

OFFSITE DOSE CALCULATION MANUAL
FOR
TEXAS UTILITIES GENERATING COMPANY
COMANCHE PEAK NUCLEAR STATION

OCTOBER 1984

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1. Boegli, T.S., R. R. Bellamy, W. L. Britz, and R. L. Waterfield, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," NUREG-0133 (October 1978).
2. Calculation of Annual Doses to Man from Routine Release of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I, U. S. NRC Regulatory Guide 1.109 (March 1976).
3. Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I, U. S. NRC Regulatory Guide 1.109, Rev. 1 (October 1977).
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5. "Final Safety Analysis Report," Texas Utilities Generating Company, Comanche Peak Steam Electric Station.
6. Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light - Water - Cooled Reactors, U. S. NRC Regulatory Guide 1.111 (March 1976).
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INTRODUCTION

The OFFSITE DOSE CALCULATION Manual is a supporting document of the RADIOLOGICAL EFFLUENT TECHNICAL SPECIFICATIONS. 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. Minimum OPERABLE configurations of the liquid and gaseous radwaste treatment systems are shown in Figures 1.4 and 2.1.

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 calculation methods or parameters will be incorporated into the ODCM in order to assure that the ODCM represents the present methodology in all applicable areas.

Offsite dose calculations utilized to implement the RADIOLOGICAL EFFLUENT TECHNICAL SPECIFICATIONS shall normally be performed with the RM-21 Report Processor. The RM-21 software utilizes NUREG-0133 (October 1978) dose calculation methodology. The methodology described in the ODCM shall be used as a manual backup to the RM-21.

SECTION 1.0

LIQUID EFFLUENTS

The Comanche Peak Steam Electric Station, Units 1 and 2, is located on the Squaw Creek Reservoir which is a point of supply and discharge for the plant circulating water. Liquid releases are made via the Circulating Water Discharge Canal. Discharge pathway for the liquid radwaste sources are shown in the diagram of Figure 1.1. Although no significant releases of radioactivity are expected from the General Service Water System, this effluent pathway is monitored as a precautionary measure.

1.1 GENERAL METHODOLOGY FOR DETERMINING LIQUID EFFLUENT MONITOR SETPOINTS

Normal liquid releases from the radwaste system will originate from the laundry holdup tanks and waste monitor tanks and terminate in Squaw Creek Reservoir. To ensure such discharges do not exceed the limits of 10CFR20, Appendix B, Table II, Column 2 at the release point to the unrestricted area, an in-line radiation detector monitors discharges to the circulating water discharge canal.

X-RV-5253 is the isolation valve controlled by detector X-RE-5253.

The isolation valve shuts automatically if the detector alarms or is placed out of service. The methodology for determining the setpoint for detector X-RE-5253 is as follows:

1.1.1 Isotopic Concentration of the Waste Tank

Determine the isotopic concentration of the waste tank to be released:

$$\sum_i C_i = \sum_g C_g + (C_a + C_s + C_t + C_{Fe})$$

$\sum_i C_i$ = Sum of the batch radioactive concentrations (uCi/ml)

$\sum_g C_g$ = Sum of the concentrations of each measured gamma emitter (uCi/ml)

C_a = concentration of alpha emitters as measured in the monthly composite sample. (Sample analyzed for gross alpha only) (uCi/ml)

C_s = concentration of Sr-89 and Sr-90 as measured in the quarterly composite sample (uCi/ml)

C_t = concentration of H-3 as measured in the monthly composite sample (uCi/ml)

C_{Fe} = concentration of Fe-55 as measured in the quarterly composite sample (uCi/ml)

1.1.2 Maximum Effluent Flow Rate (f)

The effluent discharge rate is determined from the number of pumps running and their capacity. The radwaste system is comprised of the following pumps:

Laundry Holdup and Monitor Tank - 100 gpm

Waste Monitor Tank Pump #1 - 100 gpm

Waste Monitor Tank Pump #2 - 100 gpm

Normally, only one waste tank will be pumped at a time. XRE-5253 is an in-line process monitor which only allows 46 gpm to flow past it. As a worst case condition, the effluent flow rate (f) will be determined as the capacity of one tank being pumped. This built in safety factor of 2.2 ensures that the effluent flow rate is not being underestimated. This maximum effluent flow rate of 100 gpm will be used in the calculation of dilution factor for all liquid radwaste system batch discharges.

1.1.3 Dilution of Liquid Effluents Due to Circulating Water Flow (F)

Since liquid effluent from the radwaste treatment system is mixed with circulating water prior to being returned to Squaw Creek Reservoir, the setpoint for detector X-RE-5253 is a function of the circulating water flow rate. The total circulating water flow rate per plant is 1.1 million gpm. This is determined from the Ingersoll-Rand pump curves (Fig. 1.3) which indicate a flow rate per pump of 275,000 gpm.

$$F(\text{diluting flow}) = (275,000 \text{ gpm/pump}) \times (\# \text{ of pumps}) \times SF$$

Where: SF = Safety Factor of (.9). This compensates for flow fluctuations from the rate predicted by the circulating water pump curves (Fig. 1.3).

1.1.4 Actual Dilution Factor (ADF)

ADF is the ratio of the effluent flow rate plus the circulating water flow rate divided by the effluent flow rate.

$$ADF = (f + F)/f$$

Where: $f = 100 \text{ gpm}$

$$F = (275,000 \text{ gpm/pump}) \times (\# \text{ of pumps}) \times SF (.9)$$

1.1.5 Required Dilution Factor (RDF)

The required dilution factor ensures that the isotopic concentrations expressed in 10CFR20, Appendix B, Table II, Column 2 are not exceeded during a discharge.

$$\begin{aligned} RDF &= \left(\sum_i (C_i / MPC_i) \right) \times SF \\ &= \left(\sum_g (C_g / MPC_g) + (C_a / MPC_a + C_s / MPC_s + C_t / MPC_t + C_{Fe} / MPC_{Fe}) \right) \times SF \end{aligned}$$

Where: MPC_i = Maximum Permissible Concentration of Radionuclide i

SF = Safety Factor of 2

NOTE: If RDF is less than 1, the tank effluent meets discharge limits without dilution. Detector, X-RE-5253, would then be set in accordance with Eq. 1 below with RFD set equal to 1.

1.1.6 Upper Setpoint Limit for Detector X-RE-5253

Eq. 1 $c = (ADF/RDF) \times C_g$

Where c = The gamma concentration corrected for dilution in microcuries/ml.

As a further consideration, the reservoir into which the diluted radwaste flows may build up a concentration of radioactive isotopes. It is therefore necessary to account for recirculation of previously discharged radionuclides. This is accomplished as follows:

$$\text{Eq. 2} \quad F' = F (1 - \sum_i (C'_i / \text{MPC}_i))$$

F' = Adjusted Circulating Water Flow Rate

C'_i = Radionuclide Concentration of the Reservoir

MPC_i = Maximum Permissible Concentration of Radionuclide i

$F = (275,000 \text{ gpm/pump}) \times (\# \text{ of pumps}) \times \text{SF} \times \text{AF}$

NOTE: If C'_i is less LLD then $F' = F$ and no adjusted flow rate need be considered in the calculation of ADF. LLD is the smallest concentration of radioactive material in a sample that will be detected with a 95% probability.

When considering the mixture of nuclides in the liquid effluent stream in terms of detector sensitivity, the most probable nuclides present would be those referenced in Technical Specifications 3/4.11.1.1. Figure 1.2 is a representative energy spectrum response for the RD-33 type detector used in XRE-5253. This curve illustrates that for any given mixture of the most probable nuclides present, the conversion factor between counts per minute and microcuries per ml remains relatively constant. In fact between

Cs-137 and Co-60, the total change in sensitivity is approximately 7%. Because this is well within the accuracy of measurement, there is no need to change the software sensitivity for given varied effluent concentrations. However, should the concentration of previously unexpected nuclides become significant, further evaluation would be required.

1.2 Dose Calculation for Liquid Effluents

The dose contribution from the release of liquid effluents will be calculated once per 31 days and a cumulative summation of the total body and organ doses will be maintained for each calendar quarter. The dose contribution for all batch releases for the quarter will be calculated using the following equation:

$$D_i = \sum_1 [A_{1\tau} t_k C_{ik} F_k]$$

Where: D = the cumulative dose commitment to the total body or any organ from all liquid effluent releases in a 31 day period.

t_k = the time duration of the batch release in hours.

C_{ik} = the isotopic concentration (microcuries/ml) of radionuclide (i) found in the pre-release sample. Concentrations are determined primarily from a gamma isotopic analysis of the liquid effluent sample. For Sr89, Sr90, H3, and Fe55, the last measured value will be used in the dose calculation.

F_k = near field average dilution factor during a liquid effluent release. Defined as the ratio of the average undiluted liquid waste flow during release to the average circulating water flow.

$$= \frac{\text{Actual Effluent Flow Rate}}{\text{Circulating Water Flow Rate}}$$

A_{iT} = the site related ingestion dose commitment factor to the total body or any organ for each identified principle gamma and beta emitter, mRem/hr per microcurie/ml.

$$A_{iT} = k_o (U_w / D_w + U_F BF_i) DF_i$$

Where: k_o = unit conversion factor, 1.14×10^5

U_w = adult water consumption, 730 liters/year

U_F = adult fish consumption, 21 liters/year

BF_i = Bio accumulation factor, Table A-1, Ref. 3

DF_i = Dose Conversion Factor, Table II, Ref. 2

D_w = near field dilution factor, (1) for CPSES

Calculated values for A_{iT} are given in Table 1.1.

NOTE: It may be necessary to consider the recirculation of previously discharged radionuclides should they be detected in the water of Squaw Creek Reservoir. If C'_i (lake) is greater than LLD, the D_{iT} must be calculated and added to the 31 day D_{iT} (effluent) amount.

$$D_{iT} \text{ (lake)} = A_{iT} \times t \times C'_i$$

Where: t = 744 hours (31 days)

C'_i = isotopic concentration for radionuclides in the lake.

TABLE 1.1

SITE RELATED INGESTION DOSE COMMITMENT FACTOR A_{IT}
(mREM/hr per μ Ci/ml)

ATOM	BONE	LIVER	T-BODY	THYROID	KIDNEY	LUNG	GI-LLI
H3	0.00E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
C14	3.15E+04	6.30E+03	6.30E+03	6.30E+03	6.30E+03	6.30E+03	6.30E+03
P32	4.62E+07	2.87E+06	1.79E+06	0.00E+00	0.00E+00	0.00E+00	5.20E+06
CR51	0.00E+00	0.00E+00	1.49E+00	8.94E-01	3.29E-01	1.98E+00	3.76E+02
MN54	0.00E+00	4.76E+03	9.08E+02	0.00E+00	1.42E+03	0.00E+00	1.46E+04
FE55	8.87E-02	6.13E+02	1.43E+02	0.00E+00	0.00E+00	3.42E+02	3.52E+02
FE59	1.40E+03	3.29E+03	1.26E+03	0.00E+00	0.00E+00	9.19E+02	1.10E+04
CO58	0.00E+00	1.51E+02	3.39E+02	0.00E+00	0.00E+00	0.00E+00	3.06E+03
CO60	0.00E+00	4.34E+02	9.58E+02	0.00E+00	0.00E+00	0.00E+00	8.16E+03
NI63	4.19E+04	2.91E+03	1.41E+03	0.00E+00	0.00E+00	0.00E+00	6.07E+02
NI65	2.36E+04	7.50E+04	3.39E+04	0.00E+00	5.02E+04	0.00E+00	4.73E+04
RB86	0.00E+00	1.03E+05	4.79E+04	0.00E+00	0.00E+00	0.00E+00	2.03E+04
SR89	4.78E+04	0.00E+00	1.37E+03	0.00E+00	0.00E+00	0.00E+00	7.66E+03
SR90	1.18E+06	0.00E+00	2.88E+05	0.00E+00	0.00E+00	0.00E+00	3.40E+04
Y91M	1.30E-02	0.00E+00	5.04E-04	0.00E+00	0.00E+00	0.00E+00	3.82E-02
Y91	2.02E+01	0.00E+00	5.39E-01	0.00E+00	0.00E+00	0.00E+00	1.11E+04
ZR95	2.77E+00	8.88E-01	6.01E-01	0.00E+00	1.39E+00	0.00E+00	2.82E+03
RB95	4.47E+02	2.49E+02	1.34E+02	0.00E+00	2.46E+02	0.00E+00	1.51E+00
TC99M	2.94E-02	8.32E-02	1.06E+00	0.00E+00	1.26E+00	4.07E-02	4.92E+01
RU103	1.98E+01	0.00E+00	8.54E+00	0.00E+00	7.57E+01	0.00E+00	2.31E+03
RU106	2.95E+02	0.00E+00	3.73E+01	0.00E+00	5.69E+02	0.00E+00	1.91E+04
AG110M	1.42E+01	1.31E+01	7.80E+00	0.00E+00	2.58E+01	0.00E+00	5.36E+03
TE125M	2.79E+03	1.01E+03	3.74E+02	8.39E+02	1.13E+04	0.00E+00	1.11E+04

TABLE 1.1

SITE RELATED INGESTION DOSE COMMITMENT FACTOR. A_{IT}
(mREM/hr per uCi/ml)

ATOM	BONE	LIVER	T-BODY	THYROID	KIDNEY	LUNG	GI-LLI
TE127M	7.05E+03	2.52E+03	8.59E+02	1.80E+03	2.86E+04	0.00E+00	2.36E+04
TE127	1.14E+02	4.11E+01	2.48E+01	8.48E+01	4.66E+02	0.00E+00	9.03E+03
TE129M	1.20E+04	4.47E+03	1.89E+03	4.11E+03	5.00E+04	0.00E+00	6.03E+04
TE129	3.27E+01	1.23E+01	7.96E+00	2.51E+01	1.37E+02	0.00E+00	2.47E+01
I131	4.96E+02	7.09E+02	4.06E+02	2.32E+05	1.22E+03	0.00E+00	1.87E+02
CS134	3.03E+05	7.21E+05	5.89E+05	0.00E+00	2.33E+05	7.75E+04	1.26E+04
CS136	3.17E+04	1.25E+05	9.01E+04	0.00E+00	6.97E+04	9.55E+03	1.42E+04
CS137	3.88E+05	5.31E+05	3.48E+05	0.00E+00	1.80E+05	5.99E+04	1.03E+04
BA140	1.38E+03	2.37E+00	1.23E+02	0.00E+00	8.05E+01	1.35E+00	3.88E+03
CE144	4.18E+01	1.75E+01	2.24E+00	0.00E+00	1.04E+01	0.00E+00	1.41E+04
PR143	1.32E+00	5.28E-01	6.52E-02	0.00E+00	3.05E-01	0.00E+00	5.77E+03
ND147	9.00E-01	1.04E+00	6.22E-02	0.00E+00	6.08E-01	0.00E+00	4.99E+03
W187	3.04E+02	2.55E+02	8.90E+01	0.00E+00	0.00E+00	0.00E+00	8.34E+04
NP239	1.28E-01	1.25E-02	6.91E-03	0.00E+00	3.91E-02	0.00E+00	2.57E+03

1.3 SERVICE WATER EFFLUENT RADIATION MONITORS 1RE-4269/4270

Concentration of radioactivity in this effluent line normally is expected to be insignificant. Therefore, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur. To this end, the background multiple will be three (3) [i.e., setpoint will be initially established at three times background until further data can be collected]. If this effluent stream should become contaminated with radioactivity, radionuclide concentrations must be determined and a radiation monitor setpoint determined as follows:

$$C = \left(\sum_g C_g \right) + DF \text{ (Setpoint upper limit)}$$

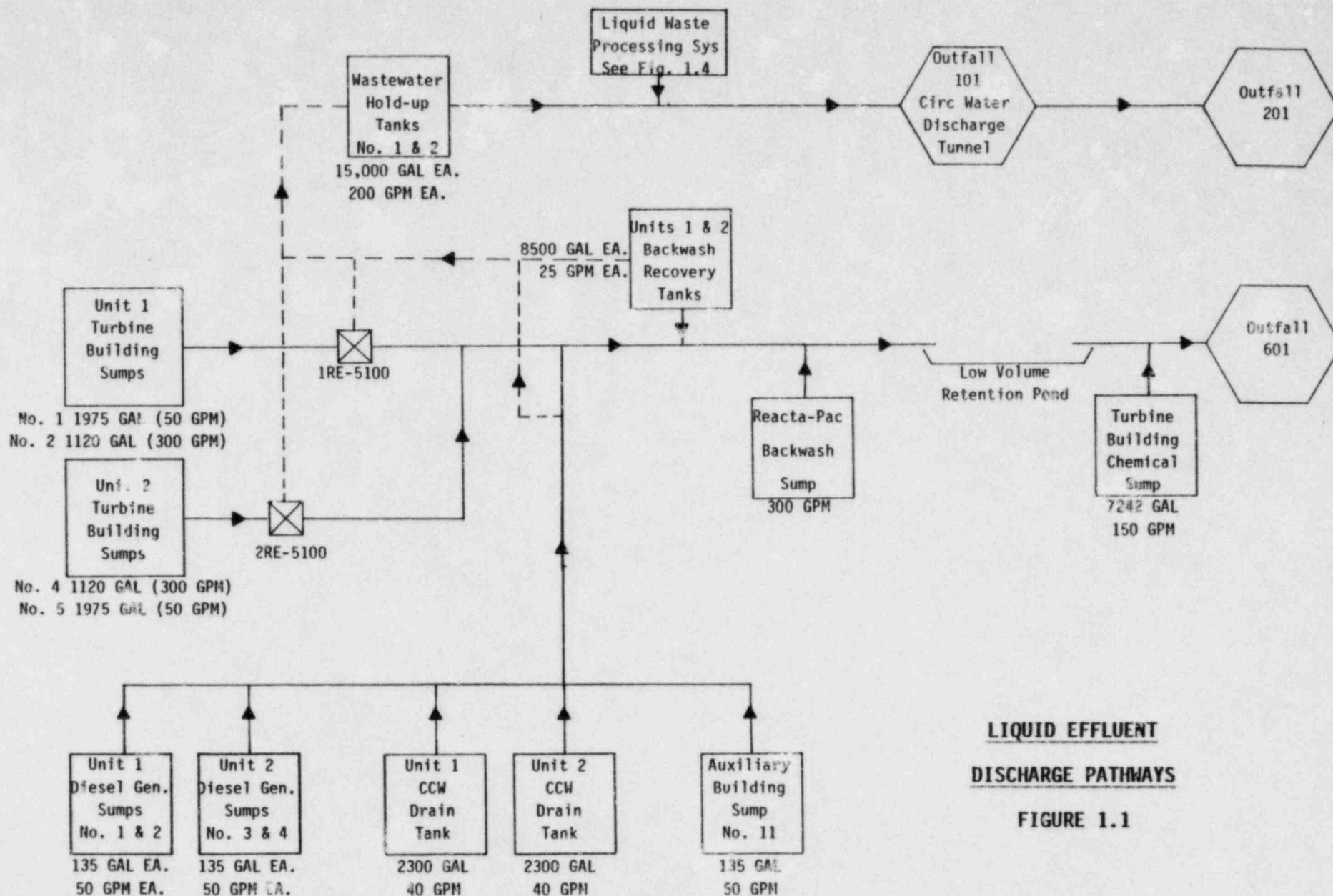
Where $\sum_g C_g$ = Sum of the concentrations of each measured gamma emitter observed in the effluent ($\mu\text{Ci/ml}$)

$$DF = \sum_i (C_i / MPC_i)$$

For this release pathway no additional dilution is available. Therefore, no releases are permissible if DF is greater than 1.

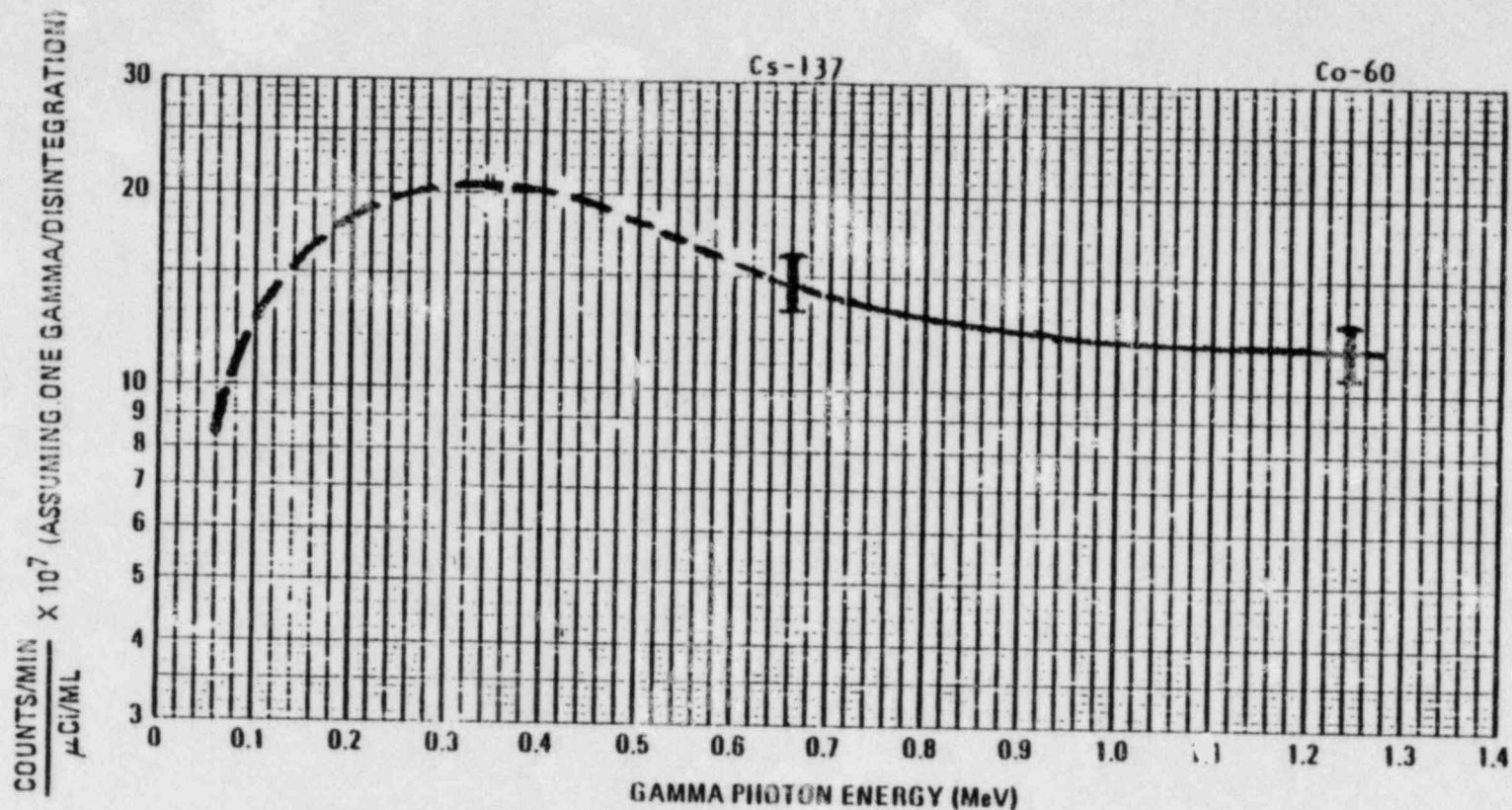
1.4 Turbine Building Sump Effluent Radiation Monitor IRE-5100

The purpose of the detector for the turbine building sumps is to monitor discharges and divert the turbine building sumps from the Low Volume Waste Pond to the Waste Water Holdup Tanks if they become radioactive. Because the only sources to the sump effluent are from the secondary steam system, activity is expected in the turbine building sump effluent only if a significant primary-to-secondary leak is present. Since only non-radioactive turbine building sump water is allowed to go to the Low Volume Waste Pond, 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. To this end, the background multiple will be three (3) [i.e., setpoint will be initially established at three times background until further data can be collected]. Then, if this setpoint is exceeded, IRE-5100 will direct valves IRV-5100A and B to divert the turbine building sumps to the Waste Water Holdup Tanks where they can then be sampled and released to Squaw Creek Reservoir per 10 CFR 20 limits.



**LIQUID EFFLUENT
DISCHARGE PATHWAYS**
FIGURE 1.1

71-1



EL-3509

NOTE: Shape of curve is taken from earlier data (reference report E-199-558) for photon energies below .662 keV.

Figure 1-2 Detector energy response to gamma radiations for Rb-33 offline gamma detector

DESIGN CONDITIONS

GPM 276,000 EFF 88
TH (FT) 28 BHP 2200 BQL 1.0
RPM 2500 DRIVER 2500
1.18 SF

FIGURE 1.3

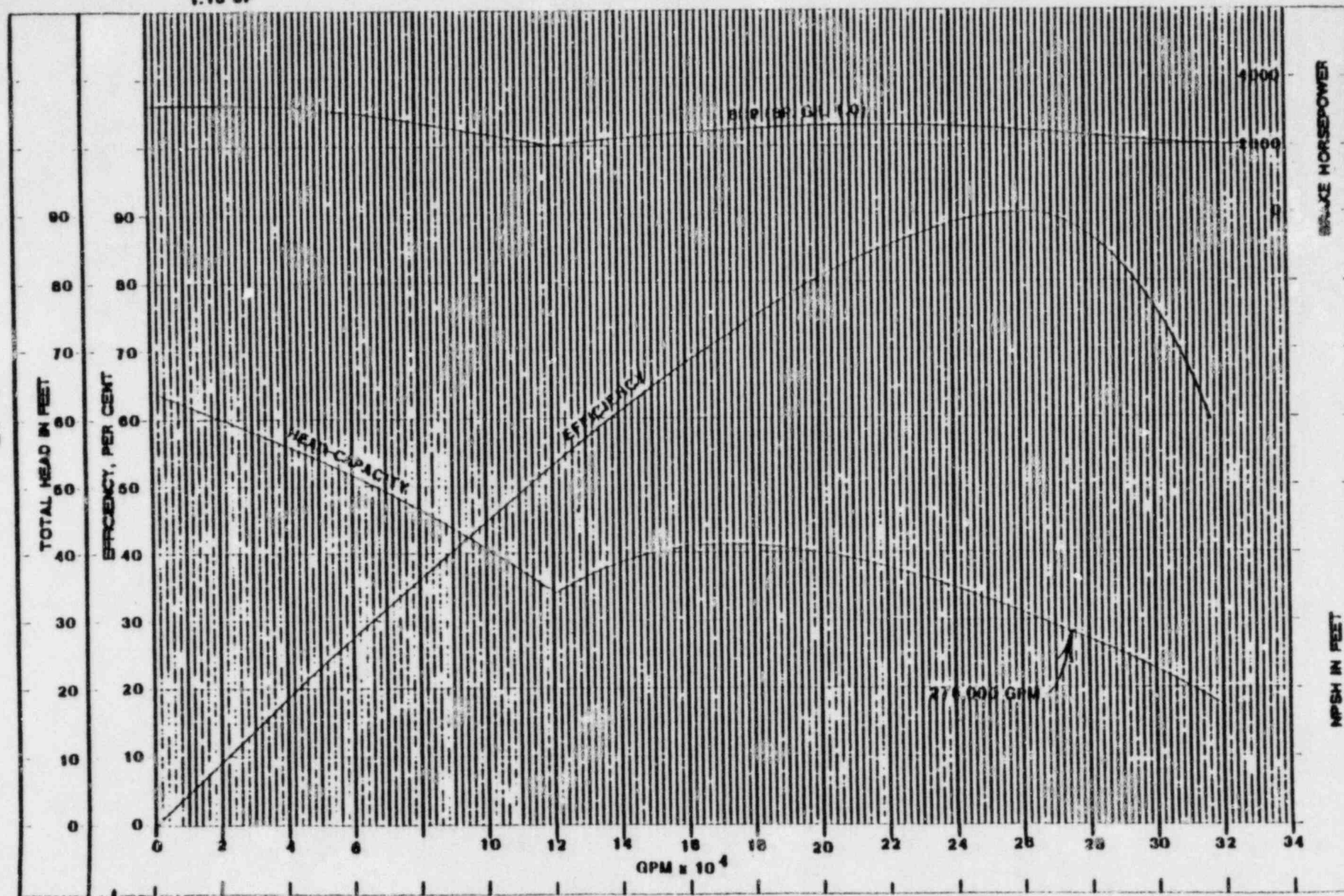
CIRCULATING WATER PUMP CURVES

INGERSOLL-RAND CURVE # HY-3552-3

for Pump 83 APMA-1

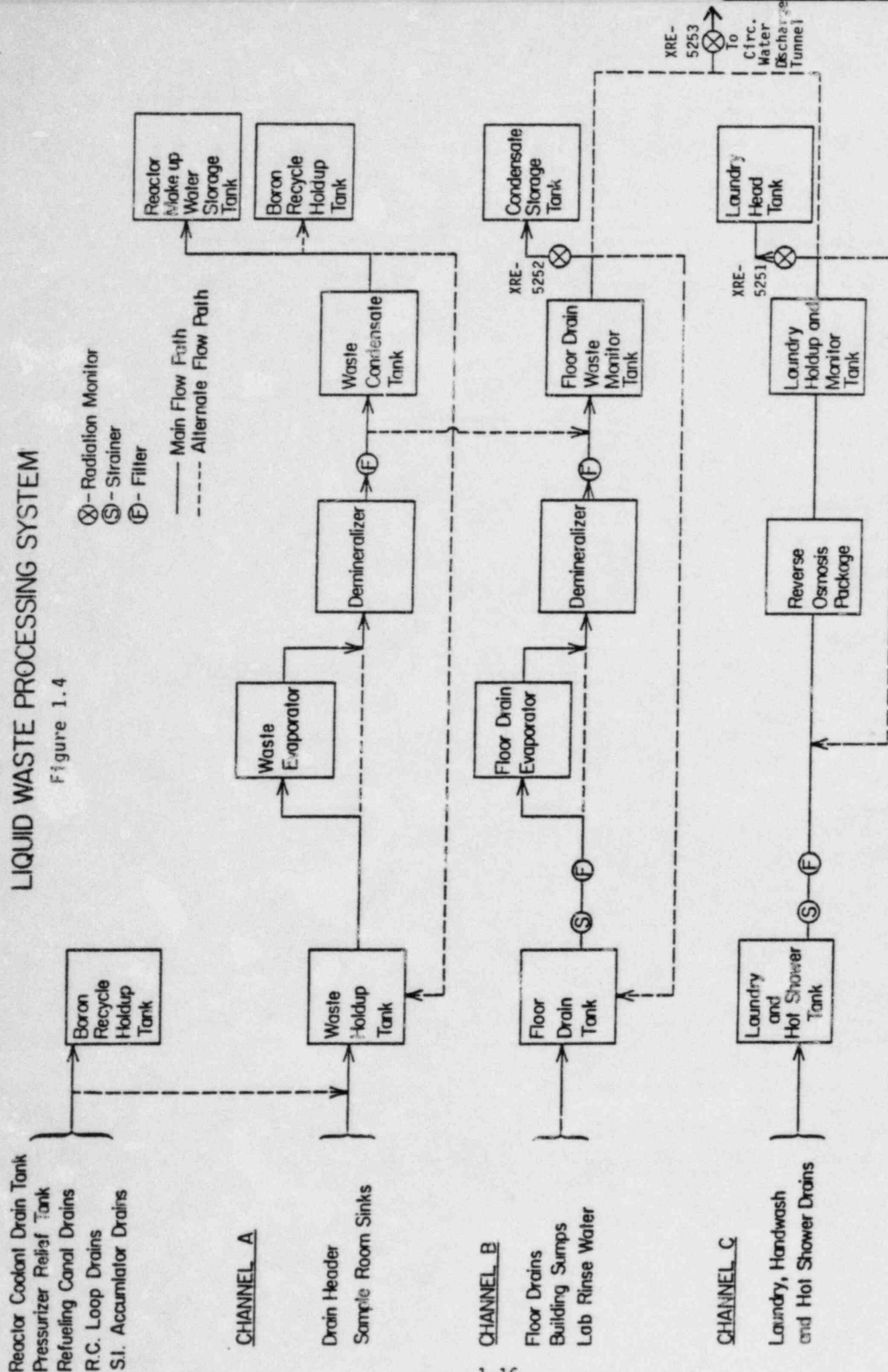
DATE 8/25/77

1-15



LIQUID WASTE PROCESSING SYSTEM

Figure 1.4



SECTION 2.0
GASEOUS EFFLUENTS

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 made 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 a calculated setpoint is less than the monitor reading associated with the particular release pathway, no release may be made. Under such circumstances, contributing source terms may be reduced and the setpoint recalculated.

At CPSES, all gaseous effluents are released to the atmosphere through the two Plant Vent Stacks (Figure 2.1). Setpoint methodology for the noble gas monitors associated with the plant vent is addressed in the following section.

2.1.1.a DOSE RATES DUE TO NOBLE GASES

For implementation of Technical Specifications 3.11.2.1.a, the dose rate at the unrestricted area boundary due to noble gases shall be calculated as follows:

$$D_t = \text{average total body dose rate in the current year (mrem/yr)}$$

$$= (\overline{X/Q}) \sum_i K_i Q_i$$

$$D_s = \text{average skin dose rate in the current year (mrem/yr)}$$

$$= (\overline{X/Q}) \sum_i (L_i + 1.1 M_i) (Q_i)$$

$\overline{X/Q}$ = 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.

$$= 3.3 \times 10^{-6} \text{ sec/m}^3 \text{ in the NNW sector}$$

K_i = total body dose factor due to gamma emissions from noble gas radionuclide i (mrem/hear per microcurie/ m^3) from Table 2.1.

L_i = skin dose factor due to beta emissions from noble gas radionuclide i (mrem/yr per microcurie/ m^3) from Table 2.1.

M_i = air dose factor due to gamma emissions from noble gas radionuclide i (mrad/yr per microcurie/ m^3) from Table 2.1.

Q_i = the release rate of noble gas radionuclide i from the Plant Vent Stack (microcurie/sec).

= the product of X_{iv} and F_v , where X_{iv} is the concentration of noble gas radionuclide i (microcurie/cc) as measured at the vent and F_v is the flowrate at the vent (m^3/sec).

2.1.1.b PLANT VENT STACK NOBLE GAS MONITORS XRE5570A/B and XRE5567A/B

For implementation of Technical Specification 3.3.3.11, the alarm setpoint level for these noble gas monitors will be calculated as follows:

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

$$\begin{aligned} & (SF) \times R_t \times D_{TB} \times AF \\ = & \text{the lesser of} \qquad \qquad \text{or} \\ & (SF) \times R_s \times D_{ss} \times AF \end{aligned}$$

SF = Safety Factor (.5); a conservative factor applied to each noble gas monitor to compensate for statistical fluctuations and errors of measurement.

AF = Allocation Factor (.5); a factor allowing for releases from both plant stacks simultaneously.

R_t = monitor reading per mrem/yr to the total body
 $= C + (X/Q) \sum_i K_i Q_i D_t$

R_s = monitor reading per mrem/yr to the skin
 $= C + (X/Q) \sum_i (L_i + 1.1 M_i) Q_i$

1.1 = mrem skin dose per mrad air dose

C = calculated monitor reading of a noble gas monitor corresponding to the concentration due to the combined sources as calculated from the grab sample radionuclide concentrations taken in accordance with RETS Table 4.11-2.

D_{TB} = dose rate limit to the total body of an individual in an unrestricted area.

= 500 mrem/year (Technical Specification 3.11.2.1a).

D_{ss} = Dose rate limit to the skin of the body of an individual in an unrestricted area.

= 3000 mrem/year (Technical Specification 3.11.2.1.a).

With the addition of a batch release (waste gas decay tank or containment purge) into the effluent stream, the Q_1 term will be calculated in a similar manner as previously shown. The flow rate at the vent monitor is given by

$$F_v = F_c + F_B$$

where

F_c = the flow rate contribution of the plant ventilation system (ml/sec).

F_B = the flow rate contribution associated with the release rate of the batch source (ml/sec). This value will be very small as compared to the value of F_c .

The resulting concentration due to the combined sources that would be detected by the Plant Vent Stack Monitor is given by:

$$X_{iv} = \frac{X_{ic} F_c + X_{iB} F_B}{F_c + F_B}$$

where:

X_{ic} = the concentration of noble gas radionuclide i
(microcurie/ml) in the continuous release stream as
sampled in accordance with RETS Table 4.11-2.

X_{iB} = the concentration of noble gas radionuclide i
(microcurie/ml) in the batch release stream as sampled
in accordance with RETS Table 4.11-2.

The count rate corresponding to this combined concentration (X_{iv})
at the vent monitor is determined by the monitor calibration
curve as previously described. The release rate at the vent for
noble gas radionuclide i (microcurie/sec) is given by

$$\begin{aligned} Q_i &= F_v X_{iv} \\ &= X_{ic} F_c + X_{iB} F_B \end{aligned}$$

2.1.1c AUXILIARY BUILDING VENTILATION EXHAUST MONITOR XRE-5701

For implementation of Technical Specification 3.3.3.11,
the alarm setpoint for the Auxiliary Building
Ventilation Exhaust Monitor will be calculated in the
following manner: The alarm setpoint is based on
Waste Gas Decay Tank Purge Operations only
(i.e., a containment purge or vent is not occurring at
the same time.)

$$F_v = F_c + F_b \quad \text{from section 2.1.1b}$$

$$F_{aux} = F_b$$

= the flowrate contribution associated with the
release of the Waste Gas Decay Tanks (ml/sec).

$$Q_i = X_{iv} F_v \quad \text{from section 2.1.1b}$$

$$X_{iv} F_v = X_{ic} F_c + X_{iaux} F_{aux}$$

X_{iaux} = the concentration of noble gas radionuclide i (microcurie/ml) in the Waste Gas Decay Tank release stream as sampled in accordance with RETS Table 4.11.2.

Assuming that X_{iaux} is much greater than X_{ic} , $X_{iv} F_v$ is approximately equal to $X_{iaux} F_{aux}$. Since the setpoint of the monitor is proportional to the concentration of the release stream,

$$C_s F_v = C_{aux} F_{aux}$$

$$C_{aux} = (C_s F_v) / F_{aux}$$

= monitor reading of the Auxiliary Building Ventilation Exhaust Monitor at the alarm setpoint concentration.

2.1.1d CONTAINMENT ATMOSPHERE GASEOUS MONITOR 1RE-5503

For implementation of Technical Specification 3.3.3.1, the alarm setpoint for the Containment Atmosphere Gaseous Monitor will be calculated in the following manner during containment purge or vent (assume Waste Gas Decay Tank Purge operations are not occurring).

$$F_v = F_c + F_b \quad \text{from Section 2.1.16}$$

$$F_{cont} = F_b$$

= the flowrate contribution associated with the release of the containment atmosphere (ml/sec)

$$Q_i = X_{iv} F_v \quad \text{from section 2.1.16}$$

$$X_{iv} F_v = X_{ic} F_c + X_{icont} F_{cont}$$

X_{icont} = the concentration of noble gas radionuclide i (microcurie/ml) in the containment release stream as sampled in accordance with RETS Table 4.11-2.

Assuming that X_{icont} is much greater than X_{ic} , $X_{iv} F_v$ is approximately equal to $X_{iaux} F_{aux}$. Since the setpoint of the monitor is proportional to the concentration of the release stream,

$$C_s F_v = C_{cont} F_{cont}$$

$$C_{cont} = (C_s F_v) / F_{cont}$$

= monitor reading of the Containment Atmosphere Gaseous Monitor at the alarm setpoint concentration

2.1.2a DOSE RATES DUE TO RADIOIODINES, TRITIUM, AND PARTICULATES

Organ doses due to radioiodines, tritium, and all radioactive materials in particulate form with half-lives greater than eight days, will be calculated to implement the requirements of Technical Specification 3.11.2.1.b as follows:

D_o = average organ dose rate in the current year
(mrem/yr)

$$= (\overline{X/Q}) \sum_i P_i Q_i$$

where: P_i = dose parameter factor for radionuclide i ;
(mrem/yr per microcurie/m³), for inhalation.
(Table 2.2)

Q_i = the release rate of radionuclide i (for
radioiodine, tritium, and particulates) as
determined from the concentrations measured in the
analysis of the appropriate sample required by
Technical Specification 3.11.2.1.b.

2.1.2b PLANT VENT STACK IODINE MONITORS XRE-5575A/B

In general it is not practical to establish a setpoint
for the Plant Vent Stack Radioiodine Monitors to ensure
compliance with Technical Specification 3.11.2.1b.

However, in an effort to establish a conservative basis
to which the alarm can be set, the monitor will be set
to provide warning of the Technical Specification limit
for the most limiting radionuclide, I-131, as indicated
in FSAR 11.5.2.5.6. Therefore, dose rate calculations
should be performed in accordance with Section 2.2.1 and
compared with the Technical Specification dose rate

limit of 1500 mrem/year for compliance. An Allocation Factor and Safety Factor should also be utilized for this determination.

$$1500 \text{ mrem/yr} = (\overline{X/Q}) \sum_i P_i Q_i \quad \text{from Section 2.1.2.a}$$

$$Q_i = F_v X_{iI} \quad \text{from Section 2.1.1.a}$$

$$X_{iI} = [(AF) X (SF) X 1500 \text{ mrem/yr}] / [(\overline{X/Q}) P_i F_v]$$

$$X_{iI} = 6.98 / F_v$$

where X_{iI} = the monitor reading of Iodine at the alarm setpoint concentration.

(all other variables previously defined)

2.1.2c PLANT VENT STACK PARTICULATE MONITORS XRE-5568A/B

Continuous integrating particulate monitors cannot practically be set to an instantaneous alarm setpoint as indicated in NUREG 0133 Section 5.1.1. However, in an effort to establish a conservative basis to which the alarm can be set, the monitor will be set to provide warning of the Technical Specification limit for the most limiting particulate, Cs-137 as indicated in FSAR 11.5.2.5.6.

$$X_{ip} = [(AF) (SF) \times 1500 \text{ mrem/yr}] / [(\overline{X/Q}) P_i F_v]$$

$$X_{ip} = 125.4 / F_v$$

where X_{ip} = the monitor reading of particulate Cs-137 at the alarm setpoint concentration.

(all other variables previously defined)

TABLE 2.1

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

<u>Nuclide</u>	<u>-Body*** (K)</u>	<u>-Skin***(L)</u>	<u>-Air**(M)</u>	<u>-Air**(N)</u>
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

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

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

2.2 GASEOUS EFFLUENT DOSE CALCULATIONS

2.2.1 AIR DOSE IN UNRESTRICTED AREAS

For implementation of Technical Specification 3.11.2.1 and 3.11.2.4, the air dose in unrestricted areas shall be determined as follows:

D = air dose due to gamma emissions from noble gas

radionuclide i (mrad)

$$= 3.17 \times 10^{-8} \sum_i M_i (\bar{X}/Q) \tilde{Q}_i$$

where: 3.17×10^{-8} = the fraction of a year represented by one second

M_i is defined in section 2.1.1a

\bar{X}/Q = the relative concentration for the location occupied by the maximum exposed individual.

If actual value not available, use X/Q .

$= 3.3 \times 10^{-6}$ sec/m³ in the NNW Sector

\tilde{Q}_i = the cumulative release of noble gas radionuclide i (microcuries) for the type of release under consideration

D = air dose due to beta emissions from noble gas

radionuclide i (mrad)

$$= 3.17 \times 10^{-8} \sum_i N_i (\bar{X}/Q) \tilde{Q}_i$$

where: N_i = the air dose factor due to beta emissions

from noble gas radionuclide i (mrad/yr per microcurie/m³) Table 2.1

2.2.2 DOSE TO AN INDIVIDUAL

Dose to an individual from radioiodine, tritium, and radioactive materials in particulate form will be calculated to implement Technical Specification 3.11.2.3 and 3.11.2.4 as follows:

$$D_p = \text{dose to an individual from radioiodine, tritium, and radionuclides in particulate form (mrem)}$$

$$= 3.17 \times 10^{-8} \sum_i R_i W \tilde{Q}_i$$

where: W = the dispersion parameter for estimating the dose to an individual at the controlling location

$$W = \overline{X/Q} \text{ for the inhalation pathway in sec/m}^3$$

$$= 3.3 \times 10^{-6} \text{ sec/m}^3 \text{ in the NNW sector}$$

$$W = \overline{D/Q} \text{ for the food and groundplane pathway in m}^{-2}$$

$$= 2.8 \times 10^{-9} \text{ m}^{-2} \text{ in the WNW sector}$$

NOTE: for tritium, the dispersion parameter, W, is always taken as $\overline{X/Q}$.

$$R_i = \text{dose factor for radionuclide } i \text{ (Table 2.3 - 2.6)}$$

$$\tilde{Q}_i = \text{cumulative release of radionuclide } i \text{ as required by Technical Specification 3.11.2.3 in (microcuries)}$$

2.2.3 DOSE CALCULATIONS TO SUPPORT OTHER TECHNICAL SPECIFICATIONS

For the purpose of implementing Technical Specification 6.9.1.11, dose calculations will be performed using the above equations with the substitution of average meteorological parameters for the period of the report, and the appropriate pathway receptor dose factors (R_1). Values for R_1 may be found in Tables 2.3 through 2.6.

For the purpose of implementing Technical Specification 6.9.1.7, dose calculations may be performed using the above equations with the substitution of the dispersion parameters (X/Q , D/Q) which are concurrent with actual releases, and the appropriate pathway receptor dose factors.

For the purpose of implementing Technical Specification 3.12.2, dose calculations may be performed using the above equations substituting the appropriate pathway receptor dose factors and the appropriate dispersion parameters for the location(s) of interest. Annual average dispersion parameters (or grazing period average) for D/Q may be used for these calculations.

For the purpose of implementing Technical Specification 3.11.4, the total annual dose to an individual may be determined by combining the annual doses determined for a member of the public in accordance with Technical Specification 3.11.1.2

and/or 3.11.2.3 with the direct radiation dose received by the particular member of the public. This determination is required only in the event calculated doses exceed twice the limits of 3.11.1.2 or 3.11.2.3 as specified in Technical Specification 3.11.4. The dose component due to direct radiation may be determined by thermoluminescent dosimeters or other appropriate methods of determining direct radiation levels.

TABLE 2.2

ATOM	PATHWAY DOSE FACTOR (P_1)		
	INHALATION*	GROUND PLANE**	FOOD**
H3	1.125E+03	0.000E+00	2.430E+03
P32	2.605E+06	0.000E+00	7.781E+10
CR51	1.702E+04	7.880E+06	5.402E+06
NM54	1.576E+06	1.288E+09	2.097E+07
FL 5	1.110E+05	0.000E+00	1.118E+08
FE59	1.269E+06	4.609E+08	2.031E+08
CO58	1.110E+06	6.225E+08	7.088E+07
CO60	7.067E+06	5.171E+09	2.391E+08
NI63	8.214E+05	0.000E+00	2.965E+10
ZN65	9.953E+05	7.903E+08	1.101E+10
RB86	1.983E+05	1.470E+07	8.780E+09
SR89	2.157E+06	3.579E+04	6.627E+09
SR90	1.010E+08	0.000E+00	1.117E+11
Y91	2.627E+06	1.715E+06	5.209E+06
ZR95	2.231E+06	4.075E+08	8.833E+05

*mrem/yr per uCi/m³**m² (mrem/yr) per uCi/sec

TABLE 2.2

PATHWAY DOSE FACTOR (P_i)

<u>ATOM</u>	<u>INHALATION</u> [*]	<u>GROUND PLANE</u> ^{**}	<u>FOOD</u> ^{**}
NB95	6.142E+05	2.298E+08	2.290E+08
RU103	6.623E+05	1.749E+08	1.118E+05
RU106	1.432E+07	3.593E+08	1.437E+06
AG110	5.476E+06	3.665E+09	1.679E+10
TE125	4.773E+05	3.008E+06	7.380E+07
TE127	1.480E+06	1.395E+05	5.932E+08
TE129	1.761E+06	3.353E+07	8.011E+08
II131	1.628E+07	2.993E+07	4.343E+11
II133	3.848E+06	4.262E+06	3.952E+09
CS134	1.014E+06	3.279E+09	3.715E+10
CS136	1.709E+05	2.414E+08	2.760E+09
CS137	9.065E+05	1.337E+09	3.224E+10
BA140	1.743E+06	3.358E+07	1.173E+08
CE141	5.439E+05	2.198E+07	1.361E+07
CE143	1.273E+05	3.756E+06	1.490E+06

* mrem/yr per uCi/m³** m² (mrem/yr) per uCi/sec

TABLE 2.2

PATHWAY DOSE FACTOR (P_i)

<u>ATOM</u>	<u>INHALATION</u> [*]	<u>GROUND PLANE</u> ^{**}	<u>FOOD</u> ^{**}
CE144	1.195E+07	6.766E+07	1.327E+08
PR143	4.329E+05	0.000E+00	7.752E+05
ND147	3.282E+05	1.450E+07	5.735E+05
NP239	6.401E+04	2.826E+06	9.153E+04

* mrem/yr per uCi/m³

** m² (mrem/yr) per uCi/sec

TABLE 2.3
PATHWAY DOSE FACTOR (R_1)

ATOM	INFANT					
	<u>INHAL</u> *	<u>G/P</u> **	<u>COW/MILK</u> **	<u>COW/MEAT</u> **	<u>VEG</u> **	<u>GT/MILK</u> **
H3	6.468E+02	0.000E+00	2.382E+03	0.000E+00	0.000E+00	4.860E+03
P32	2.030E+06	0.000E+00	1.603E+11	0.000E+00	0.000E+00	1.924E+11
CR51	1.284E+04	5.517E+06	4.692E+06	0.000E+00	0.000E+00	5.631E+05
MN54	9.996E+05	1.629E+09	3.920E+07	0.000E+00	0.000E+00	4.704E+06
FE55	8.694E+04	0.000E+00	1.351E+08	0.000E+00	0.000E+00	1.757E+06
FE59	1.015E+06	3.238E+08	3.930E+08	0.000E+00	0.000E+00	5.109E+06
CO58	7.770E+05	4.490E+08	6.062E+07	0.000E+00	0.000E+00	7.274E+06
CO60	4.508E+06	2.523E+10	2.098E+08	0.000E+00	0.000E+00	2.517E+07
NI63	3.388E+05	0.000E+00	3.493E+10	0.000E+00	0.000E+00	4.192E+09
ZN65	6.538E+05	8.574E+08	1.904E+10	0.000E+00	0.000E+00	2.285E+09
RB86	1.904E+05	1.029E+07	2.228E+10	0.000E+00	0.000E+00	2.673E+09
SR89	2.030E+06	2.523E+04	1.255E+10	0.000E+00	0.000E+00	2.636E+10
SR90	4.088E+07	0.000E+00	1.216E+11	0.000E+00	0.000E+00	2.553E+11
Y91	2.450E+06	1.217E+06	5.261E+06	0.000E+00	0.000E+00	6.313E+05

* mrem/yr per uCi/m³

** m² (mrem/yr) per uCi/sec

TABLE 2.3
PATHWAY DOSE FACTOR (R_1)

ATOM	INFANT					
	<u>INHAL</u> *	<u>G/P</u> **	<u>COW/MILK</u> **	<u>COW/MEAT</u> **	<u>VEG</u> **	<u>GT/MILK</u> **
ZR95	1.750E+06	2.915E+08	8.302E+05	0.000E+00	0.000E+00	9.962E+04
NB95	4.788E+05	1.610E+08	2.064E+08	0.000E+00	0.000E+00	2.476E+07
RU103	5.516E+05	1.226E+08	1.059E+05	0.000E+00	0.000E+00	1.271E+04
RU106	1.156E+07	5.063E+08	1.445E+06	0.000E+00	0.000E+00	1.734E+05
AG110	3.668E+06	4.062E+09	1.462E+10	0.000E+00	0.000E+00	1.754E+09
TE125	4.480E+05	2.133E+06	1.502E+08	0.000E+00	0.000E+00	1.802E+07
TE127	1.312E+06	1.083E+05	1.037E+09	0.000E+00	0.000E+00	1.244E+08
TE129	1.680E+06	2.348E+07	1.401E+09	0.000E+00	0.000E+00	1.681E+08
I131	1.484E+07	2.095E+07	1.055E+12	0.000E+00	0.000E+00	1.267E+12
I133	3.556E+06	2.983E+06	9.590E+09	0.000E+00	0.000E+00	1.151E+10
CS134	7.028E+05	7.972E+09	6.801E+10	0.000E+00	0.000E+00	2.040E+11
CS136	1.344E+05	1.690E+08	5.768E+09	0.000E+00	0.000E+00	1.730E+10

* mrem/yr per uCi/m³

** m² (mrem/yr) per uCi/sec

TABLE 2.3

PATHWAY DOSE FACTOR (R_1)

INFANT

<u>ATOM</u>	<u>INHAL</u> [*]	<u>G/P</u> ^{**}	<u>COW/MILK</u> ^{**}	<u>COW/MEAT</u> ^{**}	<u>VEG</u> ^{**}	<u>GT/MILK</u> ^{**}
CS137	6.118E+05	1.203E+10	6.024E+10	0.000E+00	0.000E+00	1.807E+11
BA140	1.596E+06	2.351E+07	2.413E+08	0.000E+00	0.000E+00	2.896E+07
CE141	5.166E+05	1.539E+07	1.366E+07	0.000E+00	0.000E+00	1.639E+06
CE143	1.162E+05	2.630E+06	1.539E+06	0.000E+00	0.000E+00	1.846E+05
CE144	9.842E+06	8.046E+07	1.334E+08	0.000E+00	0.000E+00	1.601E+07
PR143	4.326E+05	0.000E+00	7.843E+05	0.000E+00	0.000E+00	9.412E+04
ND147	3.220E+05	1.015E+07	5.767E+05	0.000E+00	0.000E+00	6.920E+04
NP239	5.950E+04	1.978E+06	9.416E+04	0.000E+00	0.000E+00	1.130E+04

* mrem/yr per uCi/m³** m² (mrem/yr) per uCi/sec

TABLE 2.4
PATHWAY DOSE FACTOR (R_1)

ATOM	CHILD					
	<u>INHAL</u> *	<u>G/P</u> **	<u>COW/MILK</u> **	<u>COW/MEAT</u> **	<u>VEG</u> **	<u>GT/MILK</u> **
H3	1.125E+03	0.000E+00	1.570E+03	2.341E+02	4.008E+03	3.203E+03
P32	2.605E+06	0.000E+00	7.781E+10	7.427E+09	3.375E+09	9.337E+10
CR51	1.702E+04	5.517E+06	5.402E+06	4.669E+05	6.232E+06	6.482E+05
MN54	1.576E+06	1.629E+09	2.097E+07	8.013E+06	6.651E+08	2.517E+06
FE55	1.110E+05	0.000E+00	1.118E+08	4.571E+08	8.012E+08	1.453E+06
FE59	1.269E+06	3.238E+08	2.031E+08	6.374E+08	6.766E+08	2.640E+06
CO58	1.110E+06	4.490E+08	7.088E+07	9.616E+07	3.786E+08	8.505E+06
CO60	7.067E+06	2.528E+10	2.391E+08	3.837E+08	2.095E+09	2.870E+07
NI63	8.214E+05	0.000E+00	2.965E+10	2.913E+10	5.949E+10	3.557E+09
ZN65	9.953E+05	8.574E+08	1.101E+10	1.000E+09	2.164E+09	1.322E+09
RB86	1.983E+05	1.029E+07	8.780E+09	5.780E+08	4.539E+08	1.054E+09
SR89	2.157E+06	2.523E+04	6.627E+09	4.828E+08	3.611E+10	1.392E+10
SR90	1.010E+08	0.000E+00	1.117E+11	1.040E+10	1.243E+12	2.346E+11

* mrem/yr per uCi/m³

** m² (mrem/yr) per uCi/sec

TABLE 2.4
PATHWAY DOSE FACTOR (R_1)

ATOM	CHILD					
	<u>INHAL</u> *	<u>G/P</u> **	<u>COW/MILK</u> **	<u>COW/MEAT</u> **	<u>VEG</u> **	<u>GT/MILK</u> **
Y91	2.627E+06	1.217E+06	5.209E+06	2.409E+08	2.501E+09	6.250E+05
ZR95	2.231E+06	2.915E+08	8.833E+05	6.172E+08	9.025E+08	1.060E+05
NB95	6.142E+05	1.610E+08	2.290E+08	2.232E+09	2.961E+08	2.748E+07
RU103	6.623E+05	1.226E+08	1.118E+05	4.062E+09	4.052E+08	1.341E+04
RU106	1.432E+07	5.063E+08	1.437E+06	6.903E+10	1.160E+10	1.724E+05
AG110	5.476E+06	4.062E+09	1.679E+10	6.749E+08	2.587E+09	2.014E+09
TE125	4.773E+05	2.133E+06	7.380E+07	5.695E+08	3.512E+08	8.857E+06
TE127	1.480E+06	1.083E+05	5.932E+08	5.060E+09	3.769E+09	7.118E+07
TE129	1.761E+06	2.348E+07	8.011E+08	5.315E+09	2.521E+09	9.613E+07
I131	1.628E+07	2.095E+07	4.343E+11	5.540E+09	4.770E+10	5.212E+11
I133	3.848E+06	2.983E+06	3.952E+09	1.320E+02	8.124E+08	4.743E+09
CS134	1.014E+06	7.972E+09	3.715E+10	1.51E+09	2.631E+10	1.114E+11

* mrem/yr per uCi/m³
 ** m² (mrem/yr) per uCi/sec

TABLE 2.4
PATHWAY DOSE FACTOR (R_1)

ATOM	INHAL*	CHILD				
		G/P**	COW/MILK**	COW/MEAT**	VEG**	GT/MILK**
CS136	1.709E+05	1.690E+08	2.760E+09	4.374E+07	2.216E+08	8.280E+09
CS137	9.065E+05	1.203E+10	3.224E+10	1.334E+09	2.392E+10	9.672E+10
BA140	1.743E+06	2.351E+07	1.173E+08	4.398E+07	2.777E+08	1.407E+07
CE141	5.439E+05	1.539E+07	1.361E+07	1.381E+07	4.078E+08	1.633E+06
CE143	1.273E+05	2.630E+06	1.990E+06	2.538E+02	1.365E+07	1.788E+05
CE144	1.195E+07	8.046E+07	1.327E+08	1.893E+08	1.039E+10	1.592E+07
PR143	4.329E+05	0.000E+00	7.752E+05	3.607E+07	1.574E+08	9.302E+04
ND147	3.282E+05	1.015E+07	5.735E+05	1.521E+07	9.287E+07	6.882E+04
NP239	6.401E+04	1.978E+06	9.153E+04	2.249E+03	1.358E+07	1.098E+04

* mrem/yr per uCi/m³

** m² (mrem/yr) per uCi/sec

TABLE 2.5
PATHWAY DOSE FACTOR (R_1)

ATOM	TEENAGER					
	INHA [*]	G/P ^{**}	COW/MILK ^{**}	COW/MEAT ^{**}	VEG ^{**}	GT/MILK ^{**}
H3	1.272E+03	0.000E+00	9.938E+02	1.938E+02	2.580E+03	2.027E+03
P32	1.888E+06	0.000E+00	3.155E+10	3.939E+09	1.611E+09	3.786E+10
CR51	2.096E+04	5.517E+06	8.393E+06	9.487E+05	1.040E+07	1.007E+06
MN54	1.984E+06	1.629E+09	2.875E+07	1.437E+07	9.324E+08	3.450E+06
FE55	1.240E+05	0.000E+00	4.454E+07	2.382E+08	3.259E+08	5.790E+05
FE59	1.520E+06	3.238E+08	2.869E+08	1.178E+09	1.000E+09	3.729E+06
CO58	1.344E+06	4.490E+08	1.096E+08	1.945E+08	6.057E+08	1.316E+07
CO60	8.800E+06	2.528E+10	3.621E+08	7.600E+08	3.237E+09	4.345E+07
NI63	5.800E+05	0.000E+00	1.182E+10	1.519E+10	1.607E+10	1.419E+09
ZN65	1.240E+06	8.574E+08	7.314E+09	8.687E+08	1.471E+09	8.777E+08
RB86	1.904E+05	1.029E+07	4.734E+09	4.076E+08	2.747E+08	5.680E+08
SR89	2.416E+06	2.523E+04	2.677E+09	2.351E+08	1.521E+10	5.623E+09
SR90	1.080E+08	0.000E+00	6.612E+10	8.049E+09	7.507E+11	1.389E+11

* mrem/yr per uCi/m³

** m² (mrem/yr) per uCi/sec

TABLE 2.5

PATHWAY DOSE FACTOR (R_1)

TEENAGER

<u>ATOM</u>	<u>INHAL</u> [*]	<u>G/P</u> ^{**}	<u>COW/MILK</u> ^{**}	<u>COW/MEAT</u> ^{**}	<u>VEG</u> ^{**}	<u>GT/MILK</u> ^{**}
Y91	2.960E+06	1.217E+06	6.487E+06	3.923E+08	3.233E+09	7.784E+05
ZR95	2.688E+06	2.915E+08	1.208E+06	1.103E+09	1.278E+09	1.449E+05
NB95	7.512E+05	1.610E+08	3.341E+08	4.260E+09	4.568E+08	4.009E+07
RU103	7.832E+05	1.226E+08	1.519E+05	7.219E+09	5.788E+08	1.823E+04
RU106	1.608E+07	5.063E+08	1.818E+06	1.143E+11	1.500E+10	2.182E+05
AG110	6.752E+06	4.062E+09	2.561E+10	1.347E+09	4.039E+09	3.073E+09
TE125	5.360E+05	2.133E+06	8.868E+07	8.950E+08	4.383E+08	1.064E+07
TE127	1.856E+06	1.083E+05	3.420E+08	3.816E+09	2.236E+09	4.105E+07
TE129	1.976E+06	2.348E+07	4.631E+08	4.019E+09	1.544E+09	5.557E+07
II131	1.464E+07	2.095E+07	2.209E+11	3.685E+09	3.162E+10	2.651E+11
II133	2.920E+06	2.983E+06	1.677E+09	7.324E+01	4.593E+08	2.012E+09
CS134	1.128E+06	7.972E+09	2.310E+10	1.231E+09	1.670E+10	6.930E+10

* mrem/yr per uCi/m³** m²(mrem/yr) per uCi/sec

TABLE 2.5
PATHWAY DOSE FACTOR (R_1)

TEENAGER						
<u>ATOM</u>	<u>INHAL</u> [*]	<u>G/P</u> ^{**}	<u>COW/MILK</u> ^{**}	<u>COW/MEAT</u> ^{**}	<u>VEG</u> ^{**}	<u>GT/MILK</u> ^{**}
CS136	1.936E+05	1.690E+08	1.761E+09	3.650E+07	1.698E+08	5.282E+09
CS137	8.480E+05	1.203E+10	1.781E+10	9.634E+08	1.348E+10	5.342E+10
BA140	2.032E+06	2.351E+07	7.493E+07	3.675E+07	2.137E+08	8.991E+06
CE141	6.136E+05	1.539E+07	1.696E+07	2.251E+07	5.399E+08	2.035E+06
CE143	2.552E+05	2.630E+06	1.673E+06	3.727E+02	2.042E+07	2.008E+05
CE144	1.336E+07	8.046E+07	1.655E+08	3.089E+08	1.326E+10	1.986E+07
PR143	4.832E+05	0.000E+00	9.551E+05	5.813E+07	2.308E+08	1.146E+05
ND147	3.720E+05	1.015E+07	7.146E+05	2.478E+07	1.436E+08	8.575E+04
NP239	1.320E+05	1.978E+06	1.062E+05	3.413E+03	2.100E+07	1.274E+04

* mrem/yr per uCi/m³

** m²(mrem/yr) per uCi/sec

TABLE 2.6
PATHWAY DOSE FACTOR (R_1)

ATOM	INHAL [*]	ADULT				
		G/P ^{**}	COW/MILK ^{**}	COW/MEAT ^{**}	VEG ^{**}	GT/MILK ^{**}
H3	1.264E+03	0.000E+00	7.629E+02	3.248E+02	2.260E+03	1.556E+03
P32	1.320E+06	0.000E+00	1.710E+10	4.661E+09	1.406E+09	2.052E+10
CR51	1.440E+04	5.517E+06	7.203E+06	1.778E+06	1.173E+07	8.644E+05
MN54	1.400E+06	1.629E+09	2.578E+07	2.813E+07	9.589E+08	3.094E+06
FE55	7.208E+04	0.000E+00	2.511E+07	2.933E+08	2.096E+08	3.265E+05
FE59	1.016E+06	3.238E+08	2.333E+08	2.091E+09	9.969E+08	3.033E+06
CO58	9.280E+05	4.490E+08	9.575E+07	3.710E+08	6.274E+08	1.149E+07
CO60	5.968E+06	2.528E+10	3.082E+08	1.413E+09	3.139E+09	3.699E+07
NI63	4.320E+05	0.000E+00	6.729E+09	1.888E+10	1.041E+10	8.075E+08
ZN65	8.640E+04	8.574E+08	4.365E+09	1.132E+09	1.009E+09	5.238E+08
RB86	1.360E+05	1.029E+07	2.598E+09	4.884E+08	2.201E+08	3.117E+08
SR89	1.400E+06	2.523E+04	1.452E+09	3.023E+08	1.001E+10	3.050E+09
SR90	9.920E+07	0.000E+00	4.680E+10	1.244E+10	6.046E+11	9.828E+10

* mrem/yr per uCi/m³

** m²(mrem/yr) per uCi/sec

TABLE 2.6
PATHWAY DOSE FACTOR (R_1)

ATOM	ADULT					
	INHAL*	G/P**	COW/MILK**	COW/MEAT**	VEG**	GT/MILK**
Y91	1.704E+06	1.217E+06	4.734E+06	6.253E+08	2.831E+09	5.681E+05
ZR95	1.768E+06	2.915E+08	9.639E+05	1.923E+09	1.216E+09	1.157E+05
N395	5.048E+05	1.610E+08	2.788E+08	7.764E+09	4.814E+08	3.346E+07
RU103	5.048E+05	1.226E+08	1.194E+05	1.239E+10	5.649E+08	1.422E+04
RU106	9.360E+06	5.063E+08	1.320E+06	1.811E+11	1.248E+10	1.584E+05
AG110	4.632E+06	4.062E+09	2.200E+10	2.526E+09	3.987E+09	2.640E+09
TE125	3.120E+05	2.133E+06	6.690E+07	1.474E+09	3.970E+08	8.028E+06
TE127	9.600E+05	1.083E+05	1.860E+08	4.531E+09	1.418E+09	2.232E+07
TE129	1.160E+06	2.348E+07	3.047E+08	5.774E+09	1.288E+09	3.656E+07
I131	1.200E+07	2.095E+07	4.080E+11	1.486E+10	1.113E+11	4.896E+11
I133	2.160E+06	2.983E+06	9.910E+08	9.452E+01	5.337E+08	1.189E+09
CS134	8.480E+05	7.972E+09	1.345E+10	1.565E+09	1.110E+10	4.035E+10
CS136	1.464E+05	1.690E+08	1.032E+09	4.668E+07	1.660E+08	3.095E+09

* mrem/yr per uCi/m³

** m²(mrem/yr) per uCi/sec

TABLE 2.6
PATHWAY DOSE FACTOR (R_1)

ADULT						
<u>ATOM</u>	<u>INHAL</u> [*]	<u>G/P</u> ^{**}	<u>COW/MILK</u> ^{**}	<u>COW/MEAT</u> ^{**}	<u>VEG</u> ^{**}	<u>GT/MILK</u> ^{**}
CS137	6.208E+C5	1.203E+10	1.010E+10	1.193E+09	8.696E+09	3.029E+10
BA140	1.272E+06	2.351E+07	5.542E+07	5.936E+07	2.652E+08	6.650E+06
CE141	3.616E+05	1.539E+07	1.252E+07	3.630E+07	5.094E+08	1.503E+06
CE143	2.264E+05	2.630E+06	1.150E+06	5.595E+02	2.761E+07	1.380E+05
CE144	7.776E+06	8.046E+07	1.210E+08	4.929E+08	1.112E+10	1.451E+07
PR143	2.808E+05	0.000E+00	6.921E+05	9.198E+07	2.747E+08	8.305E+04
ND147	2.208E+05	1.015E+07	5.252E+05	3.978E+07	1.865E+08	6.302E+04
NP239	1.192E+05	1.978E+06	7.397E+04	5.191E+03	2.876E+07	8.876E+03

* mrem/yr per uCi/m³

** m²(mrem/yr) per uCi/sec

TABLE 2.7

ATMOSPHERIC DISPERSION PARAMETERS*FOR TECHNICAL SPECIFICATION 4.11.2.4.1

<u>Sector</u>	<u>Miles</u>	<u>X/Q</u>	<u>D/Q</u>
N	4.5	2.4E-07	1.0E-09
NNE	2.4	4.7E-07	2.3E-09
NE	2.4	3.2E-07	1.1E-09
ENE	2.6	2.2E-07	4.1E-10
E	3.5	1.5E-07	2.7E-10
ESE	2.3	3.7E-07	9.0E-10
SE	5.0	1.4E-07	3.7E-10
SSE	2.0	5.8E-07	3.2E-09
S	4.8	1.0E-07	3.6E-10
SSW	4.3	9.2E-08	2.9E-10
SW	3.5	1.2E-07	3.3E-10
WSW	1.5	6.9E-07	2.2E-09
W	1.7	6.5E-07	2.2E-09
WNW	3.0	3.7E-07	1.0E-09
NW	5.0	2.2E-07	5.3E-10
NNW	3.4	4.9E-07	1.9E-09

* Reference Comanche Peak SES, Environmental Report, Operating License Stage, Tables 2.3-16 and 2.3-17.

TABLE 2.8

CONTROLLING RECEPTORS, LOCATIONS, AND PATHWAYS

(For Dose Calculations required by Technical Specifications
3.11.2.3, 3.11.2.4 and 6.9.1.13)

<u>SECTOR</u>	<u>DISTANCE (MILES)</u>	<u>PATHWAY</u>	<u>AGE GROUP</u>
N	4.5	Vegetation	Child
NNE	2.4	Vegetation	Child
NE	2.4	Vegetation	Child
ENE	2.6	Vegetation	Child
E	3.5	Vegetation	Child
ESE	2.3	Vegetation	Child
SE*	5.0	Cow/Milk	Infant
SSE	2.0	Vegetation	Child
S	4.8	Cow/Milk	Infant
SSW	4.3	Vegetation	Child
SW	3.5	Vegetation	Child
WSW	1.5	Vegetation	Child
W	1.7	Vegetation	Child
WNW	3.0	Vegetation	Child
NW*	5.0	Cow/Milk	Infant
NIW	3.4	Vegetation	Child

*No pathway currently exists in this sector. Cow/Milk pathway to infant is assumed at distance of 5 miles.

2.3 METEOROLOGICAL MODEL

Atmospheric dispersion for releases are calculated using a straight line flow Gaussian model.*

X/Q = average atmospheric dispersion (sec/m^3) for a given wind direction (sector) and distance.

$$= 2.032 \delta K \sum_{j,k} \left(\frac{n_{j,k}}{N r u_{j,k} \sum_j} \right)$$

2.03 = $(2/\pi)^{1/2}$ divided by the width in radians of a 22.5° sector (0.3927 radians).

$n_{j,k}$ = number of hours meteorological conditions are observed to be in a given wind direction, windspeed class k, and atmospheric stability class j which establishes a joint frequency distribution of grouped meteorological data.

NOTE: If periodic data (hourly) are used instead of the joint frequency data, all variable subscripts are dropped, the $n_{j,k}$ is set equal to 1 and the hourly averaged meteorological variables are entered into the model.

N = total hours of valid meteorological data throughout the period of effluent release.

r = distance from the release point to location of interest (meters)

$u_{j,k}$ = wind speed (midpoint of windspeed class k) measured at the 10 meter level (m/sec) during atmospheric stability class j

*Model Reference 8 Chapter 3 and Data Chapter 3 Comanche Peak FSAR.

σ_j = building wake corrected vertical standard deviation of the plume concentration.

$$(\sigma_j^2 + b^2/2\pi)^{1/2}$$

= the lesser of or

$$(\sqrt{3} \sigma_j) \quad \text{where:}$$

σ_j = vertical standard deviation of the plume concentration (meters) at distance r for releases (Fig. 2.3)

K = terrain recirculation factor (Fig. 2.5)

δ = plume depletion factor (radioiodines and particulates) at distance r for the applicable stability class. Normally a factor of 1 is assumed when undepleted X/Q values are to be used in dose calculations. (Fig. 2.2)

π = 3.1416

b = vertical height of reactor containment structure (79.4 meters).

Relative deposition per unit area is calculated.

D/Q = relative deposition per unit area (m^{-2}), for a given wind direction and at a given distance, r

$$= \frac{2.55K}{r} D_g$$

D_g = relative deposition rate for a ground-level release determined from Figure 2.4.

2.55 = (radians per 22.5° Sector)⁻¹

2.4 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS

Term	Definition	Section of Initial Use
AF	= Allocation Factor (.5); a factor allowing for releases from both stacks simultaneously.	2.1.1.b
b	= maximum height of the adjacent building.	2.3
C	= calculated monitor reading of a gaseous effluent monitor corresponding to associated sample radionuclide concentrations.	2.1.1.b
C _s	= monitor reading of the stack noble gas monitor at the alarm setpoint concentration	2.1.1.b
C _{aux}	= monitor reading of the Auxiliary Building Ventilation Exhaust monitor at the alarm setpoint.	2.1.1.c
C _{cont}	= monitor reading of the Containment Atmosphere Gaseous monitor at the alarm setpoint.	2.1.1.d
D _g	= relative deposition rate for a ground-level release	2.3
D _o	= average organ dose rate in the current year (mrem/yr)	2.1.2.a
D _p	= dose to an individual from radioiodines and radionuclides in particulate from with half-lives greater than eight days (mrem).	2.2.2
D _s	= calculated skin dose rate (mrem/yr)	2.1.1.a
D _{ss}	= limiting dose rate to the skin = 3000 mrem/yr	2.1.1.b
D _t	= calculated total body dose rate (mrem/yr)	2.1.1.a
D _{TB}	= limiting dose rate to the body = 500 mrem/yr	2.1.1.b
D _β	= air dose due to beta emissions from noble gas	2.2.1
D _γ	= air dose due to gamma emissions from noble gas	2.2.1
D/Q	= the sector averaged annual average relative deposition for any distance in a given sector.	2.2.3
D/Q'	= annual average relative deposition at the location of the maximum exposed individual. = $2.8 \times 10^{-9} \text{ m}^{-2}$ in the WNW sector	2.2.2
δ	= plume depletion factor at distance r for the appropriate stability class (radioiodines and particulates).	2.3

2.4 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS

<u>Term</u>	<u>Definition</u>	<u>Section of Initial Use</u>
F_b	= the flow rate contribution associated with the release rate at the batch source (ml/sec).	2.1.1.b
F_c	= the flow rate contribution of the plant ventilation system (ml/sec)	2.1.1.b
F_v	= the flow rate at the vent (cc/sec)	2.1.1.a
F_{aux}	= the flow rate contribution associated with the release of the Waste Gas Decay Tanks (ml/sec)	2.1.1.c
F_{cont}	= the flow rate contribution associated with the release of the Containment Atmosphere (ml/sec)	2.1.1.d
K	= terrain recirculation factor	2.3
K_i	= total body dose factor due to gamma emissions from isotope i (mrem/year per microcurie/m ³)	2.1.1.a
L_i	= skin dose factor due to beta emissions from isotope i (mrem/yr per microcurie/m ³)	2.1.1.a
M_i	= air dose factor due to gamma emissions from isotope i (mrad/yr per microcurie/m ³)	2.1.1.a
N_i	= air dose factor due to beta emissions from noble gas radionuclide i (mrad/yr per microcurie/m ³)	2.2.1
n_{jk}	= number of hours meteorological conditions are observed to be in a given wind direction, wind-speed class k, and atmospheric stability class j.	2.3
N	= total hours of valid meteorological data.	2.3
P_i	= dose parameter for radionuclide i, (mrem/yr per microcurie/m ³)	2.1.2.a
Q_i	= rate of release of noble gas radionuclide i (microcurie/sec)	2.1.1.a
\bar{Q}_i	= cumulative release of noble gas radionuclide i over the period of interest (microcurie).	2.2.1
\bar{Q}_i'	= cumulative release of radionuclide i of iodine or material in particulate form over the period of interest (microcurie).	2.2.2

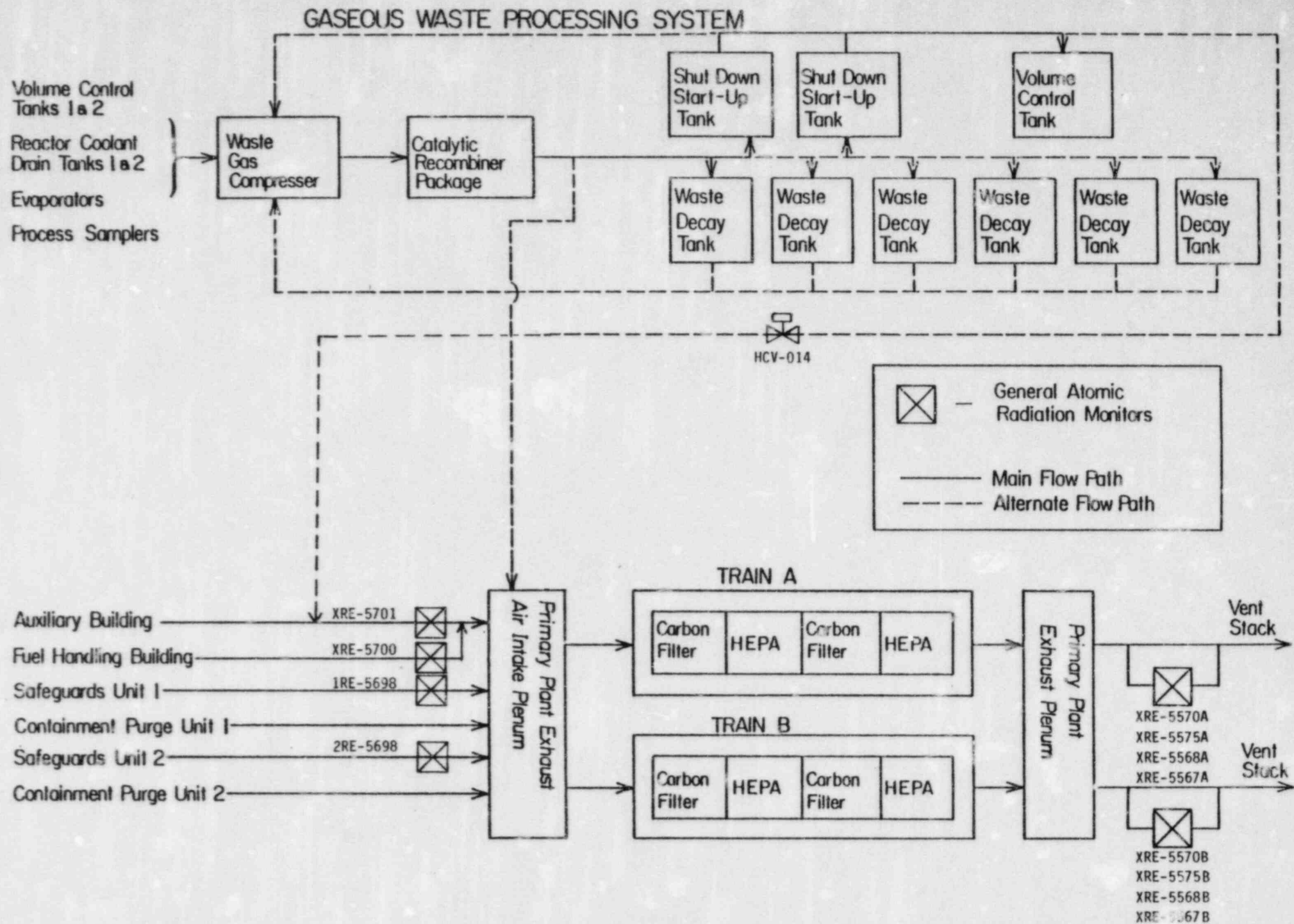
2.4 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS

<u>Term</u>	<u>Definition</u>	<u>Section of Initial Use</u>
R_i	= dose factor for radionuclide i, (mrem/yr per microcurie/m ³) or (m ² -mrem/yr per microcurie/sec)	2.2.2
R_s	= monitor reading per mrem/yr to the skin.	2.1.1.b
R_t	= monitor reading per mrem/yr to the total body.	2.1.1.b
r	= distance from the point of release to the location of interest for dispersion calculations (meters).	2.3
SF	= Safety Factor (.5); a conservative factor applied to each noble gas monitor to compensate for statistical fluctuations and errors of measurement.	2.1.1.b
σ_j	= vertical standard deviation of the plume concentration with building wake correction.	2.3
σ_j	= vertical standard deviation of the plume concentration (in meters), at distance r for ground level releases under the stability category j indicated by T	2.3
u_{jk}	= wind speed (midpoint of windspeed class k) at ground level (m/sec) during atmospheric stability class j.	2.3
W	= the dispersion parameter for estimating the dose to an individual at the controlling location	2.2.2
X/Q	= the Sector-averaged annual average relative concentration at any distance r in a given sector. (sec/m ³)	2.2.1
$\overline{X/Q}$	= the highest annual average relative concentration in any sector, at the site boundary. (sec/m ³) = 3.3×10^{-6} sec/m ³ in the NNW sector	2.1.1.a
X_{ib}	= the concentration of noble gas radionuclide i in the batch release stream (microcuries/ml)	2.1.1.b
X_{ic}	= the concentration of noble gas radionuclide i in the continuous release stream (microcuries/ml)	2.1.1.b
X_{1I}	= the monitor reading of Iodine at the alarm setpoint concentration	2.1.2.b
X_{1p}	= the monitor reading of particulate (s-137) at the alarm setpoint concentration	2.1.2.c
X_{iv}	= the concentration of noble gas radionuclide i as measured at the vent (microcuries/ml)	2.1.1.a

2.4 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (cont.)

<u>Term</u>	<u>Definition</u>	<u>Section of Initial Use</u>
X_{iaux}	= the concentration of noble gas radionuclide i in the Waste Gas Decay Tank release stream (microcuries/ml)	2.1.1.c
X_{icont}	= the concentration of noble gas radionuclide i in the containment release stream (microcuries/ml)	2.1.1.d

FIGURE 2.1



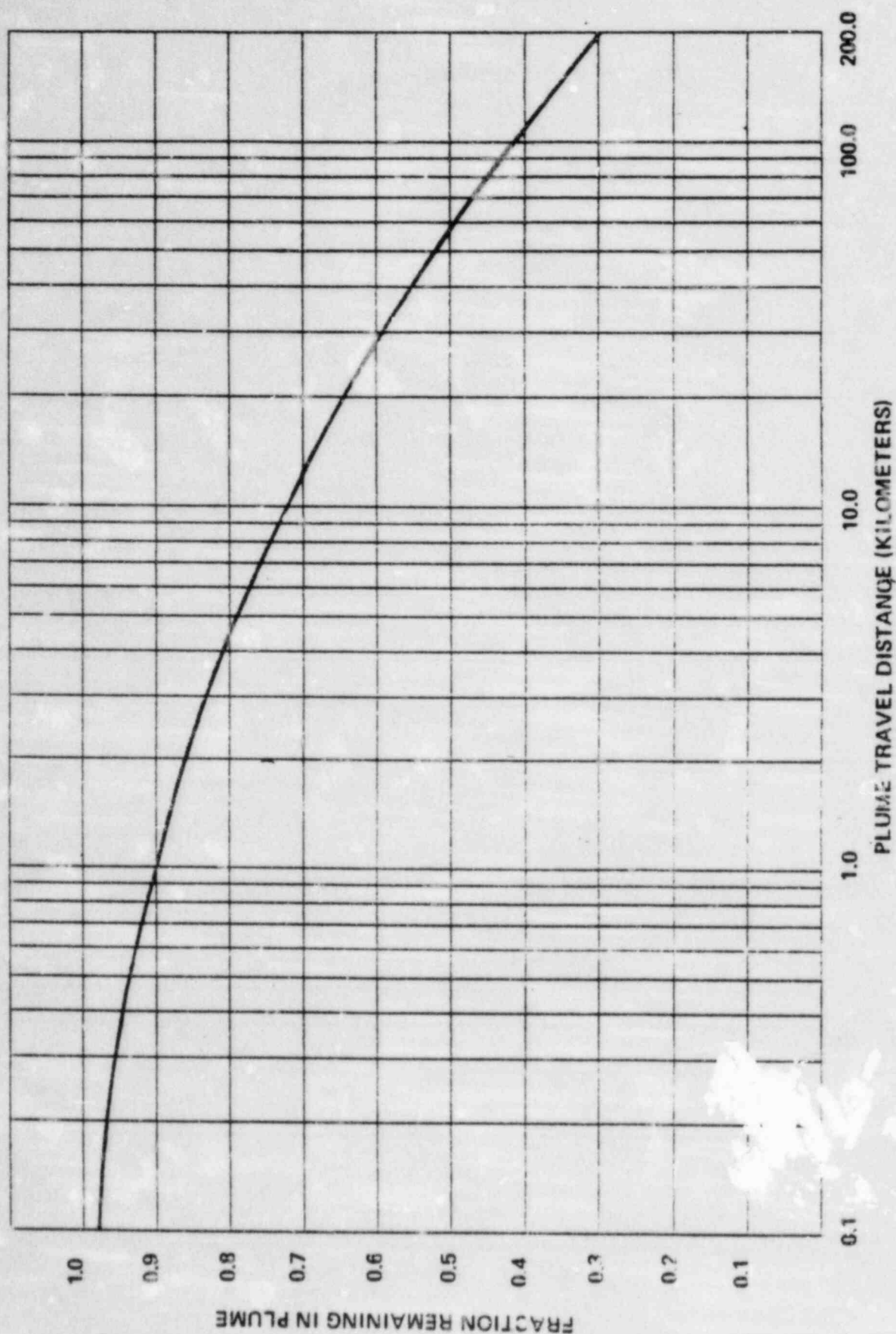


Figure 2-2 Plume Depletion Effect for Ground-Level Releases (All Atmospheric Stability Classes)

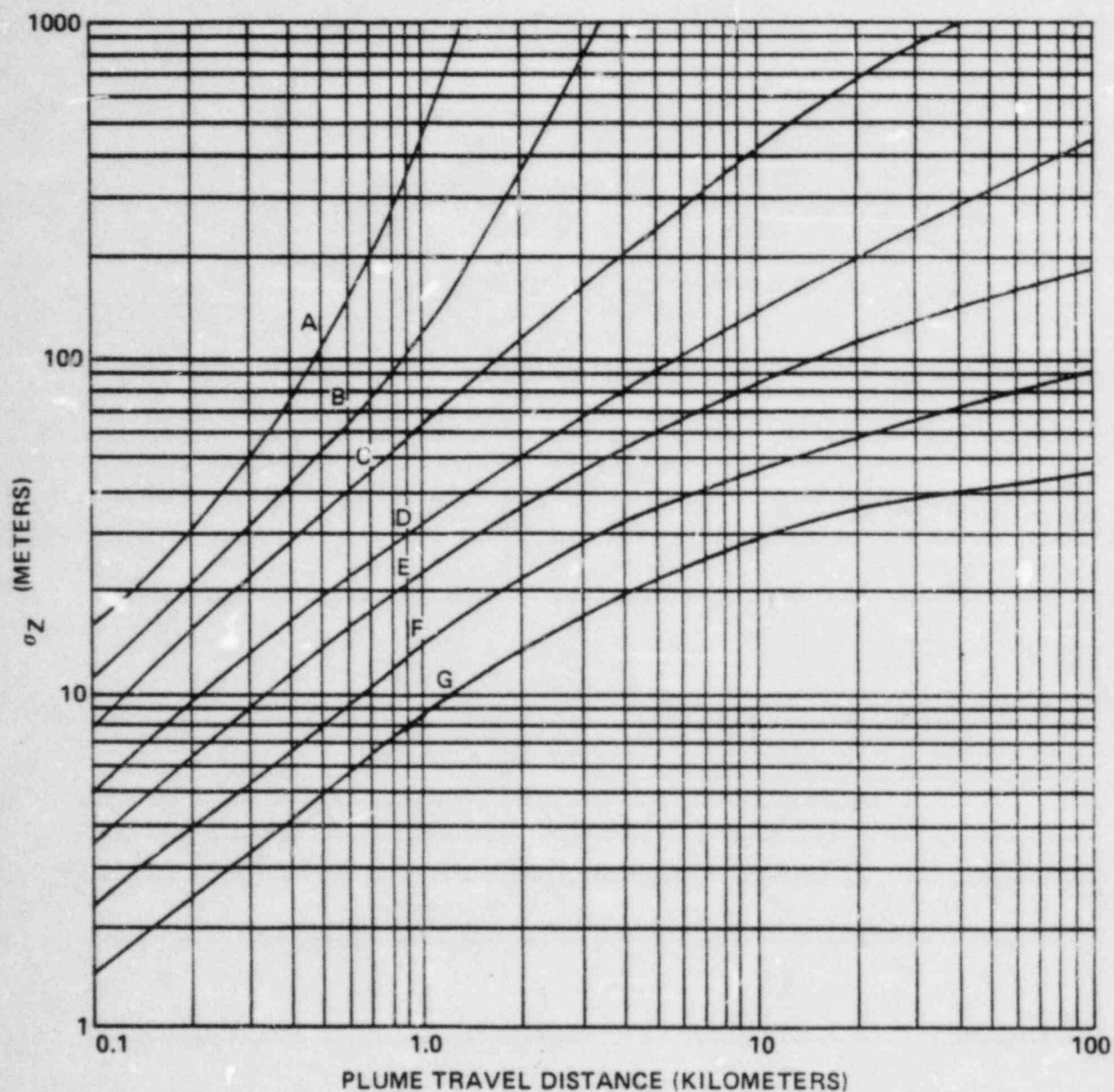


Figure 2-3 Vertical Standard Deviation of Material in a Plume (Letters denote Pasquill Stability Class)

NOTE: THESE ARE STANDARD RELATIONSHIPS AND MAY HAVE TO BE MODIFIED FOR CERTAIN TYPES OF TERRAIN AND/OR CLIMATIC CONDITIONS (E.G., VALLEY, DESERT, OVER WATER).

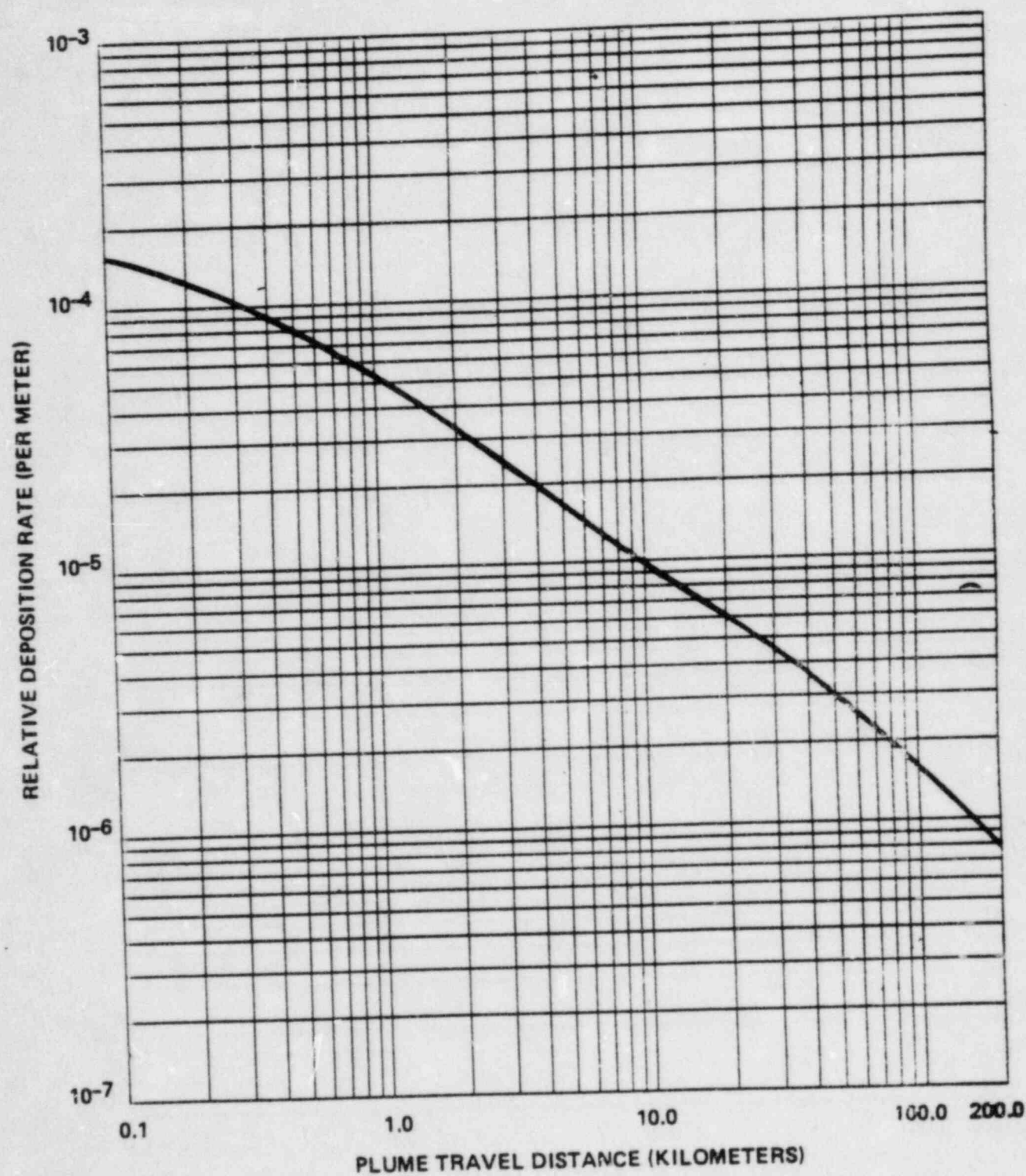


Figure 2-4 Relative Deposition for Ground-Level Releases (All Atmospheric Stability Classes)

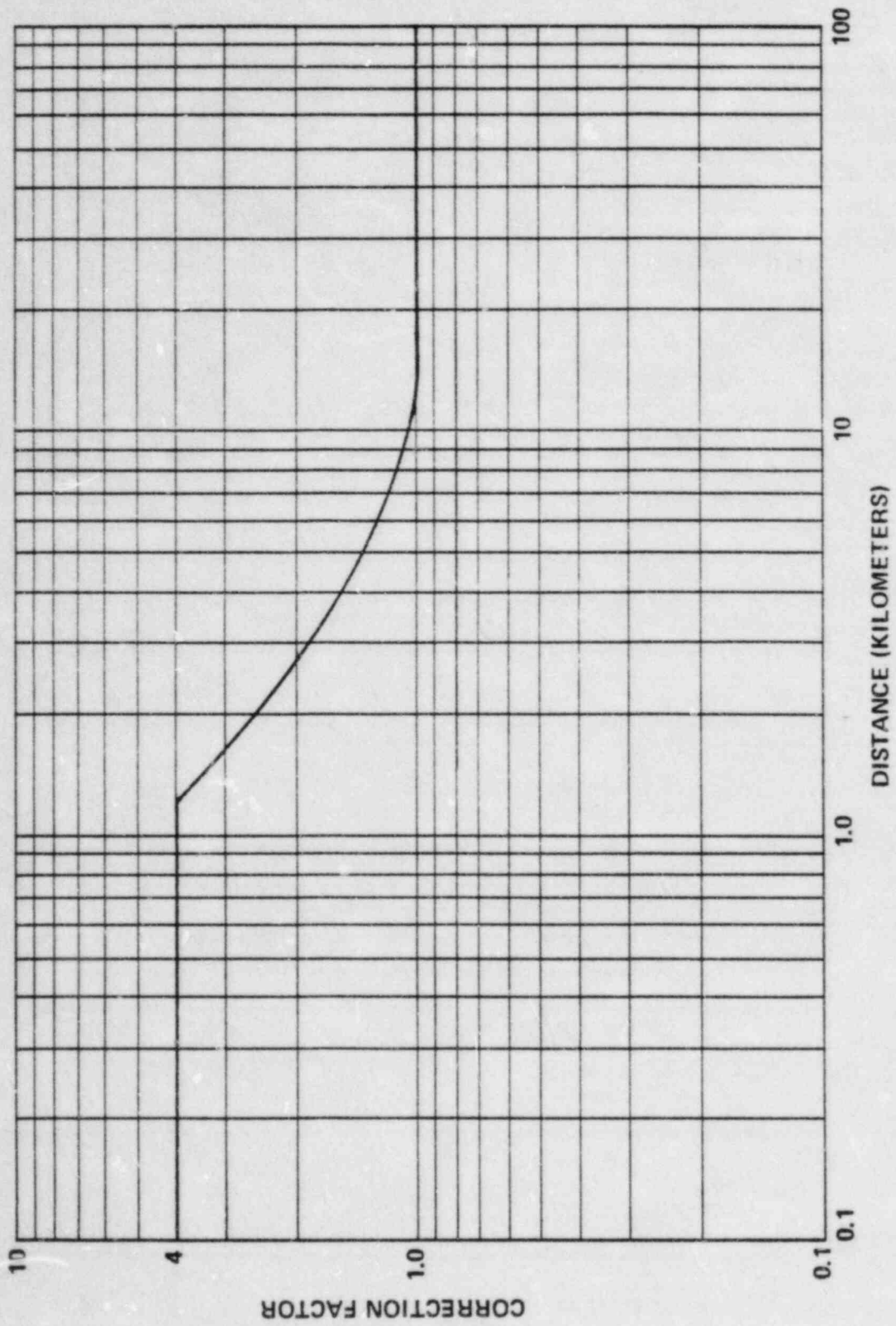


Figure 2-5 Open Terrain Correction Factor

SECTION 3.0

RADIOLOGICAL ENVIRONMENTAL MONITORING

3.1 SAMPLING LOCATIONS

Sampling locations as required in Technical Specification 3/4.12.1 are described in Table 3.1 and shown on the map in Figure 3.1.

NOTE: For the purpose of implementing Technical Specification 3.12.2, sampling locations will be modified as required to reflect the findings of the Land Use Census.

3.2 INTERLABORATORY COMPARISON PROGRAM

For the purpose of implementing technical specification 3.12.3 the Interlaboratory Comparison Program will be conducted to ensure independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices. The requirements will be two-fold: First, to analyse reference-type samples for providing independent checks on the analytical system. These may be available from the EPA as QC samples, from the National Bureau of Standards as standard reference materials, or from commercial sources. If performance limits are not provided, the results should fall within the routine limits of each laboratory for a standard at a level comparable to the specified true value. Second, the program will participate in performance evaluation and method studies as available from the EPA, from the American Society for Testing and Materials, and from other agencies.

Table 3.1

Environmental Sampling Locations

<u>Sampling</u> <u>Point</u>	<u>Location</u> <u>(Sector - Miles)</u>	<u>Sample</u> <u>Type*</u>
1	E-0.5	A
2	N-2.2	A
3	W-2.0	A
4	NNW-4.6	A
5	E-3.5	A
6	SE-3.85	A
7	SSE-4.5	A
8	N-9.4	A
9	SW-12.3	A
10	N-1.2	R
11	N-4.4	R
12	N-6.5	R
13	N-9.4	R
14	NNE-1.1	R
15	NNE-5.65	R
16	NE-1.7	R
17	NE-4.8	R
18	ENE-2.5	R
19	ENE-5.0	R
20	E-0.5	R

Table 3.1 (Continued)

Environmental Sampling Locations, continued

<u>Sampling</u>	<u>Location</u>	<u>Sample</u>
<u>Point</u>	<u>(Sector - Miles)</u>	<u>Type*</u>
21	E-1.9	R
22	E-3.5	R
23	E-4.2	R
24	ESE-1.4	R
25	ESE-4.7	R
26	SE-1.3	R
27	SE-3.85	R
28	SE-4.6	R
29	SSE-1.3	R
30	SSE-4.4	R
31	SSE-4.5	R
32	S-1.5	R
33	S-4.2	R
34	SSW-1.0	R
35	SSW-4.4	R
36	SW-0.9	R
37	SW-4.8	R
38	SW-12.3	R
39	WSW-1.0	R
40	WSW-5.35	R

Table 3.1 (Continued)

Environmental Sampling Locations

<u>Sampling</u>	<u>Location</u>	<u>Sample</u>
<u>Point</u>	<u>(Sector - Miles)</u>	<u>Type*</u>
41	WSW-7.0	R
42	W-1.0	R
43	W-2.0	R
44	W-5.5	R
45	WNW-1.0	R
46	WNW-5.0	R
47	WNW-6.7	R
48	NW-1.0	R
49	NW-5.7	R
50	NW-9.9	R
51	NNW-1.35	R
52	NNW-4.6	R
53	NNW-0.1	SW
54	N-9.9	SW
55	W-1.2	GW
56	WSW-0.1	GW
57	SSE-4.5	GW
58	N-19.3	GW
59	NNE-1.0	SS
60	N-9.9	SS

Table 3.1 (Continued)

Environmental Sampling Locations

<u>Sampling Point</u>	<u>Location (Sector - Miles)</u>	<u>Sample Type*</u>
61	S-4.8	M
62	SW-13.5	M
63	ENE-2.0	F
64	NNE-8.0	F
65	E-4.2	V
66	SW-13.5	V
67	NNW-1.6	V
68	SE-1.3	V
69	SSE-1.3	V

*Types: A - Air Sample, R - Direct Radiation, SW - Surface Water,
 GW - Ground Water, SS - Shoreline Sediment, M - Milk, F - Fish;
 V - Vegetation.

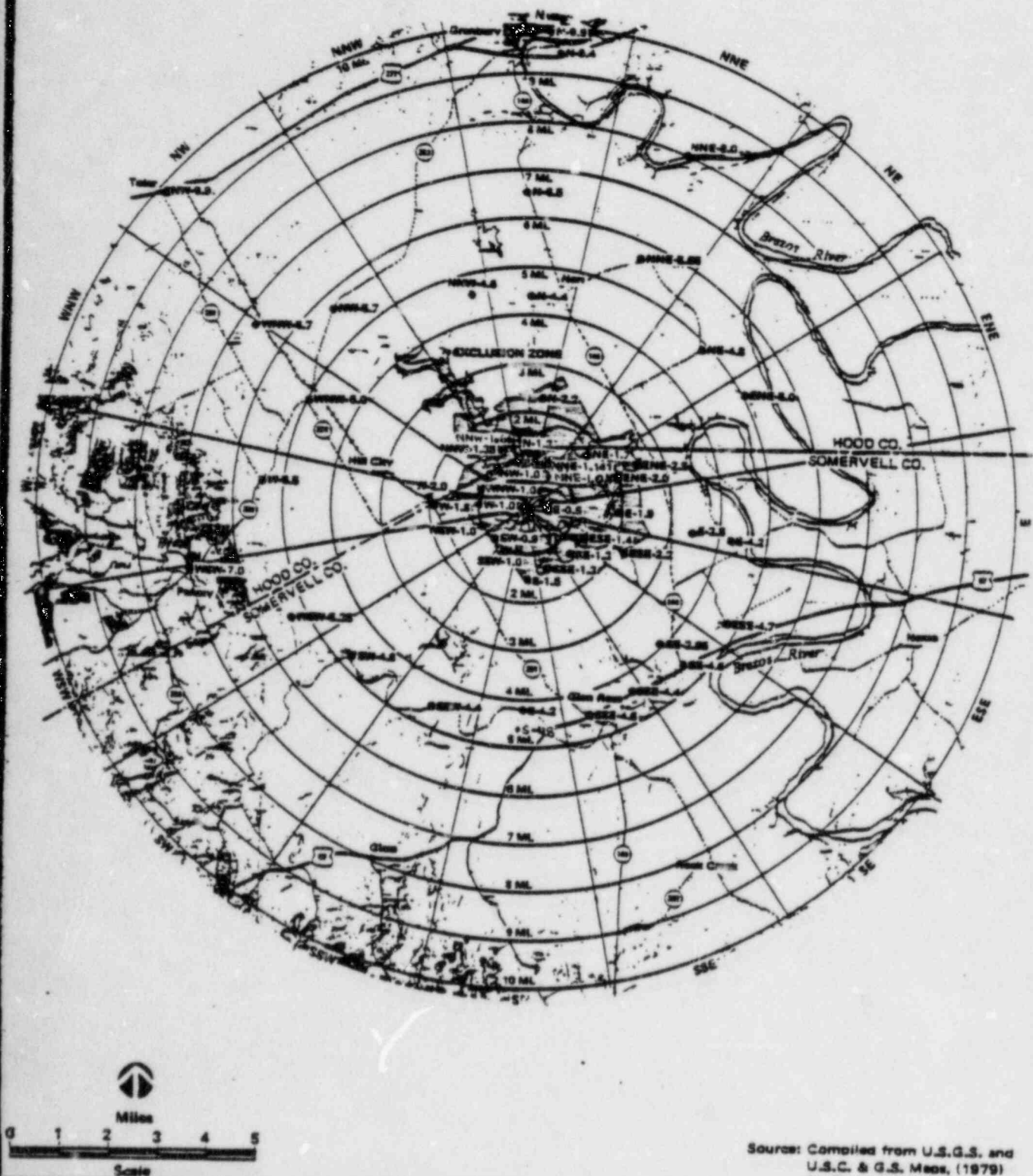


Figure 3.1
Comanche Peak S.E.S.
Radiological Environmental Monitoring Program
Sample Locations Within 10 Miles of the Site

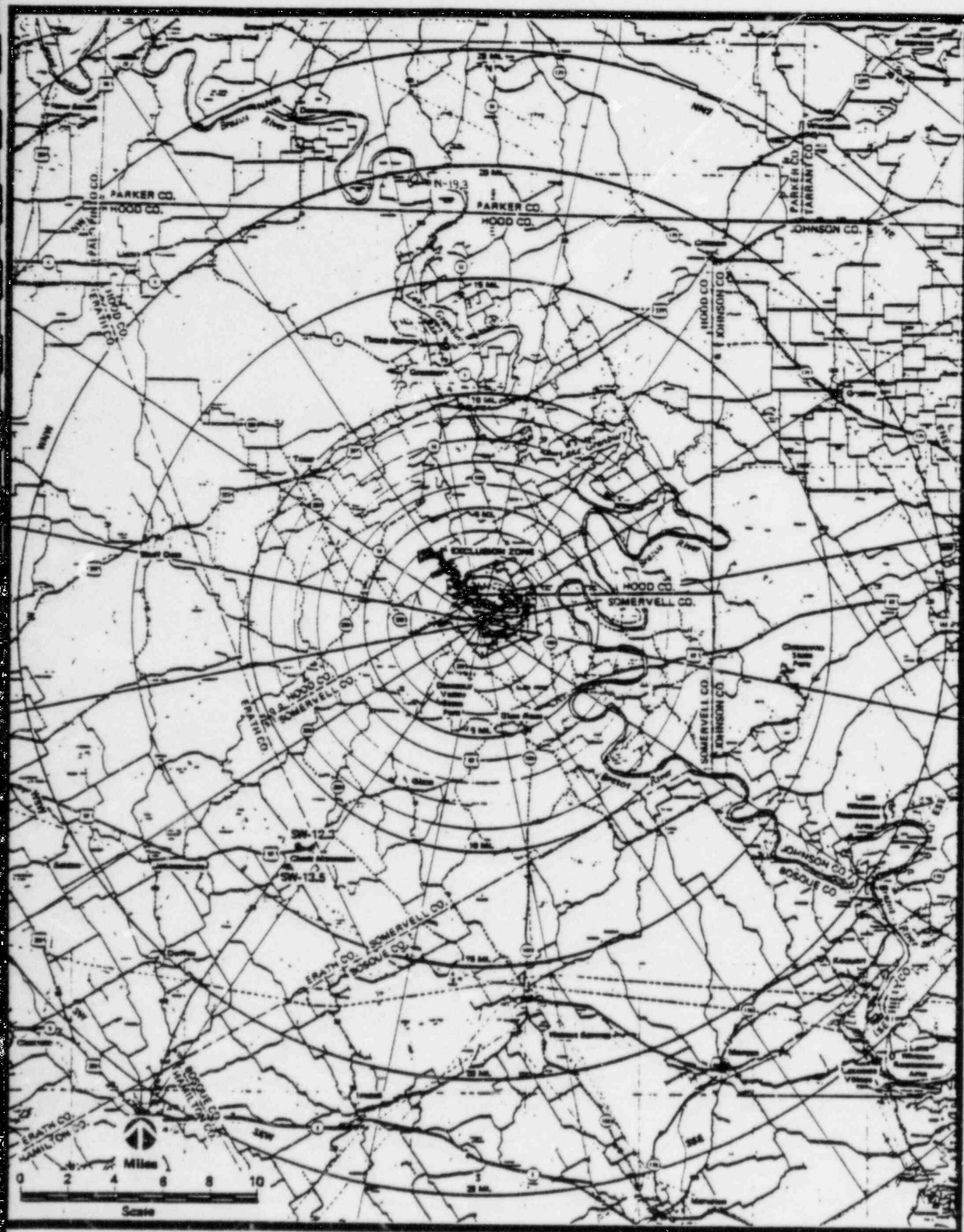


Figure 3.1 (Cont.)

Comanche Peak S.E.S.

Radiological Environmental Monitoring Program

Sample Locations Greater than 10 Miles from the Site

Source: Compiled from Texas Highway Dept.
"General Highway Maps, (1979)"
for Texas Utilities Services, Inc.

APPENDIX A

Calculation of P_1 (Inhalation)

$$P_1 = k' (BR) DFA_1$$

where

P_1 = the dose parameter for radionuclides other than noble gases for the inhalation pathway, in mrem/yr per microcurie/m³. The dose factors are based on the critical individual organ for the child age group.

k' = conversion factor, 10⁶ pCi/microcurie

BR = 3700 m³/yr, breathing rate for child, Ref. 3

DFA_1 = the maximum organ inhalation dose factor for the child age group

Resolution of the units yields:

$$P_1 \text{ (inhalation)} = 3.7 \times 10^9 DFA_1$$

The latest NRC Guidance has deleted the requirement to determine P_1 (ground plane) and P_1 (food). In addition, the critical age group has been changed from infant to child.

APPENDIX B

Inhalation Pathway Factor, R_1^I (X/Q)

$$R_1^I (X/Q) = k' (BR) (DFA_1) \text{ (mrem/yr per microcurie/m}^3\text{)}$$

where

k' = conversion factor, 10^6 pCi/microcurie

BR = breathing rate, 1400, 3700, 8000, 8000 m³/yr for infant, child, teenager, and adult respectively

DFA_1 = the maximum organ inhalation dose factor for the receptor of given age group for the i th radionuclide, in mrem/pCi. The total body is considered as an organ in the selection of (DFA_1).

APPENDIX C

Ground Plan Pathway Factor, R_i^G (D/Q)

$$R_i^G \text{ (D/Q)} = k' k'' (\text{SF}) \text{DFG}_i (1 - e^{-\lambda t}) / \lambda$$

where

k' = conversion factor, 10^6 pCi/microcurie

k'' = Conversion factor, 8760 hr/yr

λ = radionuclide decay constant, sec^{-1}

t = the decay time, assuming that decay is the only operating removal mechanism, 4.73×10^8 sec.

DFG_i = the ground plane dose conversion factor for the i th radionuclide (mrem/hr per pCi/m²)

SF = .7, shielding factor, from Table E15 Reg. Guide 1.109

APPENDIX D

Grass-Cow-Milk Pathway Factor, R_i^c (D/Q)

$$R_i^c (D/Q) = k' (Q_F \times U_{AP}) / (\lambda_i + \lambda_w) \times (F_m) \times (r) \times (DFL_i) \times ((fp \times fs) / Y_p + ((1-fp \times fs) e^{-\lambda_i t_h}) Y_s) e^{-\lambda_i t_f}$$

where

- k' = conversion factor, 10^6 pCi/microcurie
- Q_F = cow consumption rate, 50 kg/day, R.G.1.109
- U_{AP} = Receptor's milk consumption rate; 330,330,400,310 for infant, child, teenager, and adult resp. R.G. 1.109
- Y_p = agricultural productivity by unit area of pasture feed grass, .7 kg/m², NUREG 133
- Y_s = agricultural productivity by unit area of stored feed, 2.0 kg/m², NUREG 133
- F_m = stable element transfer coefficient, Table E1 R.G. 1.109
- r = fraction of deposited activity retained on cow's feed grass, .2 for particulates, 1.0 for radioiodine
- DFL_i = the maximum organ ingestion dose factor for the i th radionuclide for each respective age group tables E-11 to E-14 R. G. 1.109
- λ_i = radionuclide decay constant, sec⁻¹
- λ_w = decay constant for weathering, 5.73×10^{-7} sec⁻¹, NUREG 133
- t_f = 1.73×10^5 sec, the transport time from pasture to cow, to milk to receptor, in seconds
- t_h = 7.78×10^6 sec, the transport time from pasture, to harvest, to cow to milk, to receptor
- fp = 1.0, the fraction of the year that the cow is on pasture. Land Census Report 1982

APPENDIX D (CONTINUED)

f_s = 1.0 the fraction of the cow feed that is stored feed while the cow is on pasture. Land Census 1982

The concentration of tritium in milk is based on the airborne concentration rather than the deposition. Therefore $R_i^C (X/Q)$ becomes:

$$R_i^C (X/Q) = k'k''' F_m Q_F U_{AP} DFL_i (.75 (.5/H))$$

where

k''' = 10^{-3} grams/kg

H = 8 grams/ m^3 , absolute humidity of the atmosphere

.75 = fraction of total feed grass mass that is water

.5 = ratio of the specific activity of the feed grass water to the atmospheric water. NUREG 133

NOTE: Goat-milk pathway factor, $R_i^G (D/Q)$ will be computed using the cow-milk pathway factor equation. F_m factor for goat-milk will be from table E-2 R.G. 1.109.

APPENDIX E

COW-MEAT PATHWAY FACTOR R_1^M (D/Q)

$$R_1^M (D/Q) = k' (Q_F \times U_{AP}) / (\lambda_i + \lambda_w) \times (F_f) \times (r) \times (DFL_i) \times \\ ((f_p \times f_s) / Y_p + ((1 - f_p f_s) e^{-\lambda_i t_h}) / Y_s) \times e^{-\lambda_i t_f}$$

where

- k' = conversion factor, 10^6 pci/microcurie
- Q_F = cow consumption rate, 50 kg/day, R.G. 1.109
- U_{AP} = receptor's meat consumption rate for age 0, 41, 65, 110 kg/yr
for infant, child, teenager, and adult respectively R.G. 1.109
- F_f = the stable element transfer coefficients, days/11g. Table
E1 R.6. 1.109
- r = fraction of deposited activity retained on cow's feed grass,
.2 for particulates, 1.0 for radioiodine
- DFL_i = the maximum organ ingestion dose factor for the i th
radionuclide for each respective age group tables E-11
to E-14. R.G. 1.109
- λ_i = radionuclide decay constant, sec^{-1}
- λ_w = decay constant for weathering, $5.73 \times 10^{-7} \text{ sec}^{-1}$ NUREG 133
- t_f = 1.73×10^6 sec, the transport time from pasture to receptor
NUREG 133
- t_h = 7.78×10^6 sec, the transport time from crop field to receptor
NUREG 133

APPENDIX E, CONTINUED

COW-MEAT PATHWAY FACTOR R_1^M (D/Q)

- Y_p = AGRICULTURAL PRODUCTIVITY by unit area of pasture feed grass,
.7 kg/m², NUREG 133
- Y_s = AGRICULTURAL PRODUCTIVITY by unit area 2.0 Kg/m² NUREG 013
- f_p = 1.0 the fraction of the year that the cow is on pasture
- f_s = 1.0 the fraction of the cow feed that is pasture grass while
cow is on pasture

APPENDIX F

Vegetation Pathway Factor, R_1^V (D/Q)

$$R_1^V (D/Q) = k' \times [r / (Y_v (\lambda_i + \lambda_w))] \times (DFL_1) \times [(U_A^L f_L e^{-\lambda_i t_L} + U_A^S f_g e^{-\lambda_i t_h})]$$

where

k' = 10^6 pCi/microcurie

U_A^L = the consumption rate of fresh leafy vegetation, 0,26,42,64 for infant, child, teen, or adult respectively

U_A^S = the consumption rate of stored vegetation, 0,520,630,520 for infant, child, teen, or adult respectively

f_L = the fraction of the annual intake of fresh leafy vegetation grown locally, 1.0 NUREG 133

f_g = the fraction of the stored vegetation grown locally
.76 NUREG 133

t_L = the average time between harvest of leafy vegetation and its consumption, 8.6×10^4 seconds Table E-15 R.G. 1.109

t_h = the average time between harvest of stored vegetation and its consumption, 5.18×10^6 seconds Table E-15 R.G.1.109

Y_v = 2.0 kg/m² Table E-15 R.G.1.109

The concentration of tritium in vegetation is based on the airborne concentration rather than the deposition. Therefore, R_1^V is based on (X/Q)

$$R_1^V = k' k''' [U_A^L f_L + U_A^S f_g] (DFL_1) (.75 (.5/H))$$

k''' = 10^3 grams/kg

H = 8 grams/m³

.75 = the fraction of total feed grass mass that is water

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

APPENDIX G

```

1  ! PROGRAM: UDCM_1
2  !
3  DATA H3,1.58E-7,1.59E-7,3.04E-7,4.62E-7,1.05E-7,1.06E-7,2.03E-7,3.08E-7,0,
1E-2,1.2E-2,1.78E-9
4  !
5  ! DATA C14,2.27E-6,3.25E-6,9.7E-6,1.89E-5,2.84E-6,4.1E-6,1.21E-5,2.4E-5,0,1.
2E-2,3.1E-2
6  ! DATA 3.84E-12
7  ! DATA NA24,1.28E-6,1.72E-6,4.35E-6,7.54E-6,1.7E-6,2.3E-6,5.8E-6,1.01E-5,2.9
E-8,4E-2,3E-2
8  ! DATA 1.283E-5
9  DATA P32,1.65E-4,2.36E-4,7.04E-4,1.45E-3,1.93E-4,2.76E-4,8.25E-4,1.7E-3,0,
2.5E-2,4.6E-2
10 DATA 5.61E-7
11 DATA CR51,1.8E-6,2.62E-6,4.6E-6,9.17E-6,6.7E-7,6.05E-7,4.72E-7,4.1E-7,2.6E-10
,2.2E-3,2.4E-3
12 DATA 2.89E-7
13 DATA MN54,1.75E-4,2.48E-4,4.26E-4,7.14E-4,1.4E-5,1.21E-5,1.07E-5,2E-5,5.8E-9
,2.5E-4,8E-4
14 DATA 2.56E-8
15 ! DATA MN56,2.53E-6,7.2E-6,3.33E-5,5.1E-5,3.67E-6,1.04E-5,4.84E-5,7.43E-5,1.3
E-8,2.5E-4,8E-4
16 ! DATA 7.46E-5
17 DATA FES5,4.01E-6,1.55E-5,3E-5,6.21E-5,2.75E-6,3.78E-6,1.15E-5,1.39E-5,0,1.
2E-3,4E-2
18 DATA 8.14E-9
19 DATA FES9,1.27E-4,1.9E-4,3.46E-4,7.25E-4,3.4E-5,3.24E-5,2.78E-5,5.38E-5,9.4E-
9,1.2E-3,4E-2
20 DATA 1.78E-7
21 ! DATA C058,1.16E-4,1.68E-4,3E-4,5.55E-4,1.51E-5,1.34E-5,1.05E-5,8.98E-6,8.2E-
9,1E-3,1.3E-2
22 ! DATA 2.12E-5
23 DATA C058,1.16E-4,1.68E-4,3E-4,5.55E-4,1.51E-5,1.34E-5,1.05E-5,8.98E-6,8.2E-
9,1E-3,1.3E-2
24 DATA 1.12E-7
26 !
27 DATA C060,7.46E-4,1.1E-3,1.91E-3,3.22E-3,4.02E-5,3.66E-5,2.93E-5,2.57E-5,2E-8
,1E-3,1.3E-2
28 DATA 4.18E-9
29 DATA NI63,5.4E-5,7.25E-5,2.22E-4,2.42E-4,1.30E-4,1.77E-4,5.38E-4,6.34E-4,0,6
.7E-3,5.3E-2
30 DATA 2.0E-10
31 ! DATA NI65,1.54E-6,4.6E-6,2.3E-5,3.6E-5,1.74E-6,5.2E-6,2.6E-5,4.05E-5,4.3E-9
,6.7E-3,5.3E-2
32 ! DATA 7.55E-5
33 ! DATA CU64,6.12E-6,7.68E-6,9.9E-6,1.07E-5,7.1E-6,8.9E-6,1.15E-5,1.25E-5,1.7
E-9,1.4E-2,8E-3
34 ! DATA 1.51E-5
35 DATA ZN65,1.08E-5,1.55E-4,2.69E-4,4.67E-4,1.54E-5,2E-5,3.65E-5,6.31E-5,4.6E-9
,3.9E-2,3E-2
36 DATA 3.29E-8
37 ! DATA ZN69,1.15E-7,2E-7,2.75E-6,9.44E-6,1.97E-8,5.16E-8,4E-6,1.37E-5,0,3.9E-
2,3E-2,1.41E-5
38 !
40 !
41 ! DATA KR83,3.01E-8,4.3E-8,1.28E-7,2.72E-7,5.79E-8,5.74E-8,1.71E-7,3.63E-7,9
.3E-11,0,0
42 ! DATA 8.02E-5
44 !
46 !
48 !
50 !
51 DATA KR86,1.7E-5,2.38E-5,5.36E-5,1.36E-4,2.11E-5,2.98E-5,6.7E-5,1.7E-4,7.2E-1

```

0,3E-2,3.1E-2
52 DATA 4.29E-7

APPENDIX G

54 !
56 !
57 DATA SR89,1.75E-4,3.02E-4,5.83E-4,1.45E-3,3.08E-4,4.4E-4,1.32E-3,2.5E-3,6.5E-
13,8E-4,6E-4
58 DATA 1.58E-7
59 DATA SR90,1.24E-2,1.35E-2,2.73E-2,2.92E-2,7.58E-3,8.3E-3,1.7E-2,1.85E-2,0.8E-
4,6E-4,7.6E-10
60 !
61 ! DATA SR91,2.3E-5,3.24E-5,4.7E-5,5.24E-5,2.7E-5,3.66E-5,5.3E-5,5.92E-5,8.3E-
9,8E-4,6E-4
62 ! DATA 1.99E-5
63 ! DATA SR92,5.38E-6,1.249E-5,6.55E-5,1E-4,4.26E-5,7.77E-5,1.71E-4,2.07E-4,1E-
8,8E-4,6E-4
64 ! DATA 7.16E-5
65 ! DATA Y90,6.32E-5,7E-5,7.24E-5,1.92E-4,1.02E-4,1.13E-4,1.17E-4,1.2E-4,2.6E-1
2,1E-5,4.6E-3
66 ! DATA 6.03E-5
67 ! DATA Y90,6.32E-5,7E-5,7.24E-5,1.92E-4,1.02E-4,1.13E-4,1.17E-4,1.20E-4,2.6E-
12,1E-5,4.6E-3
68 ! DATA 3.01E-6
70 !
71 DATA Y91,2.13E-4,3.7E-4,7.1E-4,1.75E-3,7.76E-5,8.24E-5,8.02E-5,8.1E-5,2.7E-11
,1E-5,4.6E-3
72 DATA 1.36E-7
73 ! DATA Y92,9.2E-6,2.06E-5,6.46E-5,9.04E-5,1.48E-5,3.32E-5,1.04E-4,1.46E-4,1.9
E-9,1E-5,4.6E-3
74 ! DATA 5.45E-5
75 ! DATA Y93,5.27E-5,7.24E-5,1.05E-4,1.19E-4,8.5E-5,1.17E-4,1.7E-4,1.92E-4,7.8E
-10,1E-5,4.6E-3
76 ! DATA 1.89E-5
77 DATA ZR95,2.21E-4,3.36E-4,6.03E-4,1.25E-3,3.09E-5,3E-5,2.66E-5,2.5E-5,5.8E-9,
5E-6,3.4E-2
78 DATA 1.22E-7
79 ! DATA ZR97,6.54E-5,7.88E-5,9.49E-5,1E-4,1.05E-4,1.27E-4,1.53E-4,1.62E-4,6.4E
-9,5E-6,3.4E-2
80 ! DATA 1.15E-5
81 ! DATA NB95,1.3E-5,9.39E-5,1.66E-4,3.42E-4,2.1E-5,1.95E-5,1.62E-5,1.46E-5,6E-9
,2.5E-3,2.8E-1
82 ! DATA 2.21E-6
83 DATA NB95,6.31E-5,9.39E-5,1.66E-4,3.42E-4,2.1E-5,1.95E-5,1.62E-5,1.46E-5,6E-9
,2.5E-3,2.8E-1
84 DATA 2.285E-7
85 ! DATA M099,3.1E-5,3.36E-5,3.66E-5,9.63E-5,10E-6,1.38E-5,2.84E-5,5.08E-5,2.2E
-9,7.5E-3,8E-3
86 ! DATA 2.89E-6
87 ! DATA 1C99,5.2E-7,7.66E-7,1.3E-6,1.45E-6,4.13E-7,6.08E-7,1.03E-6,1.15E-6,1.1
E-7,2.5E-2,4E-1
88 ! DATA 3.21E-5
89 !
93 DATA RU103,6.31E-5,9.79E-5,1.79E-4,3.94E-4,2.16E-5,2.13E-5,1.9E-5,1.8E-5,4.02
E-9,1E-6,4E-1
94 DATA 2.01E-7
95 ! DATA RU105,6.02E-6,1.13E-5,2.7E-5,3.46E-5,9.42E-6,1.76E-5,4.21E-5,5.41E-5,5
.1E-9,1E-6,4E-1
96 ! DATA 4.34E-5
97 DATA RU106,1.17E-3,2.01E-3,3.87E-3,8.26E-3,1.78E-4,1.9E-4,1.82E-4,1.83E-4,1.8
E-9,1E-6,4E-1
98 DATA 2.18E-8
99 DATA AG110,5.79E-4,8.44E-4,1.48E-3,2.62E-3,6.04E-5,5.45E-5,4.33E-5,3.77E-5,2.
1E-8,5E-2,1.7E-2
100 DATA 3.17E-8
111 !
121 DATA TE125,3.9E-5,6.7E-5,1.29E-4,3.2E-4,1.1E-5,1.13E-5,1.14E-5,2.32E-5,4.8E-
11,1E-3,7.7E-2

APPENDIX G

131 DATA 1.38E-7
141! DATA TE127, 7.17E-6, 1E-5, 1.52E-5, 1.74E-5, 8.68E-6, 1.22E-5, 1.84E-5, 2.1E-5, 1E-11
, 1E-3, 7.7E-2, 7.36E-8
151 !
161 DATA TE127, 1.2E-4, 2.07E-4, 4E-4, 9.37E-4, 2.75E-5, 3.92E-5, 8.24E-5, 1.44E-4, 1.3E-
12, 1E-3, 7.7E-2
171 DATA 7.36E-8
181 DATA TE129, 1.45E-4, 2.47E-4, 4.76E-4, 1.2E-3, 5.79E-5, 6.82E-5, 1.43E-4, 2.50E-4, 9E-
-10, 1E-3, 7.7E-2
191 DATA 2.35E-7
221 ! DATA TE131, 1.74E-7, 2.9E-7, 5.55E-7, 5.9E-6, 8.63E-8, 1.2E-7, 4.36E-7, 7.1E-6, 2.6
E-6, 1E-3, 7.7E-2
231 ! DATA 6.42E-6
261 ! DATA TE132, 6.37E-5, 5.61E-5, 1.02E-4, 2.43E-4, 7.71E-5, 7E-5, 4.5E-5, 6.44E-5, 2E-9
, 1E-3, 7.7E-2, 2.47E-6
271 !
291 !
301 ! DATA 1130, 1.42E-4, 1.86E-4, 5E-4, 1.14E-3, 1.89E-4, 2.43E-4, 6.5E-4, 1.48E-3, 1.7E-
-8, 6E-3, 2.9E-3
311 ! DATA 1.55E-5
321 DATA 1131, 1.5E-3, 1.83E-3, 4.4E-3, 1.06E-2, 5.72E-3, 2.4E-3, 5.72E-3, 1.39E-2, 3.4E-
9, 6E-3, 2.9E-3
331 DATA 9.95E-7
341 DATA 1133, 2.7E-4, 3.65E-4, 1.04E-3, 2.54E-3, 3.63E-4, 4.76E-4, 1.36E-3, 3.3E-3, 4.
5E-9, 6E-3, 2.9E-3
351 DATA 9.25E-6
381 ! DATA 1135, 5.6E-5, 7.76E-5, 2.14E-4, 4.97E-4, 7.65E-5, 1E-4, 2.79E-4, 6.49E-4, 1.4E-
-8, 6E-3, 2.9E-3
391 ! DATA 2.87E-5
401! DATA CS134, 1.06E-4, 3.4E-4, 2.74E-4, 5.02E-4, 1.48E-4, 2E-4, 3.84E-4, 7.03E-4, 1.4E-
8, 1.2E-2, 4E-3
411! DATA 6.64E-5
421 DATA CS134, 1.06E-4, 1.41E-4, 2.74E-4, 5.02E-4, 1.48E-4, 1.97E-4, 3.84E-4, 7.03E-4, 1.
4E-8, 1.2E-2, 4E-3
431 DATA 1.07E-8
441 DATA CS136, 1.83E-5, 2.42E-5, 4.62E-5, 9.6E-5, 2.57E-5, 3.4E-5, 6.46E-5, 1.35E-4, 1.7
E-8, 1.2E-2, 4E-3
442 DATA 6.17E-7
443 DATA CS137, 7.76E-5, 1.06E-4, 2.45E-4, 4.37E-4, 1.09E-4, 1.49E-4, 3.27E-4, 6.11E-4, 4
.9E-9, 1.2E-2, 4E-3
444 DATA 7.27E-10
449 DATA BA140, 1.59E-4, 2.54E-4, 4.71E-4, 1.14E-3, 4.18E-5, 4.38E-5, 8.31E-5, 1.71E-4, 2
4E-9, 4E-4, 3.2E-3
450 DATA 6.26E-7
455 ! DATA LA140, 5.73E-5, 6.09E-5, 6.1E-5, 1.2E-4, 9.25E-5, 9.82E-5, 9.84E-5, 9.77E-5, 1
.7E-8, 5E-6, 2E-4
456 ! DATA 4.78E-6
459 DATA CE141, 4.52E-5, 7.67E-5, 1.47E-4, 3.69E-4, 2.42E-5, 2.54E-5, 2.47E-5, 2.48E-5, 6
.2E-10, 1E-4, 1.2E-3
460 DATA 2.47E-7
461 DATA CE143, 2.83E-5, 3.19E-5, 3.44E-5, 8.3E-5, 4.56E-5, 5.14E-5, 5.55E-5, 5.73E-5, 2.
5E-9, 1E-4, 1.2E-3
462 DATA 5.83E-6
463 DATA CE144, 9.72E-4, 1.67E-3, 3.23E-3, 7.03E-3, 1.65E-4, 1.75E-4, 1.7E-4, 1.71E-4, 3.
7E-10, 1E-4, 1.2E-3
464 DATA 2.82E-8
465 DATA PR143, 3.51E-5, 6.04E-5, 1.17E-4, 3.09E-4, 4.03E-5, 4.31E-5, 4.24E-5, 4.29E-5, 0
, 5E-6, 4.7E-3, 5.91E-7
466 !
471 DATA ND147, 2.76E-5, 4.65E-5, 8.87E-5, 2.3E-4, 3.49E-5, 3.68E-5, 3.58E-5, 3.6E-5, 1.2
E-9, 5E-6, 3.3E-3
472 DATA 7.25E-7
473 ! DATA W187, 1.94E-5, 2.21E-5, 2.46E-5, 2.83E-5, 2.82E-5, 3.22E-5, 3.57E-5, 3.69E-5,
3.6E-9, 5E-4, 1.3E-3
474 ! DATA 8.05E-6
475 DATA NP239, 1.49E-5, 1.65E-5, 1.73E-5, 4.25E-5, 2.4E-5, 2.67E-5, 2.79E-5, 2.87E-5, 1.

APPENDIX G

478 ! THIS PROGRAM COMPUTES (R), PATHWAY DOSE FACTORS FOR ADULTS, TEENAGERS, C
CHILDREN AND INFANTS

479 ! TO USE THE PROGRAM, PRESS RUN AND THEN RESPOND TO THE QUESTIONS ASKED.

480 !

481 ! NOTE: SOME ISOTOPES WITH HALF LIVES LESS THAN 8 DAYS HAVE BEEN DELETED IAW
RG1.109.

482 !

483 ! C-14 HAS BEEN DELETED FROM THE GASEOUS RELEASE CALCULATIONS.

485 !

486 ! DEFINITION OF TERMS

487 !

490 ! DfA=MAX ORGAN INHALATION DOSE FACTOR, TABLE E-6 THROUGH E-10 R.G. 1.

109

500 !

510 ! DFG=GROUND PLANE DOSE CONVERSION FACTOR, TABLE E-6 R.G. 1.109

520 !

530 ! DFL=MAX ORGAN INGESTION DOSE FACTOR, TABLE E-11 THROUGH E-14, R.G. 1.109

540 !

550 ! Fm=STABLE ELEMENT TRANSFER COEFFICIENT MILK, TABLE E1 R.G. 1.109

551 !

560 ! Ff=STABLE ELEMENT TRANSFER COEFFICIENT MEAT, TABLE E1 R.G. 1.109

570 !

580 ! K=CONSTANT, 1.0E6, NUREG 133

590 !

600 ! BR=BREATHING RATE, 1400, 3700, 8000, 8000 FOR INFANT, CHILD, TEEN, ADULT
RESP.

610 !

620 ! Kv=CONSTANT, 8760, NUREG 133

630 !

640 ! SF=SHIELDING FACTOR, .7, TABLE E15 R.G. 1.109

650 !

660 ! LAMDA=NUCLIDE DECAY CONSTANT

670 !

680 ! T=DECAY TIME, ASSUMING THAT DECAY IS THE ONLY REMOVAL MECHANISM, 4.73E8,
NUREG 133

690 !

700 ! QF=COW'S CONSUMPTION RATE, 50, TABLE E3, R.G. 1.109

710 !

720 ! R=FRACTION OF DEPOSITED ACTIVITY RETAINED ON COW'S FEED GRASS, 1.0 FOR 7
OVINE, .2 FOR

721 ! PARTICULATE.

740 !

750 ! UAP1=RECEPTOR'S MILK CONSUMPTION RATE, 330, 330, 400, 310 FOR INFANT, CHIL
LD, TEENAGER AND

760 ! ADULT RESPECTFULLY.

770 !

780 ! Yp=AGRICULTURAL PRODUCTIVITY, .7, NUREG 133

790 !

800 ! Ys=AGRICULTURAL PRODUCTIVITY (STORED FEED), 2.0, NUREG 133.

810 !

820 ! Tf=TRANSPORT TIME FROM PASTURE TO RECEPTOR, 1.73E5, NUREG 133.

830 !

840 ! Th=TRANSPORT TIME FROM PASTURE TO HARVEST TO RECEPTOR, 7.78E6, NUREG 133

850 !

860 ! Fp=FRACTION OF YEAR COW IS ON PASTURE, 1.0, VALUE MAY CHANGE ANNUALLY.

871 !

880 ! Ff=FRACTION OF THE COW FEED THAT IS PASTURE GRASS WHILE COW ON PASTURE.

Ff=1.0

890 ! Ff CAN POTENTIALLY CHANGE ANNUALLY. TO UP-DATE THIS VALUE, SIMPLY CHANGE
THE Ff ASSIGNMENT

891 !

900 ! KKK=CONSTANT 1.0E3, NUREG 133

910 !

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920  ! H=HUMIDITY, 8, NUREG 133
930  !
940  ! LAMDAW=DECAY CONSTANT FOR REMOVAL OF ACTIVITY FROM PLANTS BY WEATHERING,
    5.73E-7, NUREG 133
950  !
960  ! UAP2=RECEPTOR'S MEAT CONSUMPTION, 0, 41, 65, 110 FOR INFANT,CHILD,TEENAGE
    R, AND ADULT
970  !
980  ! UAL=CONSUMPTION RATE OF FRESH LEAFY VEGETABLES 0, 26, 42, 64, FOR INFANT,
    CHILD,TEENAGER,ADULT
990  !
1000 ! UAS=CONSUMPTION RATE OF STORED VEGETABLES 0, 520, 630, 520, INFANT,CHILD,
    TEENAGER,ADULT
1010 !
1020 ! FL=FRACTION FRESH VEGETABLES GROWN LOCALLY
1030 !
1040 ! FG=FRACTION STORED VEGETABLES GROWN LOCALLY
1050 !
1060 ! TL=AVG. TIME BETWEEN HARVEST OF VEGETABLES AND CONSUMPTION, 8.6 E4 SEC.
    NUREG 133
1070 !
1080 ! THH=AVERAGE TIME BETWEEN HARVEST OF STORED VEGETABLES AND CONSUMPTION 5
    18E6 SEC. NUREG 133
1090 !
1100 !
1110 K=1.0E+6 ! UNITS CONVERSION FACTOR
1120 Kk=8760 ! UNITS CONVERSION FACTOR
1130 Sf=7 ! SHIELDING FACTOR
1140 T=4.73E+8 ! DECAY TIME FOR DECAY AS ONLY REMOVAL MECHANISM
1150 Cf=50 ! COW CONSUMPTION RATE
1160 R=2 ! FRACTION OF DEPOSITED ACTIVITY RETAINED ON COW'S FEED GRASS.
1170 Yp=7 ! AGRICULTURAL PRODUCTIVITY
1180 Ys=2.0 ! AGRICULTURAL PRODUCTIVITY FOR STORED FEED
1190 Tf=1.73E+5 ! TRANSPORT TIME FROM PASTURE TO RECEPTOR.
1200 Yv=2 !
1201 Tff=1.73E+6
1210 Th=7.78E+6 ! TRANSPORT TIME FROM PASTURE TO HARVEST TO RECEPTOR.
1220 Fp=1.0 ! FRACTION OF THE YEAR COW IS ON PASTURE.
1230 Fv=1.0 ! FRACTION OF THE COW'S FEED THAT IS STORED FEED WHILE COW ON PAST
    URE.
1240 Kkv=1.0E+3 ! UNITS CONVERSION FACTOR
1250 H=8 ! ABSOLUTE HUMIDITY-DEFAULT VALUE
1260 LamdaW=5.73E-7 ! DECAY CONSTANT FOR WEATHERING
1270 Ff=1 ! FRACTION OF FRESH VEG. GROWN LOCALLY
1280 Fg=.76 ! FRACTION OF STORED VEG. GROWN LOCALLY
1290 Tl=8.6E+4 ! AVG. TIME BETWEEN HARVEST OF VEG. AND CONSUMPTION
1300 Thh=5.18E+6 ! AVG. TIME BETWEEN HARVEST OF STORED VEG. AND CONSUMPTION
1301 ! BY ENTERING THE AGE GROUP OF CONCERN, THE COMPUTER WILL GENERATE A TABLE
    OF DOSE FACTORS.
1302 !
1303 !
1310 INPUT "PLEASE INDICATE INFANT,CHILD,TEENAGER, OR ADULT",Age$
1311 !
1312 !
1314 INPUT "PLEASE INDICATE PATHWAY DOSE FACTOR R OR P",As
1315 !
1317 IF As="" THEN 1397
1318 READ Atom$,Dfa1,Dfa2,Dfa3,Dfa4,Df11,Df12,Df13,Df14,Dfg,Fm,Ff,Landa
1319 IF Age$="INFANT" THEN 1404
1320 IF Age$="CHILD" THEN 1480
1321 IF Age$="TEENAGER" THEN 1570
1322 IF Age$="ADULT" THEN 1660
1323 PRINT USING "26X,26A","PATHWAY DOSE FACTOR (P)"
1324 PRINT " "
1325 PRINT " "

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APPENDIX G

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1326 IMAGE 13X,4A,4X,10A,5X,12A,8X,4A, // APPENDIX G
1327 PRINT USING 1326,"ATOM","INHALATION","GROUND PLANE","FOOD"
1328 IF Atom#="I130" THEN R=1 IR=1 FOR ALL ISOTOPES OF RADIOIODINE.
1329 IF Atom#="I131" THEN R=1
1330 IF Atom#="I132" THEN R=1
1331 IF Atom#="I133" THEN R=1
1332 IF Atom#="I134" THEN R=1
1333 IF Atom#="I135" THEN R=1
1334 IF Lambda*3.15E+7<700 THEN 1337 ! AVOID REAL UNDERFLOW.
1335 Expo10=1.0E-300 ! DEFAULT VALUE FOR EXPONENTIALS TOO LARGE TO BE COMPUTED.
1336 GOTO 1338
1337 Expo10=EXP(-Lambda*3.15E+7)
1338 P2=K*KK*Qfg*(1-Expo10)/Lambda
1339 IF Lambda*1f<700 THEN 1342 ! AVOID REAL UNDERFLOW
1340 Expo12=1.0E-300 ! DEFAULT VALUE FOR EXPONENTIALS TOO LARGE TO BE COMPUTED.
1341 GOTO 1343
1342 Expo12=EXP(-Lambda*1f)
1343 P3=(K*KK*Qf*Uap1)/(Yp*(Lambda+LamdaW))*Fm*DF1*Expo12
1344 IF Atom#="H3" THEN P3=2.43E+3 ! SEE NUREG 133 PAGE 28
1345 P1=K*Br*DFa
1346 IF Atom#("NB95" THEN 1352
1347 PAUSE
1348 PRINT USING "26X,26A,/,/,", "PATHWAY DOSE FACTOR (P)"
1349 IMAGE 13X,4A,4X,10A,5X,12A,8X,4A, //
1350 PRINT USING 1349,"ATOM","INHALATION","GROUND PLANE","FOOD"
1352 IMAGE 13X,5A,4X,0.3DE,5X,0.3DE,11X,0.3DE, //
1353 PRINT USING 1352:Atom#,P1,P2,P3
1354 K=2
1355 IF Atom#="NP23Y" THEN 1394 ! CHECK FOR END OF DATA.
1356 READ Atom#,Dfa1,Dfa2,Dfa3,Dfa4,Df11,Df12,Df13,Df14,Dfg,Fm,Ff,Lambda ! THIS
STATEMENT READS THE
1357 ! DATA ASSOCIATED WITH THE PATHWAY DOSE FACTOR (K) CALCULATIONS.
1358 IF Age#("INFANT" THEN 1367 ! ASSIGNS AGE GROUP SPECIFIC DATA.
1359 Dfa=Dfa4
1360 Df1=Df14
1361 Br=1400
1362 Uap1=330
1363 Uap2=0
1364 Ua1=0
1365 Uas=0
1366 GOTO 1328
1367 IF Age#("CHILD" THEN 1376 ! ASSIGNS AGE GROUP SPECIFIC DATA.
1368 Dfa=Dfa3
1369 Df1=Df13
1370 Br=3700
1371 Uap1=330
1372 Uap2=41
1373 Ua1=26
1374 Uas=520
1375 GOTO 1328
1376 IF Age#("TEENAGER" THEN 1385 ! ASSIGNS AGE GROUP SPECIFIC DATA.
1377 Dfa=Dfa2
1378 Df1=Df12
1379 Br=8000
1380 Uap1=400
1381 Uap2=65
1382 Ua1=42
1383 Uas=630
1384 GOTO 1328
1385 IF Age#("ADULT" THEN 1393 ! ASSIGNS AGE GROUP SPECIFIC DATA.
1386 Dfa=Dfa1
1387 Df1=Df11
1388 Br=8000
1389 Uap1=310
1390 Uap2=110
1391 Ua1=63

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APPENDIX G

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1392 Uas=520
1393 GOTO 1328
1394 GOTO 2370
1395 ! THE FOLLOWING CODE PRINTS THE PAGE TITLE AND THE COLUMN HEADS.
1396 !
1397 PRINT USING "28X,26A,/,/,,";"PATHWAY DOSE FACTOR (R) ";Age$
1398 IMAGE 3X,4A,4X,5A,6X,3A,8X,8A,4X,8A,6X,3A,8X,7A,/
1399 PRINT USING 1398;"ATOM","INHAL","G/P","COW/MILK","COW/MEAT","VEG","GI/MILK
"
1400 ! THIS READ STATEMENT READS THE NUCLIDE OF CONCERN PLUS THE DFA AND DFL VAL
UES FOR THAT NUCLIDE
1401 ! NOTE DFA1 IS THE DFA VALUE FOR AN ADULT, DFA2 IS THE VALUE FOR A TEEN, DF
A3 AND DFA4 ARE THE
1402 ! VALUES FOR CHILDREN AND INFANTS RESPECTIVELY
1403 RE/ ATOMS,Dfa1,Dfa2,Dfa3,Dfa4,DF11,DF12,DF13,DF14,Dfg,Fm,Ff,Lamda
1404 IF Age$()"INFANT" THEN 1480
1405 Dfa=Dfa4 ! ASSIGN INFANT RELATED VALUES
1410 DF1=DF14
1420 Br=1400
1430 Uap1=330
1440 Uap2=0
1450 Ual=0
1460 Uas=0
1461 IF AS="P" THEN 1323
1470 GOTO 1740
1480 IF Age$()"CHILD" THEN 1570
1490 Dfa=Dfa3 ! ASSIGN CHILD RELATED VALUES
1500 DF1=DF13
1510 Br=3700
1520 Uap1=360
1530 Uap2=41
1540 Ual=26
1550 Uas=520
1551 IF AS="P" THEN 1323
1560 GOTO 1740
1570 IF Age$()"TEENAGER" THEN 1660
1580 Dfa=Dfa2 ! ASSIGN TEENAGER RELATED VALUES
1590 DF1=DF12
1600 Br=8000
1610 Uap1=400
1620 Uap2=65
1630 Ual=42
1640 Uas=630
1641 IF AS="P" THEN 1323
1650 GOTO 1740
1660 IF Age$()"ADULT" THEN 1740
1670 Dfa=Dfa1 ! ASSIGN ADULT RELATED VALUES
1680 DF1=DF11
1690 Br=8000
1700 Uap1=310
1710 Uap2=110
1720 Ual=64
1730 Uas=520
1731 IF AS="P" THEN 1323
1740 IF ATOMS="I131" THEN R=1 !SEE NUREG 133 P.34 FOR EXPLANATION.
1750 IF ATOMS="I132" THEN R=1
1760 IF ATOMS="I130" THEN R=1
1770 IF ATOMS="I133" THEN R=1
1780 IF ATOMS="I134" THEN R=1
1790 IF ATOMS="I135" THEN R=1
1791 ! THE FOLLOWING CODE CALCULATES FOUR EXPONENTIAL VALUES. A DEFAULT VALUE
OF 1.0E-300 IS USED
1792 ! TO AVOID THE ERROR "REAL UNDERFLOW"
1793 IF Lamda*Tff<700 THEN 1796
1794 Expo7=1.0E-300
1795 GOTO 1800

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APPENDIX G

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1796 Expo7=EXP(-Lamda*Iff)
1800 IF Lamda*Ihh(700 THEN 1830
1810 Fxpo1=1.0E-300
1820 GOTO 1840
1830 Expo1=EXP(-Lamda*Ih)
1840 IF Lamda*Iff(700 THEN 1870
1850 Expo2=1.0E-300
1860 GOTO 1880
1870 Expo2=EXP(-Lamda*Iff)
1880 IF Lamda*I1(700 THEN 1910
1890 Expo3=1.0E-300
1900 GOTO 1920
1910 Expo3=EXP(-Lamda*I1)
1920 IF Lamda*Ihh(700 THEN 1950
1930 Fxpo4=1.0E-300
1940 GOTO 1960
1950 Expo4=EXP(-Lamda*Ihh)
1951 ! EXP04 IS A FACTOR UTILIZED IN THE CALCULATION OF THE COW/MILK AND COW/ME
AT DOSE PATHWAYS.
1960 Expoa=((Fp*Fs)/Yp+((1-Fp*Fs)*Expo1)/Ys)*Expo2
1961 ! EXPOB IS USED IN THE CALCULATION OF VEGETABLE DOSE PATHWAY.
1970 Expeb=Ua1*F1*Expo3+Uas*Fq*Expo4
1971 Expec=((Fp*Fs)/Yp+((1-Fp*Fs)*Expo1)/Ys)*Expo7
1980 IF Atom$="H3" THEN 2030
1990 R3=K*Fm*Qf*Uap1*DF1*((.75*S/H)) ! H3 COW/MILK PATHWAY
2000 R4=K*Fm*Qf*Uap2*DF1*((.75*S/H)) ! H3 COW/MEAT PATHWAY
2010 R5=K*Fm*(Ua1*F1+Qf*Uas)*DF1*((.75*S/H)) ! H3 VEGETABLE PATHWAY
2020 R6=K*Fm*.17*Uap1*DF1*((.75*S/H)) ! H3 GT/MILK PATHWAY
2030 K1=K*Fm*DFa ! INHALATION DOSE FACTOR
2040 IF Lamda*I(700 THEN 2070
2050 Expo5=1.0E-300 ! DEFAULT VALUE TO AVOID "REAL UNDERFLOW"
2060 GOTO 2080
2070 Expo5=EXP(-Lamda*I)
2080 K2=K*Fm*DFq*((1-Expo5)/Lamda) ! GROUND PLANE DOSE FACTOR
2090 IF Atom$="H3" THEN 2340 ! H3 VALUES WERE CALCULATED ABOVE
2100 R3=K*(Qf*Uap1)/(Lamda+Lamdaw)*Fm*DF1*Expoa ! COW/MILK PATHWAY
2110 R4=K*(Qf*Uap2)/(Lamda+Lamdaw)*Fm*DF1*Expec ! COW/MEAT PATHWAY
2111 !
2120 R5=K*(Yv*(Lamda+Lamdaw))*DF1*Expeb
2121 ! THE FOLLOWING CODE ITEMS ASSIGN FM VALUES FOR THE GOAT/MILK CALCULATION
2130 IF Atom$="H3" THEN Fm=.17
2150 IF Atom$="P32" THEN Fm=.25
2160 IF Atom$="FE55" THEN Fm=1.3E-4
2170 IF Atom$="FE59" THEN Fm=1.3E-4
2180 IF Atom$="CU64" THEN Fm=.013
2190 IF Atom$="SR90" THEN Fm=.014
2200 IF Atom$="SR90" THEN Fm=.014
2210 IF Atom$="I130" THEN Fm=.06
2220 IF Atom$="I131" THEN Fm=.06
2230 IF Atom$="I132" THEN Fm=.06
2240 IF Atom$="I133" THEN Fm=.06
2250 IF Atom$="I134" THEN Fm=.06
2260 IF Atom$="I135" THEN Fm=.06
2270 IF Atom$="CS134" THEN Fm=.3
2280 IF Atom$="CS136" THEN Fm=.3
2290 IF Atom$="CS137" THEN Fm=.3
2300 IF Atom$="CS138" THEN Fm=.3
2310 Qf=.6
2311 ! R6 CALCULATES THE GOAT/MILK PATHWAY.
2320 R6=K*(Qf*Uap1)/(Lamda+Lamdaw)*Fm*DF1*Expoa
2330 Qf=.50
2331 K=.2 ! REASSIGN FOR NON-IODINE
2340 IMAGE 3X,5A,3X,D.3DE,2X,D.3DE,2X,D.3DE,3X,D.3DE,5X,D.3DE,2X,D.3DE,77
2350 PRINT USING 2340,Atom$,R1,R2,R3,R4,R5,R6
2351 ! PAUSE
2353 IF Atom$="NB95" THEN 2361

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2354 PAUSE

APPENDIX G

2356 ! PRINT USING "E,@"

2357 ! PRINT USING "2X,@"

2358 PRINT USING "2BX,C6A,/ /,","PATHWAY DOSE FACTOR (R)",Age\$

2359 IMAGE 3X,4A,4X,5A,8X,3A,7X,8A,4X,8A,6X,3A,8X,7A,/

2360 PRINT USING 2359;"ATOM","INHAL","G/P","COW/MILK","COW/MEAT","VEG","GI/MIL
K"

2361 IF Atom\$(1)*NP239 THEN 1403

2370 END