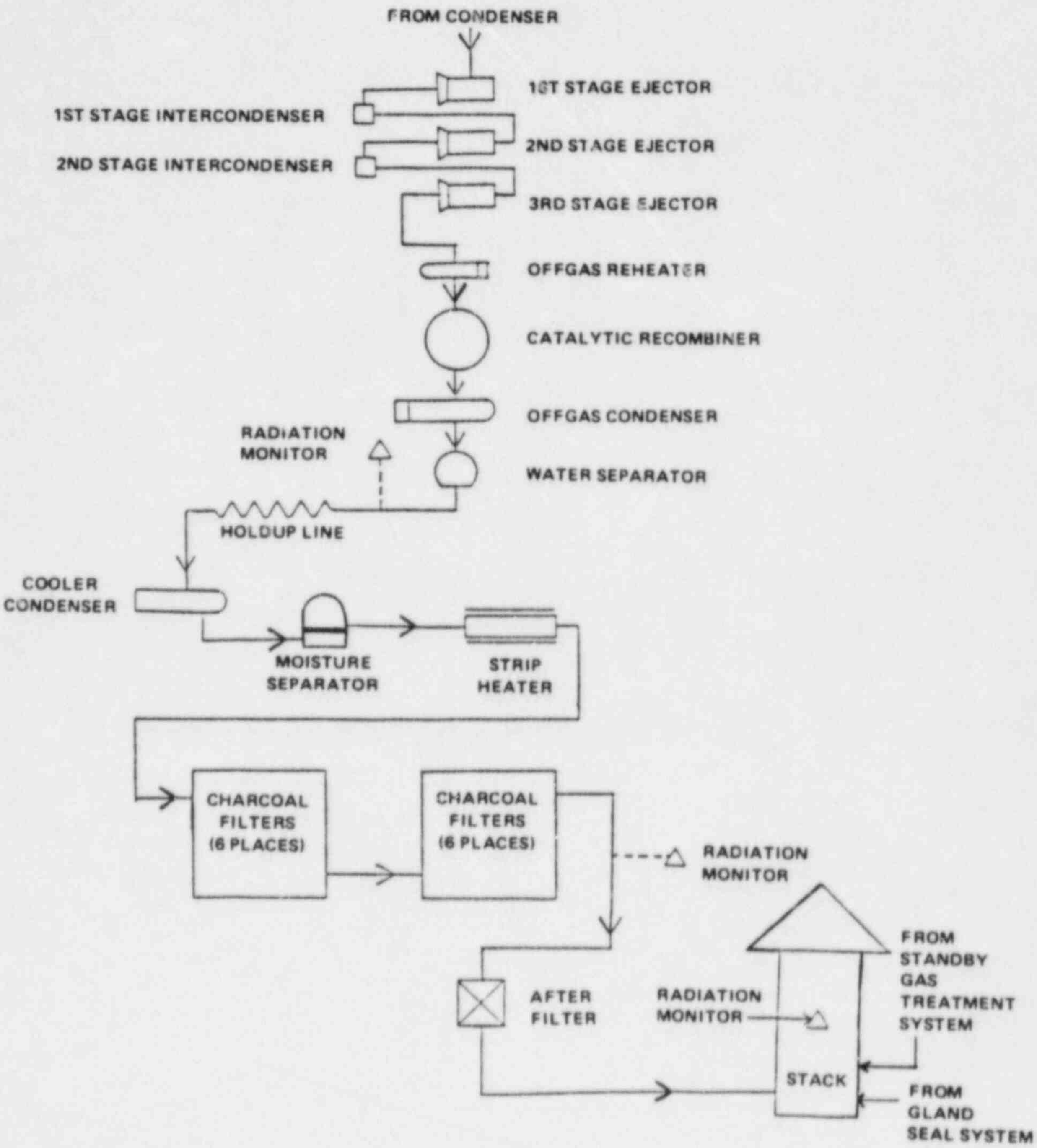
Term	Definition	Section of Initial Use
μ	= the total absorbtion coefficient for air (m^{-1}).	2.3.1
μ_a	= the energy absorbtion coefficient for air (m^{-1}).	2.3.1
μ_T	= the tissue energy absorbtion coefficient for photons of energy E_ℓ (cm^3gm^{-1}).	2.3.1
u_j	= the wind speed (midpoint of windspeed class j) at the height of release, h.	2.3.1
u_{jk}	= the wind speed (midpoint of windspeed class j) at ground level (m/sec) during atmospheric stability class k.	2.3.1
U_{jk}	= the wind speed (midpoint of windspeed class j) at the height of release, h, of an elevated release during atmospheric stability class k.	2.3.1
V_i	= a constant, which includes the dose factor, for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume resulting from the main stack release (mrem/yr per μCi/sec) from Table 2.1-2.	2.1.2
W_{vp}'	= the pathway-dependent relative dispersion or deposition in the unrestricted area at the location of the controlling receptor associated with plant vent releases.	2.2.2.b

Term	Definition	Section of Initial Use
W_{sp}'	= the pathway-dependent relative dispersion or deposition in the unrestricted area at the location of the controlling receptor associated with stack releases.	2.2.2.b
X/Q	= the sector-averaged annual average relative concentration at any distance in the given sector.	2.3.1
$\overline{X/Q}_G$	= the highest annual average relative concentration at the site boundary when considering ground-level releases.	2.1.1
$\overline{X/Q}_G$	= 6.8 x 10^{-6} sec/m³ in the W sector.	
$\overline{X/Q}_E$	= the highest annual average relative concentration in the unrestricted area associated with releases from the main stack.	2.1.1
$\overline{X/Q}_E$	= 1.0 x 10^{-7} sec/m³ in the W sector.	
$(\overline{X/Q}')_{vp}$	= the annual average relative dispersion parameter for the location of the controlling receptor for plant vent releases.	2.2.2.b
$(\overline{X/Q}')_{vp}$	= 6.1 x 10^{-7} sec/m³ in the NNE sector.	
$(\overline{X/Q}')_{sp}$	= the annual average relative dispersion parameter for the location of the controlling receptor for main stack releases.	2.2.2.b
$(\overline{X/Q}')_{sp}$	= 4.2 x 10^{-8} sec/m³ in the NNE sector.	2.2.2.b

Term		Definition	Section of Initial Use
z	=	the vertical distance from a ground-level receptor to the volume element considered as a point source in the evaluation of $I_{(r)k\ell}$.	2.3.1

2.5 GASEOUS RADWASTE TREATMENT SYSTEM

Figure 2.5-1 is a schematic of the condenser offgas treatment system showing the release points to unrestricted areas. This schematic is representative of Unit 1 and Unit 2.



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Georgia Power	EDWIN I. HATCH NUCLEAR PLANT	CONDENSER OFFGAS TREATMENT SYSTEM
		FIGURE 2.5-1

3605-0

3.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Sampling locations as required by RETS 4.16.1 are described in Table 3.0-1 and shown on maps in Figures 3.0-1 and 3.0-2.

There are no known drinking water users downstream of Plant Hatch. Therefore, the LLD for I-131 in water need not be as stringent as that for milk.

The survey of milk animals is based on the requirement in Appendix I to 10 CFR Part 50 that the licensee "Identify changes in the use of unrestricted areas (e.g., for agricultural purposes) to permit modifications in monitoring programs for evaluating doses to individuals from principal pathways of exposure." The consumption of milk from animals grazing on contaminated pasture and the consumption of vegetation contaminated by airborne radioiodine are major potential sources of exposure. Samples from milk animals are considered a better indicator of radioiodine in the environment than vegetation. Because sufficient milk samples frequently are not available within 5 miles, vegetation samples will be collected also.

Grass is available almost year-round, whereas leafy vegetation is available only for 8 months of the year at best. The sampling stations for grass are located near the site boundary in two sectors with high offsite D/Q values where it might be practical to establish a vegetation plot. The highest offsite D/Q for each individual sector occurs approximately at the site boundary.

Although either fish or clam samples may be collected from the river, fish samples are preferred, because the maximum dose commitment to a member of the public as a result of liquid effluents is through the fish consumption pathway.

Sediment will be collected annually, because shoreline recreational areas are under water and, therefore, not in use approximately half of the year.

Allowing deviations from the sampling schedule is based on the recognition of unavoidable practical difficulties which, in the absence of the allowed deviations, would result in violation of the RETS.

TABLE 3.0-1 (SHEET 1 OF 2)

RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATIONS

Location Number	Descriptive Location	Direction	Distance (miles)	Sample Type *
064	Roadside park	WNW	0.8	D
101	Inner ring	N	1.9	D
102	Inner ring	NNE	2.5	D
103	Inner ring	NE	1.8	AD
104	Inner ring	ENE	1.6	D
105	Inner ring	E	3.6	D
106	Inner ring	ESE	1.1	DV
107	Inner ring	SE	1.2	AD
108	Inner ring	SSE	1.6	D
109	Inner ring	S	0.9	D
110	Inner ring	SSW	1.1	D
111	Inner ring	SW	0.9	D
112	Inner ring	WSW	1.0	ADV
113	Inner ring	W	1.1	D
114	Inner ring	WNW	1.2	D
115	Inner ring	NW	1.1	D
116	Inner ring	NNW	1.6	AD
152	Williamson's	NNE	3.2	M
170	Upriver	WNW	**	R
172	Downriver	E	**	R
201	Outer ring	N	5.0	D
202	Outer ring	NNE	4.9	D
203	Outer ring	NE	5.0	D
204	Outer ring	ENE	4.9	D
205	Outer ring	E	7.2	D
206	Outer ring	ESE	5.0	D
207	Outer ring	SE	4.3	D
208	Outer ring	SSE	4.7	D
209	Outer ring	S	4.4	D
210	Outer ring	SSW	4.3	D
211	Outer ring	SW	4.5	D
212	Outer ring	WSW	4.4	D
213	Outer ring	W	4.3	D
214	Outer ring	WNW	5.4	D
215	Outer ring	NW	4.5	D
216	Outer ring	NNW	4.8	D

*See Sheet 2 of 2 for footnote.
**See Sheet 2 of 2 for footnote.

TABLE 3.0-1 (SHEET 2 OF 2)

RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATIONS

Location Number	Descriptive Location	Direction	Distance (miles)	Sample Type *
301	Toombs Central School	N	8.2	D
304	State prison	ENE	11.3	AD
304	State prison	ENE	10.8	M
309	Baxley substation	S	10.0	ADV
311	Johnson Brothers	SW	9.1	M

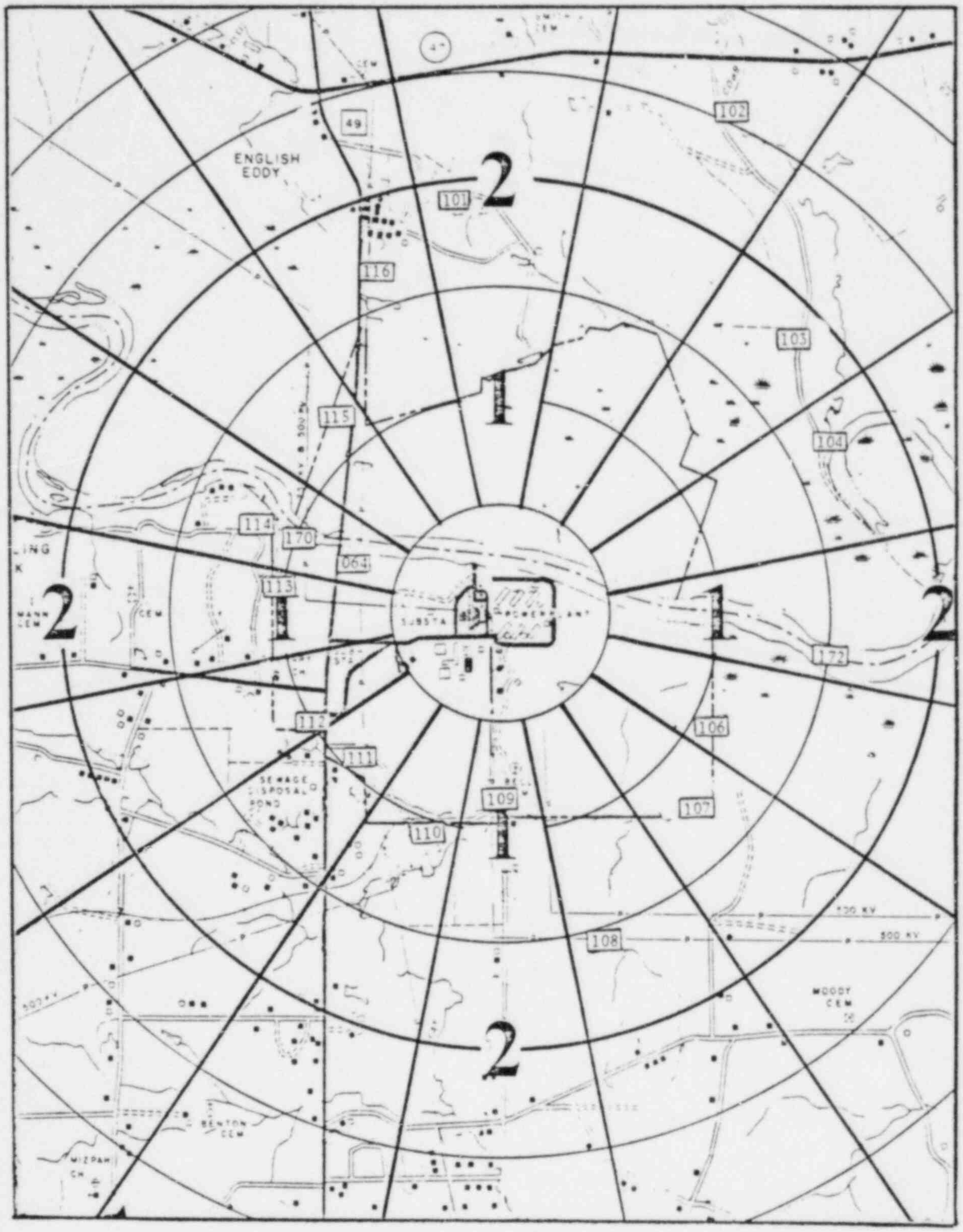
*Sample Types:

A - Airborne radioactivity
D - Direct radiation
M - Milk
R - River (fish or clams, shoreline sediment, and surface water)
V - Vegetation

** Station 170 is located at approximately 0.8 miles for riverwater, 1.1 miles for sediment and clams, and 0.9 miles for fish.

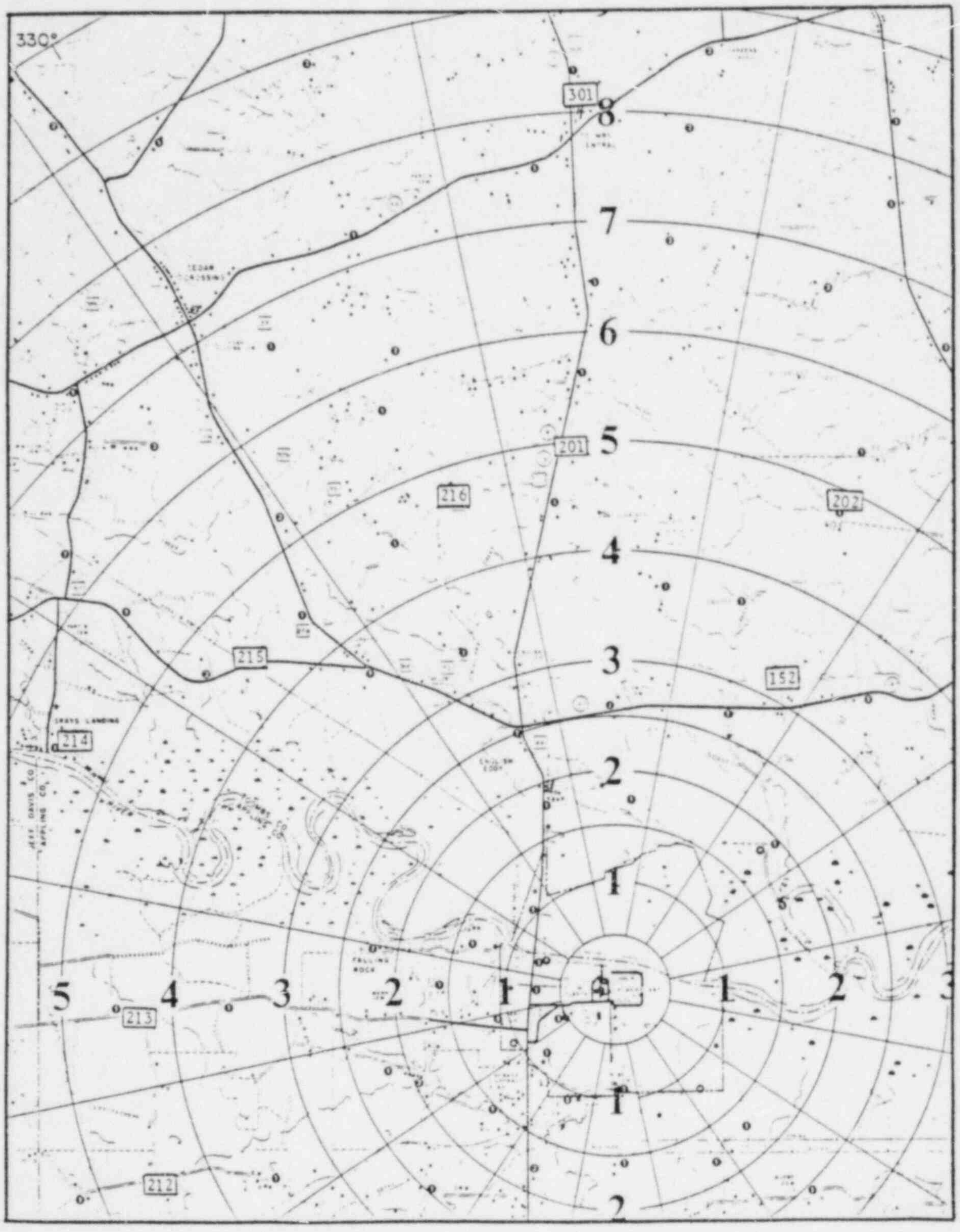
Station 172 is located at approximately 2.3 miles for riverwater, 0.5 miles for sediment and clams, and 1.7 miles for fish.

The location from which riverwater and sometimes clams and sediment may be taken can be rather precisely defined. Often, however, the sampling locations for clams have to be extended over a wide area to obtain a sufficient quantity; even then the quantity may not be sufficient. High water adds to the difficulty in obtaining clam samples; high water might also make an otherwise suitable location for sediment sampling unavailable. A stretch of the river on the order of a mile or so is generally needed to obtain adequate fish samples. The mile locations given above represent approximations of the locations about which the catches are taken.



HATCH ODCM, REV 1 5/11/84

Georgia Power EDWIN I. HATCH NUCLEAR PLANT	RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATION MAP (SITE PERIPHERY)
	FIGURE 3.0-1



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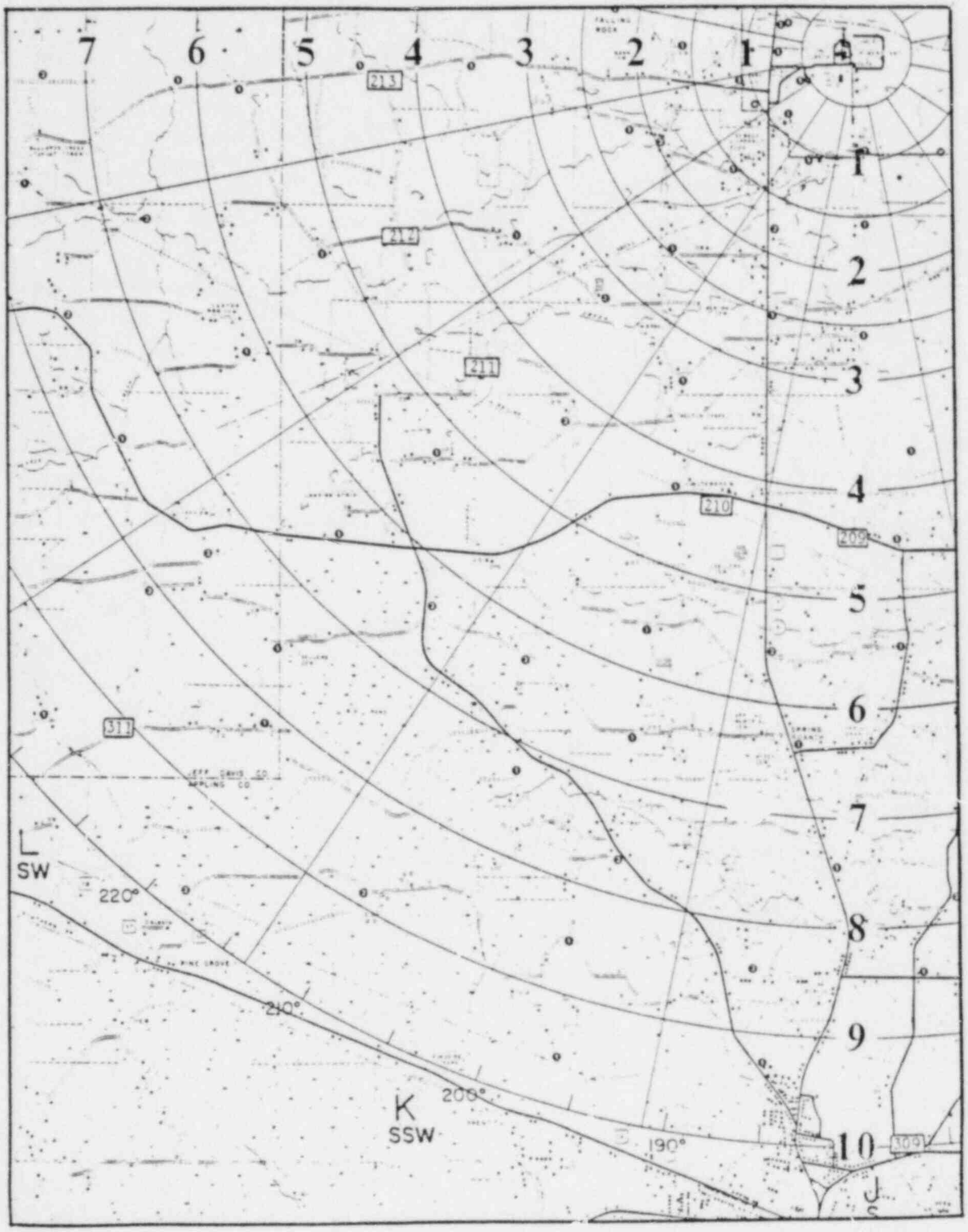
EDWIN I. HATCH NUCLEAR PLANT

RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATION MAP (BEYOND SITE VICINITY)

FIGURE 3.0-2 (SHEET 1 OF 3)

3605-0



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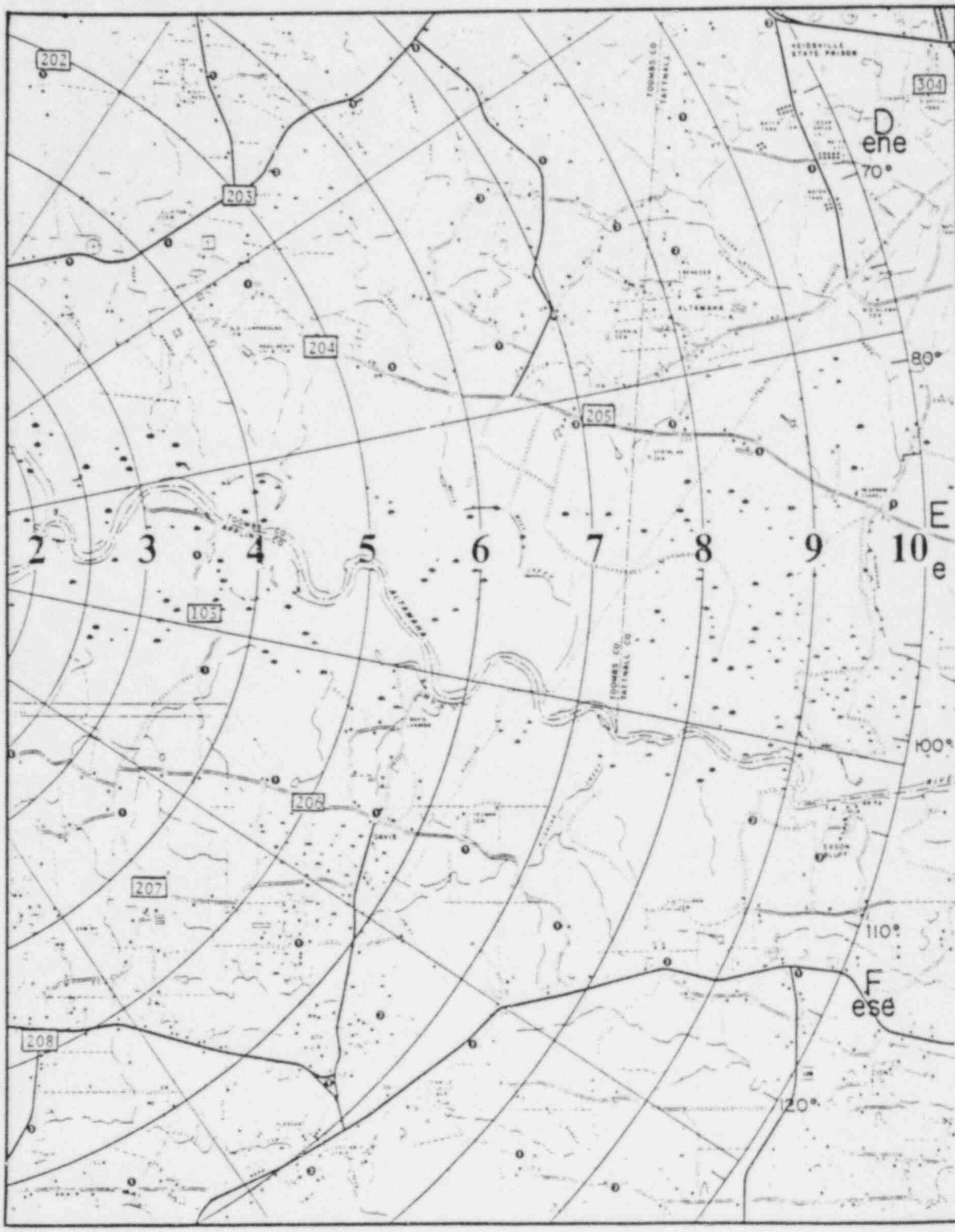
Georgia Power — EDWIN I. HATCH NUCLEAR PLANT

RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATION MAP (BEYOND SITE VICINITY)

FIGURE 3.0-2 (SHEET 2 OF 3)

3605-0



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RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATION MAP (BEYOND SITE VICINITY)

FIGURE 3.0-2 (SHEET 3 OF 3)

4.0 TOTAL DOSE DETERMINATIONS

For the purpose of implementing RETS 3.15.2.5 (Unit 1) or 3.11.2.5 (Unit 2), total dose determinations will be made by:

- Calculating doses due to liquid effluents in accordance with RETS 3.15.1.2 (Unit 1) and 3.11.1.2 (Unit 2).
- Calculating doses due to gaseous effluents in accordance with RETS 3.15.2.3 (Unit 1) and 3.11.2.3 (Unit 2).
- Combining direct radiation doses based on direct radiation measurements with these effluent doses to determine total dose to a real individual.

The methodology for calculating individual doses due to liquid effluents was presented in Section 1.2, and the methodology for calculating individual doses due to gaseous effluents was presented in Section 2.2.2.b.

5.0 POTENTIAL DOSES TO MEMBERS OF THE PUBLIC DUE TO THEIR ACTIVITIES INSIDE THE SITE BOUNDARY

For the purpose of implementing RETS 6.9.1.9, an assessment of potential doses to members of the public due to their activities within the site boundary will be performed if circumstances have changed such that any of the limits of RETS 3.11.2.2 (Unit 2), 3.11.2.3 (Unit 2), 3.15.2.2 (Unit 1) or 3.15.2.3 (Unit 1) are exceeded. The locations of concern within the site boundary are the roadside park, the camping area, the recreation area, and the Visitors Center. The relationships between annual average atmospheric dispersion of airborne radioactive materials at various locations are as follows:

Location	X/Q (sec/m³)	Estimated Occupancy Factor (by an individual during a year)
Site boundary	3.26×10^{-6}	100%
Critical receptor	6.10×10^{-7}	100%
Roadside park	3.74×10^{-6}	< 0.1% (2 hr)
Camping area	3.36×10^{-6}	< 0.6% (48 hr)
Visitors Center	1.00×10^{-5}	< 0.1% (4 hr)
Recreation area	6.71×10^{-7}	2.4% (208 hr)

In the event that any limit of RETS 3.11.2.2 or 3.15.2.2 is exceeded, an assessment will be performed considering direct radiation dose to an individual resulting in submersion in the ground-level plume. This assessment will take into consideration the annual average dispersion parameters and the estimated occupancy factor stated above, or a more precise value if available, for the locations of interest.

In the event that any limit of RETS 3.11.2.3 or 3.15.2.3 is exceeded, an assessment will be performed considering the internal dose to an individual due to inhalation of airborne radioactive materials suspended in the ground-level plume. This assessment will take into consideration the annual average dispersion parameters and the estimated occupancy factor stated above, or a more precise value if available, for the locations of interest.

If none of the limits discussed above is exceeded, potential annual doses to a member of the public at a location of concern within the site boundary are as follows:

- Potential doses to an individual at the Visitors Center are not expected to exceed 0.001 mrem due to inhalation and 0.01 mrem due to direct radiation.

- Potential doses to an individual at the roadside park are not expected to exceed 0.001 mrem due to inhalation and 0.01 mrem due to direct radiation.

- Potential doses to an individual at the camping area are not expected to exceed 0.003 mrem due to inhalation and 0.06 mrem due to direct radiation.

- Potential doses to an individual at the recreation area are not expected to exceed 0.002 mrem due to inhalation and 0.05 mrem due to direct radiation.

These values are based on annual average dispersion parameters and the estimated occupancy factors stated above. Occupancy factors for the Visitors Center, the roadside park, and the camping area are based on activities observed at these locations over the last several years. The occupancy factor for the recreation area is based on anticipated use of this facility.

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