OFFSITE DOSE CALCULATION MANUAL

ODCM

Commonwealth Edison Company

BYRON STATION

OFFSITE DOSE CALCULATION MANUAL

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OFFSITE DOSE CALCULATION MANUAL

CONTENTS

CONTENTS (Cont'd)

1.0 INTRODUCTION

TABLE OF CONTENTS

1.0 INTRODUCTION

LIST OF FIGURES

1.0 INTRODUCTION

This document provides a concise description of the environmental dose models and techniques used to calculate the offsite doses resulting from the release of radioactive material from Commonwealth Edison's nuclear power plants. A flow chart of these dose models and techniques is given in Figure 1.0-1. Documentation for both airborne (Sections 2.1 and 3.0) and aquatic pathways (Sections 2.2 and 4.0, are included.

The models consider two release modes: airborne and liquid. Airborne releases are further subdivided into two subclasses: (1) radioiodines, particulates, and other nonnoble gas nuclides, and (2) noble gases.

Radioiodines, Particulates, and Other Nuclides

In this model it is assumed that there is an adult and infant living in each of 16 sectors around the station. Infant exposure occurs through inhalation and any actual milk pathway. Adult exposure derives from inhalation, assumed leafy vegetable and produce pathways, and any actual milk and meat pathways. Doses to each of seven organs listed in Regulatory Guide 1.109 (bone, liver, total body, thyroid, kidney, lung, and GI-LLI) are computed from individual nuclide contributions in each of the sectors. Searching over sector and organ, the largest organ dose is compared to the 10 CFR 50, Appendix I design objectives. This dose calculation is performed monthly for infants and annually for adults. (The adult dose is computed annually to confirm the premise that the infant is the critical person. The adult will be substituted for the infant in the monthly schedule if found to be the critical person.) As necessary, the release rates of these nuclides will be converted to dose rates for comparison to the limits of 10 CFR 20.

Noble Gases

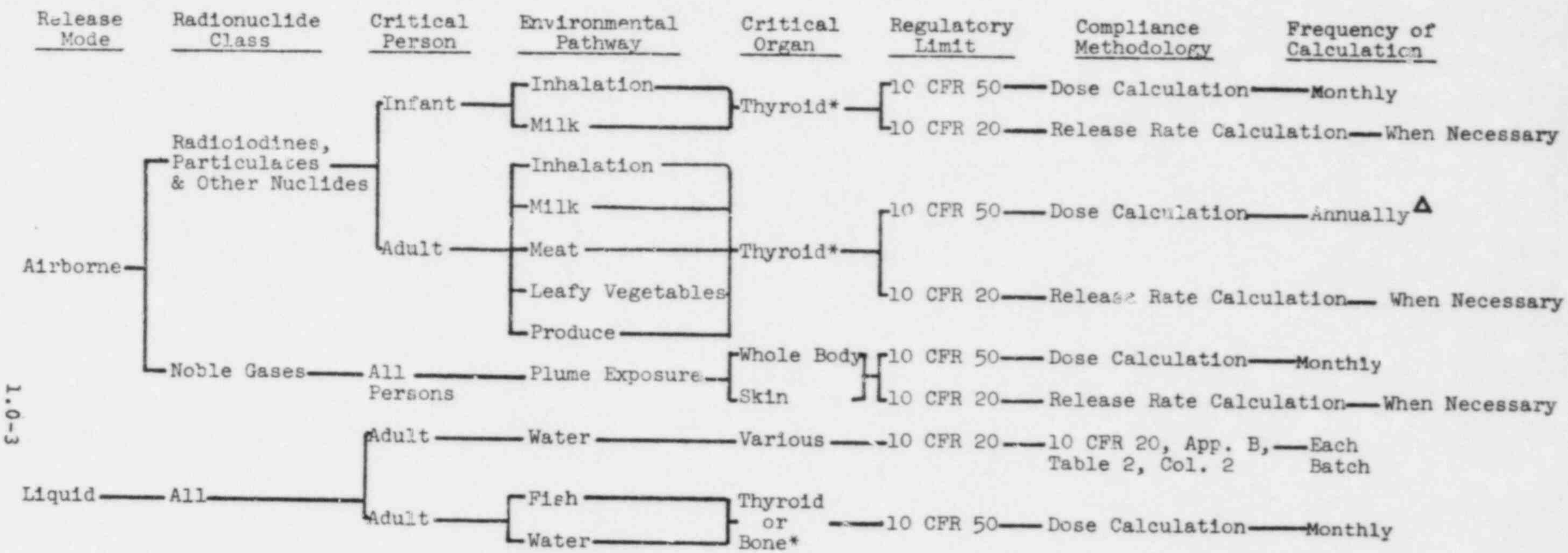
Exposure to the beta and gamma radiations of the noble gases will result in a whole body and skin dose. The maximum whole body and skin doses for each offsite sector are determined from the individual nuclide contributions and the maximum dose values are compared to the 10 CFR 50, Appendix I design objectives. This calculation is performed monthly. As necessary, the noble gas release rate will be converted to dose rates for comparison to the limits of 10 CFR 20.

For liquid releases it is assumed that liquid effluents discharged into a river undergo mixing prior to consumption as either potable water or fish by adults. For releases to Lake Michigan a finite plume dilution factor is computed for the potable water pathway and a hypothetical river model is created for the fish pathway. Doses to the seven critical organs are determined from individual nuclide contributions and the largest organ dose is compared to the 10 CFR 50 design objectives. Compliance with the 10 CFR 20 maximum permissible concentrations is done on a batch-by-batch basis prior to discharge.

Compliance with the various regulatory limits for offsite doses is demonstrated with the techniques of Section 5.0.

All site independent data used in the calculations are given in Section 7.1. Site specific data are given in Section 7.2.

The models and techniques used to establish the alarm and trip setpoints of the gaseous and liquid effluent monitors are described in Section 8.0.



* Most likely critical organ; however, dose is computed for 7 organs.

Δ The computation of dose to the adult is performed annually to confirm the premise that the infant is the critical person.

FIGURE 1.0-1
FLOW CHART FOR OFFSITE DOSE CALCULATIONS

2.0 OFFSITE DOSE LIMITS

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

2.0 OFFSITE DOSE LIMITS

LIST OF TABLES

2.0 OFFSITE DOSE LIMITS

2.1 AIRBORNE RELEASES

2.1.1 Noble Gases

2.1.1.1 10 CFR 50, Appendix I Design Objectives

2.1.1.1.1 Air Dose

The average air dose in unrestricted areas due to noble gases released in gaseous effluents from each reactor shall be limited to the following expressions:

2.1.1.1.1.1 Gamma Air Dose

2.1.1.1.1.1.1 Gamma Air Dose, Calendar Quarter

$$3.17 \times 10^{-8} \sum_i \left[S_i\ A_{is} + V_i\ A_{iv} + G_i\ A_{ig} \right] \leq 5 \text{ mrad} \qquad (2.1)$$

3.17×10^{-8} — Conversion Constant (years/second)

Converts seconds to years.

S_i — Gamma Dose Constant, Stack Release (mrad/yr per μCi/sec)

The gamma ray air dose constant for each identified noble gas radionuclide released from a stack (Tables 7.2-8 or 7.2-11). The constant is evaluated for a finite plume using the methods explained in Subsection 3.3.1.2.

A_{is} — Accumulative Radionuclide Release, Stack Release (μCi)

The accumulative release of radionuclide i from a stack. Releases shall be cumulative

over the calendar quarter or year (four consecutive quarters) as appropriate.

V_i — Gamma Dose Constant, Vent Release (mrad/yr per μCi/sec)

The gamma ray air dose constant for each identified noble gas radionuclide released from a vent (Tables 7.2-8 or 7.2-11). The plume may be elevated part of the time as determined by the criteria of Regulatory Guide 1.111 (Reference 6.4), part C.2.b. The constant is evaluated for a finite plume using the method explained in Subsection 3.3.1.2.

A_{iv} — Accumulative Radionuclide Release, Vent Release (μCi)

The accumulative release of radionuclide i from a vent. Releases shall be cumulative over the calendar quarter or year (four consecutive quarters) as appropriate.

G_i — Gamma Dose Constant, Ground Level Release (mrad/yr per μCi/sec)

The gamma ray air dose constant for each identified noble gas radionuclide released from a ground level release point (Tables 7.2-8 or 7.2-11). The constant is evaluated for a finite plume using the method explained in Subsection 3.3.1.2.

A_{ig} — Accumulative Radionuclide Release, Ground Level Release (μCi)

The accumulative release of radionuclide i from a ground level release point. Releases

shall be cumulative over the calendar quarter or year (four consecutive quarters) as appropriate.

2.1.1.1.1.1.2 Gamma Air Dose, Calendar Year (Four Consecutive Quarters)

$$3.17 \times 10^{-8} \sum_i \left[S_i A_{is} + V_i A_{iv} + G_i A_{ig} \right] \leq 10 \text{ mrad} \quad (2.2)$$

2.1.1.1.1.2 Beta Air Dose

2.1.1.1.1.2.1 Beta Air Dose, Calendar Quarter

$$3.17 \times 10^{-8} \sum_i L_i \left[(X/Q)_s A'_{is} + (X/Q)_v A'_{iv} + (X/Q)_g A'_{ig} \right] \leq 10 \text{ mrad} \quad (2.3)$$

L_i — Beta Air Dose Constant (mrad/yr per $\mu Ci/m^3$)

The air dose factor due to beta emissions for each identified noble gas radionuclide (Table 7.1-13).

$(X/Q)_s$ — Relative Effluent Concentration, Stack Release (sec/m^3)

The highest calculated annual average relative concentration in a given direction at or beyond the restricted area boundary for stack releases (Table 7.2-6 or Table 7.2-9).

A'_{is} Accumulative Radionuclide Release from Stack, Adjusted for Radiodecay (μCi)

The accumulative release of radic[illegible]lide i from a stack, adjusted to acc[illegible]or radiodecay in transit.

$$A'_{is} = A_{is} \times \exp(- \lambda_i \text{[illegible]} u_s) \quad (2.3a)$$

λ_i Radio[illegible]ecay Cons[illegible] (hr^{-1})

The radiological decay constant for radionuclide i. See Tables 7.1-9 and 7.1-11.

R Downwind Range (m)

The distance downwind to the point of interest. See Tables 7.2-6, 7.2-7, and 7.2-8.

3600 Constant (sec/hr)

Converts hours to seconds

u_s Average Wind Speed (m/sec)

The average wind speed for a stack release. See Table 7.2-6.

$(\chi/Q)_v$ Relative Effluent Concentration, Vent Release (sec/m^3)

The highest calculated annual average relative concentration in a given direction at or beyond the restricted area boundary for vent releases. The partially elevated plume model of Regulatory Guide 1.111, part C.2.b

(Reference 6.4) is used when necessary. See Subsection 3.2.2.3 and Table 7.2-6 or Table 7.2-9.

A'_{iv} Accumulative Radionuclide Release from Vent, Adjusted for Radiodecay (μCi)

The accumulative release of radionuclide i from a vent, adjusted for radiodecay in transit.

$$A'_{iv} = A_{iv} \times \exp(-\lambda_i R/3600\, u_v) \qquad (2.3b)$$

u_v Average Wind Speed (m/sec)

The average wind speed for a vent release. See Table 7.2-6.

$(X/Q)_g$ Relative Effluent Concentration, Ground Level Release (sec/m^3)

The highest calculated annual average relative concentration in a given direction at or beyond the restricted area boundary for ground level releases. (See Table 7.2-6 or Table 7.2-9.)

A'_{ig} Accumulative Radionuclide Release at Ground Level, Adjusted for Radiodecay (μCi)

The accumulative release of radionuclide i from ground level, adjusted for radiodecay in transit.

$$A'_{ig} = A_{ig} \times \exp(-\lambda_i R/3600\, u_g) \qquad (2.3c)$$

u_g Average Wind Speed (m/sec)

The average wind speed for a ground level release. See Table 7.2-6.

2.1.1.1.1.2.2 Beta Air Dose, Calendar Year (Four Consecutive Quarters)

$$3.17 \times 10^{-8} \sum_i L_i \left[(X/Q)_s A'_{is} + (X/Q)_v A'_{iv} + (X/Q)_g A'_{ig} \right]$$

$$\leq 20 \text{ mrad} \qquad (2.4)$$

2.1.1.1.2 Whole Body Dose

The average dose to individuals in unrestricted areas due to noble gases released in gaseous effluents from each reactor shall be limited to the following expressions:

2.1.1.1.2.1 Whole Body Dose, Calendar Quarter

$$(0.7)(1.11)(3.17 \times 10^{-8}) \sum_i \left[\overline{S}_i A_{is} + \overline{V}_i A_{iv} + \overline{G}_i A_{ig} \right]$$

$$\leq 2.5 \text{ mrem} \qquad (2.5)$$

0.7 Shielding and Occupancy Factor

The shielding and occupancy factor for protection against gamma radiation.

1.11 Conversion Constant (mrem/mrad)

Converts rads in air to rems in tissue.

$\overline{S}_i$ Gamma Whole Body Dose Constant, Stack Release (mrad/yr per μCi/sec)

$\overline{S}_i$ is the constant S_i multiplied by the shielding factor afforded by 5 cm of tissue; used to evaluate whole body dose. (See Subsection 3.3.1.2; also, see Tables 7.2-8 or 7.2-11.)

$\overline{V}_i$ — Gamma Whole Body Dose Constant, Vent Release (mrad/yr per µCi/sec)

The constant V_i multiplied by the shielding factor afforded by 5 cm of tissue; used to evaluate whole body dose. (See Subsection 3.3.1.2; also, see Tables 7.2-8 or 7.2-11.)

$\overline{G}_i$ — Gamma Whole Body Dose Constant, Ground Level Release (mrad/yr per µCi/sec)

The constant G_i multiplied by the shielding factor afforded by 5 cm of tissue; used to evaluate whole body dose. (See Subsection 3.3.1.2; also, see Tables 7.2-8 or 7.2-11.)

2.1.1.1.2.2 Whole Body Dose, Calendar Year (Four Consecutive Quarters)

$$(0.7)(1.11)(3.17 \times 10^{-8}) \sum_i \left[\overline{S}_i\, A_{is} + \overline{V}_i\, A_{iv} + \overline{G}_i\, A_{ig} \right] \leq 5 \text{ mrem} \qquad (2.6)$$

2.1.1.1.3 Skin Dose

The average skin dose to individuals in unrestricted areas due to noble gas released in gaseous effluents from each reactor shall be limited to the following expressions:

2.1.1.1.3.1 Skin Dose, Calendar Quarter

$$3.17 \times 10^{-8} \sum_i \left[1.0\, \overline{L}_i \left((X/Q)_s\, A'_{is} + (X/Q)_v\, A'_{iv} + (X/Q)_g\, A'_{ig} \right) + (0.7)(1.11)(S_i\, A_{is} + V_i\, A_{iv} + G_i\, A_{ig}) \right] \leq 7.5 \text{ mrem} \qquad (2.7)$$

1.0 Shielding and Occupancy Factor

The shielding and occupancy factor for protection against beta radiation.

$\overline{L}_i$ Beta Skin Dose Constant (mrem/yr per $\mu Ci/m^3$)

The skin dose factor due to beta emissions for each identified noble gas radionuclide (Table 7.1-13). Accounts for attenuation of beta radiation during passage through 7 mg/cm^2 of dead skin.

2.1.1.1.3.2 Skin Dose, Calendar Year (Four Consecutive Quarters)

$$3.17 \times 10^{-8} \sum_i \left[1.0\ \overline{L}_i \left((\chi/Q)_s A'_{is} + (\chi/Q)_v A'_{iv} + (\chi/Q)_g A'_{ig} \right) + (0.7)(1.11)(S_i A_{is} + V_i A_{iv} + G_i A_{ig}) \right] \leq 15 \text{ mrem} \quad (2.8)$$

2.1.1.2 10 CFR 20 Release Rate Limits

The maximum dose rate to individuals in unrestricted areas due to noble gases released in gaseous effluents from the site shall be limited to the following expressions:

2.1.1.2.1 Whole Body Dose Rate

$$1.11 \times \sum_i \left[\overline{S}_i Q_{is} + \overline{V}_i Q_{iv} + \overline{G}_i Q_{ig} \right] < 500 \text{ mrem/yr} \quad (2.9)$$

(10 CFR 20.105 limit)

Q_{is} Release Rate, Stack Release (μCi/sec)

The release rate for radionuclide i due to a stack release.

Q_{iv} Release Rate, Vent Release (μCi/sec)

The release rate for radionuclide i due to a vent release.

Q_{ig} Release Rate, Ground Level Release (μCi/sec)

The release rate for radionuclide i due to a ground level release.

2.1.1.2.2 Skin Dose Rate

$$\sum_i \left[\bar{L}_i \left((X/Q)_s \, Q'_{is} + (X/Q)_v \, Q'_{iv} + (X/Q)_g \, Q'_{ig} \right) + 1.11 \times (S_i \, Q_{is} + V_i \, Q_{iv} + G_i \, Q_{ig}) \right] \leq 3000 \text{ mrem/yr}$$

(10 CFR 20.105 limit)

(2.10)

Q'_{is} Release Rate, Stack Release, Adjusted for Radiodecay (μCi/sec)

The release rate for radionuclide i from a stack adjusted for radiodecay in transit.

$$Q'_{is} = Q_{is} \times \exp(-\lambda_i R/3600 \, u_s) \quad (2.10a)$$

Q'_{iv} Release Rate, Vent Release, Adjusted for Radiodecay (μCi/sec)

The release rate for radionuclide i from a vent, adjusted for radiodecay in transit.

$$Q'_{iv} = Q_{iv} \times \exp(-\lambda_i R/3600 \, u_v) \quad (2.10b)$$

Q'_{ig} Release Rate, Ground Level, Adjusted for Radiodecay (μCi/sec)

The release rate for radionuclide i from ground level, adjusted for radiodecay in transit.

$$Q'_{ig} = Q_{ig} \times \exp(-\lambda_i R/3600 \, u_g) \quad (2.10c)$$

2.1.2 Radioiodines, "Particulates", and Other (Nonnoble Gas) Radionuclides

2.1.2.1 10 CFR 50, Appendix I Design Objectives

The average dose to an individual in the unrestricted area from radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases in gaseous effluents released from each reactor with half-lives greater than 8 days, shall be limited to the following expressions:

2.1.2.1.1 Inhalation + Food Pathways Dose, Calendar Quarter

$$3.17 \times 10^{-8} \times 10^{6} R_a \sum_i DFA_{ija} \left[(X/Q)_s A'_{is} + (X/Q)_v A'_{iv} + (X/Q)_g A'_{ig} \right] + \frac{t_r}{365} \sum_i DFI_{ija} \left[U^P_a f_p C^P_i + U^M_a C^M_i + U^V_a f_V C^V_i + U^F_a C^F_i \right] \leq 7.5 \text{ mrem} \quad (2.11)$$

10^6 Conversion Constant (pCi/μCi)

Converts μCi to pCi.

$\frac{1}{365}$ Conversion Constant (yrs/day)

Converts days to years.

R_a Individual Air Intake Rate (m^3/yr)

The air intake rate for individuals in group a. See Tables 7.1-2 and 7.1-3.

t_r Deposition Time or Release Period (days)

Length of time for deposition.

DFA_{ija} — Inhalation Dose Factor (mrem/pCi)

The inhalation dose commitment factor for radionuclide i, organ j, and age group a. See Table 7.1-1.

$(X/Q)_s$ — See Table 7.2-6 or Table 7.2-9.

$(X/Q)_v$ — See Table 7.2-6 or Table 7.2-9.

$(X/Q)_g$ — See Table 7.2-6 or Table 7.2-9.

DFI_{ija} — Ingestion Dose Factor (mrem/pCi)

The ingestion dose commitment factor for radionuclide i, organ j, and age group a. See Table 7.1-1.

U_a^P, U_a^M, U_a^V, U_a^F — Foodstuff Consumption Rates (kg/yr, liters/yr, kg/yr, kg/yr, respectively)

The annual consumption rates (usages) of produce (nonleafy vegetables, fruits, and grain); milk; leafy vegetables; and meat (flesh), respectively, for individuals in age group a. See Tables 7.1-2 and 7.1-3.

f_p, f_V — Produce, Leafy Vegetable Fractions

The respective fractions of the ingested produce and leafy vegetables that are grown in the garden of interest; dimensionless. See Table 7.1-2.

C_i^P, C_i^M, C_i^V, C_i^F — Foodstuff Concentrations (pCi/kg, pCi/liter, pCi/kg, pCi/kg, respectively)

The average concentrations of radionuclide i in produce (nonleafy vegetables, fruits, and grain); milk; leafy vegetables; and meat (flesh), respectively. C_i^P and C_i^V are calculated from Equation 2.12 below.

C_i Concentration in Vegetation (pCi/kg)

The concentration of radionuclide i in vegetation.

$$C_i = d_i \times r \frac{\left[1 - \exp(-\lambda_{Ei} t_e)\right]}{Y_v \lambda_{Ei}} \exp(-\lambda_i t_h) \times f_f \quad (2.12)$$

d_i Deposition Rate (pCi/m^2- hr)

The deposition rate of radionuclide i onto the ground.

$$d_i = \frac{10^6}{24 \times t_r} \left[A'_{is} (D/Q)_s + A'_{iv} (D/Q)_v + A'_{ig} (D/Q)_g \right] \quad (2.13)$$

24 Conversion Constant (hr/day)

Converts days to hours.

$(D/Q)_s$ Relative Deposition Factor, Stack Release (m^{-2})

The calculated annual average relative deposition factor in a given direction at or beyond the restricted area boundary for stack releases. (See Subsection 3.2.3.3; see Table 7.2-6 or Table 7.2-9 for

produce and leafy vegetable pathways; and see Table 7.2-7 or Table 7.2-10 for milk and meat pathways.)

(D/Q_v) Relative Deposition Factor, Vent Release (m^{-2})

The calculated annual average relative deposition factor in a given direction at or beyond the restricted area boundary for vent releases. The partially elevated plume model of Regulatory Guide 1.111, part C.2.b is used. (See Subsection 3.2.3.3; see Table 7.2-6 or Table 7.2-9 for produce and leafy vegetable pathways; and see Table 7.2-7 or Table 7.2-10 for milk and meat pathways.)

$(D/Q)_g$ Relative Deposition Factor, Ground Level Release (m^{-2})

The calculated annual average relative deposition factor in a given direction at or beyond the restricted area boundary for ground level releases. (See Subsection 3.2.3.3; see Table 7.2-6 or Table 7.2-9 for produce and leafy vegetable pathways; and see Table 7.2-7 or Table 7.2-10 for milk and meat pathways.

r Crop Retention Fraction

The fraction of deposited activity retained on crops; dimensionless; see Tables 7.1-2 and 7.1-3.

λ_{Ei} Effective Decay Constant (hr^{-1})

The effective removal rate constant for radionuclide i from crops.

$$\lambda_{Ei} = \lambda_i + \lambda_w \qquad (2.13a)$$

λ_w Weathering Decay Constant (hr^{-1})

The removal constant for physical loss by weathering. See Tables 7.1-2 and 7.1-3.

t_e Effective Crop Exposure Time (hr)

The effective crop exposure time. See Tables 7.1-2 and 7.1-3.

t_h Harvest to Consumption Time (hr)

The time between harvest and consumption. See Tables 7.1-2 and 7.1-3.

f_f Seasonal Growing Factor

A factor which accounts for seasonal growth of vegetation. See Tables 7.1-2 and 7.1-3.

Y_v Productivity Yield (kg/m^2)

The agricultural productivity yield. See Tables 7.1-2 and 7.1-3.

C_i^M Milk Concentration (pCi/liter)

The concentration of radionuclide i in milk.

C_i^M is calculated from the following equation (after Regulatory Guide 1.109 [Reference 6.5]):

$$C_i^M = F_M \, C_i^f \, W_f \, \exp(-\lambda_i t_M) \tag{2.14}$$

F_M Milk Fraction (days/liter)

The average fraction of the animal's daily intake of radionuclide i which appears in each liter of milk. See Table 7.1-4.

C_i^f Feed Concentration (pCi/kg)

The average concentration of radionuclide i in animal feed.

For milk and meat pathways, the following expression is to be used (after Regulatory Guide 1.109, [Reference 6.5]):

$$C_i^f = f_f \, f_g \, C_i^g + (1-f_f) \, C_i^s + f_f \, (1-f_g) \, C_i^s \tag{2.15}$$

f_g Pasture Grass Fraction

The fraction of daily feed that is pasture grass when the animal grazes on the pasture. See Tables 7.1-2 and 7.1-3.

C_i^g Pasture Grass Concentration (pCi/kg)

The concentration of radionuclide i is pasture grass (calculated using Equation 2.12 for c_i with $f_f = 1$; other parameters, including f_f for use in Equation 2.15, are given in Tables 7.1-2 and 7.1-3).

C_i^s Stored Feed Concentration (pCi/kg)

The concentration of radionuclide i in stored feed (calculated using Equation 2.12 for C_i with $f_f = 1$; other parameters, including f_f for use in Equation 2.15, are given in Tables 7.1-2 and 7.1-3.

W_f Feed Consumption (kg/day)

The amount of feed consumed by the animal each day. See Tables 7.1-2 and 7.1-3.

t_M Milk Transport Time (hr)

The average time from the production of milk to its consumption. See Tables 7.1-2 and 7.1-3.

C_i^F Meat Concentration (pCi/kg)

The concentration of radionuclide i in meat.

$$C_i^F = F_F\, C_i^f\, W_f \exp\,(-\lambda_i t_s) \qquad (2.16)$$

F_F Meat Fraction (days/kg)

The fraction of the animal's daily intake of radionuclide i which appears in each kilogram of flesh. See Table 7.1-4.

t_s Slaughter to Consumption Time (hr)

The time from slaughter consumption, See Table 7.1-2.

2.1.2.1.2 Inhalation + Food Pathways Dose, Calendar Year (Four Consecutive Quarters)

$$3.17 \times 10^{-8} \times 10^{6} R_a \sum_i DFA_{ija} \left[(\chi/Q)_s A'_{is} + (\chi/Q)_v A'_{iv} + (\chi/Q) A'_{ig} \right] +$$

$$\frac{t_r}{365} \sum_i DFI_{ija} \left[U_a^P f_p C_i^P + U_a^M C_i^M + U_a^V f_V C_i^V + U_a^F C_i^F \right] \leq 15 \text{ mrem} \quad (2.17)$$

2.1.2.2 10 CFR 20 Release Rate Limit

The maximum dose rate to an organ of an adult from all radionuclides, radioactive materials in particulate form, and radionuclides other than noble gases with half-lives greater than 8 days shall be limited to the values given by the equations which follow. For purposes of demonstrating compliance with the Technical Specifications, the dose to the adult from the inhalation pathway shall be considered limiting.

$$10^6 \; R_a \sum_i DFA_{ija} \left[(\chi/Q)_s \; Q'_{is} + (\chi/Q)_v \; Q'_{iv} + (\chi/Q)_g \; Q'_{ig} \right] +$$

$$K \sum_i DFI_{ija} \; U_a^M \; C_i^M < 1500 \text{ mrem/yr} \qquad (2.18)$$

K Seasonal Adjustment Factor

K is a seasonal adjustment factor to account for nongrazing. For purposes of demonstrating technical compliance for the inhalation pathway, K = 0 throughout the year.

C_i^M Milk Concentration (pCi/liter)

The concentration of radionuclide i in milk.

$$C_i^M = F_M \; C_i^f \; W_f \; \exp\left(-\lambda_i \; t_M\right) \qquad (2.19)$$

C_i^f Feed Concentration (pCi/kg)

The concentration of radionuclide i in feed.

$$C_i^f = d_i \times r \; \frac{\left[1 - \exp\left(-\lambda_{Ei} \; t_e\right)\right]}{Y_v \quad \lambda_{Ei}} \qquad (2.20)$$

(Note that this assumes feed to be 100% pasture grass.)

d_i Deposition Rate (pCi/m^2 x hr)

$$d_i = 3600 \times 10^6 \times \left[Q'_{is} \; (D/Q)_s + Q'_{iv} \; (D/Q)_v + Q'_{ig} \; (D/Q)_g \right] \qquad (2.21)$$

$(D/Q)_s$ See Table 7.2-7 or Table 7.2-10 for milk pathway.

$(D/Q)_v$ See Table 7.2-7 or Table 7.2-10 for milk pathway.

$(D/Q)_g$ See Table 7.2-7 or Table 7.2-10 for milk pathway.

2.1.3 Symbols Used In Section 2.1

SYMBOL	NAME	UNIT
S_i	Gamma Dose Constant, Stack Release	(mrad/yr per μCi/sec)
A_{is}	Accumulative Radionuclide Release Stack Release	(μCi)
V_i	Gamma Dose Constant, Vent Release	(mrad/yr per μCi/sec)
A_{iv}	Accumulative Radionuclide Release, Vent Release	(μCi)
G_i	Gamma Dose Constant, Ground Level Release	(mrad/yr per μCi/sec)
A_{ig}	Accumulative Radionuclide Release, Ground Level Release	(μCi)
L_i	Beta Dose Constant	(mrad/yr per $\mu Ci/m^3$)
$(\chi/Q)_s$	Relative Effluent Concentration, Stack Release	(sec/m^3)
A'_{is}	Accumulative Radionuclide Release from Stack, Adjusted for Radiodecay	(μCi)
$(\chi/Q)_v$	Relative Effluent Concentration, Vent Release	(sec/m^3)
A'_{iv}	Accumulative Radionuclide Release from Vent, Adjusted for Radiodecay	(μCi)
$(\chi/Q)_g$	Relative Effluent Concentration, Ground Level Release	(sec/m^3)
A'_{ig}	Accumulative Radionuclide Release from Ground Level, Adjusted for Radiodecay	(μCi)
R	Downwind Range	(m)
u_x, u_v, u_g	Average Wind Speed, Stack, Vent, or Ground Level Release	(m/sec)
$\overline{S_i}$	Gamma Whole Body Dose Constant Stack Release	(mrad/yr per μCi/sec)
$\overline{V_i}$	Gamma Whole Body Dose Constant, Vent Release	(mrad/yr per μCi/sec)
$\overline{G_i}$	Gamma Whole Body Dose Constant, Ground Level Release	(mrad/yr per μCi/sec)
$\overline{L_i}$	Beta Skin Dose Constant	(mrem/yr per $\mu Ci/m^3$)

SYMBOL	NAME	UNIT
Q_{is}	Release Rate, Stack Release	(μCi/sec)
Q_{iv}	Release Rate, Vent Release	(μCi/sec)
Q_{ig}	Release Rate, Ground Level Release	(μCi/sec)
Q'_{is}	Release Rate from Stack, Adjusted for Radiodecay	(μCi/sec)
Q'_{iv}	Release Rate from Vent, Adjusted for Radiodecay	(μCi/sec)
Q'_{ig}	Release Rate at Ground Level, Adjusted for Radiodecay	(μCi/sec)
R_a	Individual Air Intake Rate	(m^3/yr)
DFA_{ija}	Inhalation Dose Factor	(mrem/pCi)
DFI_{ija}	Ingestion Dose Factor	(mrem/pCi)
t_r	Deposition Time	(day)
U_a^P	Produce Consumption Rate	(kg/yr)
U_a^M	Milk Consumption Rate	(liters/yr)
U_a^V	Leafy Vegetable Consumption Rate	(kg/yr)
U_a^F	Meat Consumption Rate	(kg/yr)
f_P	Produce Fraction	
f_V	Leafy Vegetable Fraction	
C_i^P	Produce Concentration	(pCi/kg)
C_i^M	Milk Concentration	(pCi/liter)
C_i^V	Leafy Vegetable Concentration	(pCi/kg)
C_i^F	Meat Concentration	(pCi/kg)
d_i	Deposition Rate	($pCi/m^2.hr$)
C_i	Vegetation Concentration	(pCi/kg)
$(D/Q)_s$	Relative Deposition Factor, Stack Release	(m^{-2})
$(D/Q)_v$	Relative Deposition Factor, Vent Release	(m^{-2})
$(D/Q)_g$	Relative Deposition Factor, Ground Level Release	(m^{-2})

SYMBOL	NAME	UNIT
r	Crop Retention Fraction	
λ_{Ei}	Effective Decay Constant	(hr^{-1})
λ_i	Radiological Decay Constant	(hr^{-1})
λ_w	Weathering Decay Constant	(hr^{-1})
t_e	Effective Crop Exposure Time	(hr)
t_h	Harvest to Consumption Time	(hr)
Y_v	Productivity Yield	(kg/m^2)
F_M	Milk Fraction	(days/liter)
C_i^f	Feed Concentration	(pCi/kg)
f_f	Seasonal Growing Factor	
f_g	Pasture Grass Fraction	
C_i^g	Pasture Grass Concentration	(pCi/kg)
C_i^s	Stored Feed Concentration	(pCi/kg)
W_f	Feed Consumption	(kg/day)
t_M	Milk Transport Time	(hr)
F_F	Meat Fraction	(day/kg)
t_s	Slaughter to Consumption Time	(hr)
K	Seasonal Adjustment Factor	

2.1.4 Constants Used In Section 2.1

NUMERICAL VALUE	NAME	UNIT
3.17×10^{-8}	Conversion Constant	(years/second)
0.7	Gamma Radiation Shielding and Occupancy Factor	
1.0	Beta Radiation Shielding and Occupancy Factor	
1.11	Conversion Constant	(mrem/mrad)
10^6	Conversion Constant	(pCi/μCi)
24	Conversion Constant	(hr/day)
365	Conversion Constant	(day/yr)
3600	Conversion Constant	(sec/hr)

2.2 RADIOACTIVITY IN LIQUID RELEASES

2.2.1 10 CFR 50, Appendix I Design Objectives

The dose contributions from measured quantities of radioactive materials identified in liquid effluents released to unrestricted areas from each reactor shall be calculated using the following expression:

$$D_j = (1.1 \times 10^{-3} \times 8760) \left[\frac{U^w M^w}{F^w} \sum_i A_i \, DFI_{ija} \exp(-\lambda_i t^w) + \frac{U^f M^f}{F^f} \sum_i A_i \, DFI_{ija} \, B_i \exp(-\lambda_i t^f) \right] \qquad (2.22)$$

D_j Cumulative dose (mrem)

The cumulative dose or dose commitment to the total body or an organ j due to an adult consuming water and fish.

$D_j \leq$ 1.5 mrem to the whole body in a calendar quarter, (2.23)

$\leq$ 5.0 mrem to any organ in a calendar quarter, (2.24)

$\leq$ 3.0 mrem to the whole body in any four consecutive quarters, and (2.25)

$\leq$ 10.0 mrem to any organ in any four consecutive quarters. (2.26)

U^w, U^f — Usage Factor (liters/hr, kg/hr)

Average consumption rate of water or fish. See Table 7.2-1.

$1/M^w$, $1/M^f$ — Additional Dilution Factor

Additional dilution factor prior to withdrawal of potable water or fish. See Table 7.2-1.

F^w — Average Flow Rate (ft^3/sec)

Average flow of receiving body of water. See Table 7.2-1.

F^f — Near-Field Flow Rate (ft^3/sec)

Near-field flow of receiving body of water. See Table 7.2-1.

A_i — Total Radionuclide Release (μCi)

Total release of radionuclide i during period of release.

DFI_{ija} — Ingestion Dose Factor (mrem/pCi)

The ingestion dose commitment factor for each identified gamma and beta emitter i, organ j, and age group a. See Table 7.1-1.

λ_i — Decay Constant (hr^{-1})

Radiological decay constant of ith radionuclide. See Table 7.1-11.

t^w, t^f — Elapsed Time (hr)

Average elapsed time between release and consumption of potable water or fish. See Table 7.2-1.

B_i Bioaccumulation Factor (liters/kg)

Bioaccumulation factor. See Table 7.1-12.

1.1×10^{-3} = factor to convert from (μCi/yr)/(ft^3/sec) to pCi/liters

8760 = number of hours per year

2.2.2 <u>10 CFR 20 Maximum Permissible Concentrations in the Unrestricted Area</u>

The concentration of nonnoble gas radioactive material released from the site to unrestricted areas (C_i) shall be limited to the concentrations specified in 10 CFR 20, Appendix B, Table II, Column 2 (MPC_i). The concentrations of dissolved or entrained noble gases shall be limited to the concentrations specified in Table 7.1-10. The sum of the fractional limits ($\sum_i \left[C_i \div MPC_i\right]$) must not exceed 1.0 for each release.

The concentration of each radionuclide in the unrestricted area is calculated as follows:

$$C_i = C_i^t \times \frac{F^r}{F^d + F^r} \tag{2.27}$$

and the combination of C_i^t, F^r, and F^d must meet the condition that:

$$100 \times \sum_i \frac{C_i}{MPC_i} = 100 \times \frac{F^r}{F^d + F^r} \times \sum_i \frac{C_i^t}{MPC_i} \leq 100\% \tag{2.28}$$

C_i Concentration in the Unrestricted Area (μCi/ml)

The concentration of radionuclide i at the restricted/unrestricted area boundary.

C_i^t Concentration in the Discharge Tank (μCi/ml)

The concentration of radionuclide i in the (radwaste discharge or other similar) tank.

F^r Flow Rate, Radwaste Discharge (ft^3/sec)

The flow rate of radwaste from the discharge tank to the initial dilution stream.

F^d Flow Rate, Initial Dilution Stream (ft^3/sec)

The flow rate of the initial dilution stream which carries the radionuclides to the unrestricted area boundary (e.g., the blowdown from cooling tower or lake or the circulating cooling water flow).

MPC_i Maximum Permissible Concentration (μCi/ml)

The maximum permissible concentration of nuclide i (or unknown nuclide) in water in the unrestricted area (see Table 7.1-10; or 10 CFR 20, Appendix B, Table II, Column 2 including Note 3.c).

2.2.3 10 CFR 20 Maximum Permissible Concentrations at the Nearest Surface Water Supply

The quantity of radionuclides, excluding tritium and dissolved or entrained noble gases, in outdoor tanks without overflow pipes connected to other storage tanks shall be limited to ensure that in the case of an overflow, the annual average concentration of radioactivity in the potable water of the nearest surface water supply is less than the 10 CFR 20, Appendix B, Table II, Column 2 limits.

The annual average concentration of each radionuclide in the potable water of the nearest surface water supply is calculated as follows:

$$C_i^w = C_i^t \left(\frac{F^t}{F_o^w + F^t} \right) M_o^w \ \exp\,(- \lambda_i \times t_o^w) \times \frac{t_o}{8760} \qquad (2.29)$$

C_i^w Concentration in Water Supply (μCi/ml)

The annual average concentration of radionuclide i in the surface water supply due to tank overflow.

C_i^t Concentration in Tank (μCi/ml)

The concentration of radionuclide i in the outdoor tank of interest.

F^t Maximum Flow Rate from Tank (ft^3/sec)

The maximum rate of overflow from the outdoor tank of interest (usually equal to the maximum tank feed rate). See Table 7.2-1.

F_o^w Flow Rate, Receiving Body of Water (ft^3/sec)

The minimum flow rate (from the most recent 10 year record) of the receiving body of water during overflow conditions. See Table 7.2-1.

$1/M_o^w$ Additional Dilution Factor

Additional dilution factor of overflowed water prior to use as potable water. See Table 7.2-1.

t_o^w Elapsed Time (hr)

The total time between overflow release and consumption of water, equal to the transit time, discharge point to intake, plus the process time at the water treatment plant. See Table 7.2-1.

t_o Release Time (hr)

The total period of the overflow conditions, assumed to be no greater than one work shift of 8 hours.

Hence the maximum quantity of radionuclide i (A_i^t, curie) in each tank of interest, excluding tritium and the dissolved or entrained noble gases, which satisfies the limiting condition:

$$\sum_i \frac{C_i^w}{MPC_i} \leq 1 \qquad (2.30)$$

is:

$$\sum_i \frac{A_i^t}{MPC_i} \exp(-\lambda_i \times t_o^w) \leq 4 \left(\frac{F_o^w + F^t}{F^t}\right) \frac{V^t}{M_o^w} \qquad (2.31)$$

A_i^t Tank Radioactivity (Ci)

The quantity of radionuclide i in the tank of interest.

V^t Tank Volume (gal)

The volume of each tank without overflow pipes connected to other storage tanks. See Table 7.2-1.

Equation 2.31 may also be written in terms of the concentration of radionuclide i in the tank of interest.

$$\sum_i \frac{C_i^t}{MPC_i} \exp(-\lambda_i \times t_o^w) \leq \left(\frac{F_o^w + F^t}{F^t}\right) \frac{1100}{M_o^w} \qquad (2.32)$$

Derivation of Equation 2.31

Since, by Equation 2.30,

$$\sum_i \frac{C_i^w}{MPC_i} \leq 1$$

where C_i^w is given by Equation 2.29 and C_i^t in Equation 2.29 is given by:

$$C_i^t = \frac{A_i^t \times 10^6 \ \mu Ci/Ci}{V^t \times 3785 \ ml/gal} \tag{2.33}$$

then:

$$\sum_i \frac{C_i^w}{MPC_i} = \sum \frac{C_i^t}{MPC_i} \left(\frac{F^t}{F_o^w + F^t}\right) M_o^w \ t_o/8760 \ \exp\ (-\lambda_i t_o^w) \leq 1 \tag{2.34}$$

$$= \left(\frac{F^t}{F_o^w + F^t}\right)\left(\frac{M_o^w}{V^t}\right) \frac{8}{8760} \times \frac{10^6}{3785} \sum_i \frac{A_i^t}{MPC_i} \ \exp\ (-\lambda_i t_o^w) < 1 \tag{2.35}$$

$$= \frac{1}{4}\left(\frac{F^t}{F_o^w + F^t}\right)\left(\frac{M_o^w}{V^t}\right) \sum_i \frac{A_i^t}{MPC_i} \ \exp\ (-\lambda_i t_o^w) \leq 1 \tag{2.36}$$

Equation 2.36 on rearrangement gives:

$$\sum_i \frac{A_i^t}{MPC_i} \ \exp\ (-\lambda_i t_o^w) \leq 4 \left(\frac{F_o^w + F^t}{F^t}\right)\left(\frac{V^t}{M_o^w}\right) \tag{2.37}$$

2.2.4 Symbols Used In Section 2.2

SYMBOL	NAME	UNIT
D_j	Cumulative Dose	(mrem)
U^w, U^f	Usage Factor	(liters/hr, kg/hr)
$1/M^w, 1/M^f, 1/M_o^w$	Additional Dilution Factor	
F^w	Average Flow Rate	(ft^3/sec)
F^f	Near-Field Flow Rate	(ft^3/sec)
A_i	Total Radionuclide Release	(μCi)
DFI_{ija}	Ingestion Dose Factor	(mrem/pCi)
λ_i	Decay Constant	(hr^{-1})
t^w, t^f, t_o^w	Elapsed Time	(hr)
B_i	Bioaccumulation Factor	(liters/kg)
C_i	Concentration at Unrestricted Area	(μCi/ml)
C_i^t	Concentration in Discharge Tank	(μCi/ml)
F^r	Flow Rate, Radwaste Discharge	(ft^3/sec)
F^d	Flow Rate, Initial Dilution Stream	(ft^3/sec)
MPC_i	Maximum Permissible Concentration	(μCi/ml)
C_i^w	Concentration in Water Supply	(μCi/ml)
F^t	Maximum Tank Overflow Rate	(ft^3/sec)
F_o^w	Minimum Flow Rate, Receiving Body of Water	(ft^3/sec)
t_o	Release Time	(hr)
A_i^t	Tank Radioactivity	(Ci)
V^t	Tank Volume	(gal)

2.2.5 Constants Used In Section 2.2

NUMERICAL VALUE	NAME	UNIT
1.1×10^{-3}	Conversion Factor	(pCi/liter)/ $\left[(\mu Ci/yr)/(ft^3/sec)\right]$
8760	Conversion Factor	(hrs/yr)
10^6	Conversion Constant	(pCi/μCi)

2.3 ENVIRONMENTAL STANDARDS FOR THE URANIUM FUEL CYCLE

In accordance with the requirements of 40 CFR 190 (Reference 6.12), the annual dose commitment to any member of the public in the general environment (i.e., the unrestricted area) from all uranium fuel cycle sources, except those specifically excluded by the regulation, is limited to 25 millirems to the whole body, 25 millirems to any organ but the thyroid, and 75 millirems to the thyroid. On the basis of results projected by the NRC for all multi-unit sites presently committed, the conservative nature of the design dose calculations as opposed to the applicability of these standards to exposures actually received, and the operational flexibility available to sites with multiple units, it is concluded that the standards can be readily achieved at all CECo sites by demonstrating compliance with 10 CFR 50 Appendix I objectives.

2.3.1 Sources of Radiation and Radioactivity

2.3.1.1 Uranium Fuel Cycle - Definition

The uranium fuel cycle is defined in 40 CFR 190 (Reference 6.12) to include:

a. operations of milling of uranium ore,
b. chemical conversion of uranium,
c. isotopic enrichment of uranium,
d. fabrication of uranium fuel,
e. generation of electricity by a nuclear power plant using uranium fuel, and
f. reprocessing of spent uranium fuel.

Specifically excluded are:

a. mining operations,
b. operations at waste disposal sites,
c. transportation of radioactive material, and

d. the use of recovered nonuranium special nuclear or by-product materials from the cycle.

2.3.1.2 Radiological Impact of Uranium Fuel Cycle Operation

Environmental Radiation Protection Standards, 40 CFR 190, require that the radiation dose resulting from all operations of the uranium fuel cycle (except the specific exclusions noted) be considered in determining compliance. Therefore, each of the operations will be discussed and the radiological impact in the Commonwealth Edison Company (CECo) service area will be considered.

2.3.1.2.1 Milling

Reference 6.13 (Page 4), Reference 6.14 (Section 2.4), and Reference 6.15 (Page IV F-29) indicate that the maximum individual doses due to milling will be less than 10 CFR 20 limits. Therefore, the dose contribution to any person living in this service area due to milling operations, all more than 100 kilometers distant, is expected to be negligible compared to 40 CFR 190 limits.

2.3.1.2.2 Conversion

Reference 6.14 (Section 3.4) and Reference 6.15 (Page IV F-40 and Table IV F-10) indicate that the maximum individual doses due to UF_6 conversion will be less than 10 CFR 20 limits. Therefore, the dose contribution to any person living in this service area due to UF_6 conversion operations, all more than 100 kilometers distant, is expected to be negligible compared to 40 CFR 190 limits.

2.3.1.2.3 Enrichment

Reference 6.14 (Section 4.4) and Reference 6.15 (Page IV F-51) indicate that the maximum individual doses due to uranium

enrichment will be less than 10 CFR 20 limits. Therefore, the dose contribution to any person living in this service area due to uranium enrichment operations, all more than 100 kilometers distant, is expected to be negligible compared to 40 CFR 190 limits.

2.3.1.2.4 Fabrication

Reference 6.14 (Section 5.4) and Reference 6.15 (Page IV F-63) indicate that the maximum individual doses due to fuel element fabrication will be less than 10 CFR 20 limits. Therefore, the dose contribution to any person living in this service area due to fuel fabrication operations, all more than 100 kilometers distant, is expected to be negligible compared to 40 CFR 190 limits.

2.3.1.2.5 Generation of Electricity

The generation of electricity, using a nuclear power plant, results in radioactivity released in gaseous and liquid effluents. The radiological impact of these requires assessment (using the methodology of Sections 2.1 and 2.2 of this report) and comparison with 40 CFR 190 limits.

Also, boiling water reactors (BWR's) contain radioactive nitrogen-16 (N-16) in their steamlines and turbines in sufficient enough quantities to result in measurable offsite doses. The magnitude of this so-called skyshine dose must also be considered in determining 40 CFR 190 compliance. Offsite doses due to other contained sources in the nuclear power plant are negligible compared to those due to effluents and N-16 skyshine.

Measurements of the radiation environment due to N-16 have been made at the Dresden Station (Reference 6.19). An empirical fit to the measured data is given in Equation 2.38:

$$D(R,P) = SF\ OF\ (2.28 \times 10^{-5})\ P\ \exp\ (-0.007\ R) \qquad (2.38)$$

D(R,P)	Dose Due to N-16 Skyshine	(mrem)
	The gamma dose due to BWR N-16 skyshine.	
SF	Shielding Factor	
	The shielding factor for protection against gamma radiation. SF = 0.7 for a home.	
OF	Occupancy Factor	
	The at-home occupancy factor: For fisherman 0.95; For all others 1.0	
2.28×10^{-5}	Constant	(mrem/MWe-hr)
	A constant to fit the equation to measured data.	
P	Electric Power Generated	(MWe-hr)
	The total electric energy generated in the time period of interest.	
0.007	Constant	(m^{-1})
	A constant to fit the equation to measured data.	
R	Distance	(m)
	Distance from the turbine to the dose point of interest.	

This equation will be used at all CECo BWR's up to a distance of 1100 meters. Beyond that distance the fit (and data) are considered unreliable and, further, the dose at this range is, at most, 0.1 mrem/yr for CECo Stations.

In certain situations, more than one nuclear power plant site may contribute to a radiological dose to be considered in making 40 CFR 190 dose assessment. At present (July 1979), the nuclear power stations in CECo's service area are sufficiently distant from one another that the radiological dose, if not negligible compared to 40 CFR 190 limits, is due to only one site. Hence, adding dose components from several stations is not required.

However, within CECo's service area the following future additive combination is considered. At some point within the triangle formed by the La Salle, Dresden, and Braidwood Stations, an additive dose from airborne releases may be postulated. However, the distances are such (La Salle to Dresden, 39 kilometers; Dresden to Braidwood, 18 kilometers; Braidwood to La Salle, 37 kilometers) that at any intermediate point postulated, the station-combined dose is less than that maximum calculated for an individual station. Therefore, the combined effect of airborne releases will not be considered further.

Such is not the case for future releases of radioactivity into the aquatic environment, where, if more than one facility uses the same receiving body of water, the station-combined dose must be considered. Dresden and (the future) La Salle County Stations discharge their liquid waste into the Illinois River and (the future) Braidwood Station discharges into the Kankakee River which flows into the Illinois at Dresden. Quad Cities and (the future) Carroll County Stations use the Mississippi River and (the future) Byron Station uses the Rock River which flows into the Mississippi at Moline, Illinois, downstream of Quad Cities. For these two situations the combined impact from upstream liquid waste discharges must be considered at each downstream location.

The dose contribution of nuclear power plants in other service areas need not be considered in CECo's 40 CFR 190 assessment. The Duane Arnold Station is about 135 kilometers from Quad Cities; the Clinton Station is about 125 kilometers from Braidwood and La Salle; and the Bailly Station is about 100 kilometers from Dresden.

2.3.1.2.6 Reprocessing

Reference 6.15 (Table IV E-12) indicates that maximum individual doses due to fuel reprocessing will be less than 10 CFR 20 limits. Therefore, the dose contribution to any person living in this service area due to fuel reprocessing operations, all more than 100 kilometers distant, is expected to be negligible compared to 40 CFR 190 limits.

2.3.1.2.7 Waste Disposal Sites

The radiation dose associated with the burial of low level radioactive radwaste need not be considered in determining compliance with 40 CFR 190 as this source is specifically excluded by the law. Inasmuch as the licensed burial facility at Sheffield, Illinois, is near CECo's service area, at least a comment regarding it as a potential source is warranted.

The radiological impact of burial sites is discussed briefly in Chapter IV, Section H, Part 3.1.2.1 of Reference 6.15 (Page IV H-28 ff). No significant movement of radioactivity into the general environment is expected, though some tritium has been found in groundwater near the Sheffield facility. However, no significant dose contribution to a person living in the vicinity of CECo's nuclear power plants is expected. (The Quad Cities Station is about 60 kilometers from Sheffield; Byron and La Salle are each about 90 kilometers from Sheffield.)

2.3.1.2.8 Transportation

The radiation dose associated with the transport of low level radioactive waste and spent fuel is also excluded from consideration by the requirements of 40 CFR 190. This subject has been reviewed in References 6.16 and 6.17, and summarized again in Reference 6.15 (Chapter IV, Section G). The expected dose associated with transportation is 3.4×10^{-3} mrem/person/reactor/year.

2.3.1.2.9 Storage of Spent Fuel in Offsite Facilities

The radiation doses associated with releases of radioactivity by independent spent fuel storage facilities (ISFSF) should also be considered in determining compliance with 40 CFR 190. One ISFSF is being operated within CECo's service area; that is, General Electric Company's Morris Operations Plant at Morris, Illinois, adjacent to CECo's Dresden Station. Minute quantities of Kr-85 and other radioactive particulates are released in airborne effluents. A dose assessment was performed using typical release data provided by the General Electric Company and the Offsite Dose Calculation Manual (ODCM) environmental dose assessment models for Dresden. (The effluent is released through a 300-foot vent stack; hence the similarity between the two facilities. However, no adjustments were made for differences in site boundary ranges or ranges to dairies. These differences are not expected to affect the conclusion from the dose assessment.)

The estimated annual airborne releases from the GE Morris Operation plant are 6×10^{4} μCi of tritium, $< 55 \times 10^{6}$ μCi of Kr-85, 3 μCi of Co-60, and 1 μCi of Cs-137. The maximum whole body dose from these radionuclides is 4×10^{-4} mrem/yr. So long as this plant remains a spent fuel storage facility and does not reprocess the fuel the dose contribution to any person living in its vicinity will be negligible and not considered further in the Dresden 40 CFR 190 analysis.

2.3.1.2.10 Long-Term Storage of High Level Radioactive Wastes

The dose associated with the long-term storage of high level radioactive wastes is excluded from consideration as far as 40 CFR 190 is concerned. The radiological impact is discussed in Reference 6.15 (Chapter IV, Section H, Part 3.2) and should be negligible in the CECo service area.

2.3.1.3 Summary

The magnitude of radiological dose due to various operations of the uranium fuel cycle and its impact in the Commonwealth Edison Company service area has been reviewed with respect to the requirements of 40 CFR 190. The only dose components requiring consideration are those due to:

a. radioactivity in nuclear power plant liquid and gaseous effluents, and

b. the direct radiation due N-16 in BWR steam piping, turbines, and associated equipment.

2.3.2 Numerical Models

2.3.2.1 Airborne Releases and Direct Radiation

2.3.2.1.1 Whole Body Dose

The maximum whole body (WB) dose from airborne releases and direct radiation will be determined by adding, for each sector, the dose contributions, if applicable, from all (1) noble gases; (2) airborne radioiodines, "particulates", and other nonnoble gas radionuclides with half-lives greater than 8 days; (3) direct radiation from BWR turbine N-16 skyshine as computed at the nearest actual residence in each sector

(Table 7.2-4); and at Dresden only, the contribution from (4) noble gases, and (5) airborne "particulates" from the Morris Operations plant if spent fuel is reprocessed.

At Zion, sectors whose site boundary is over Lake Michigan will not be considered in the 40 CFR 190 analysis.

At Dresden and Quad Cities, Equations 2.39 and 2.40, respectively, will be used to compute the direct radiation dose in sectors whose restricted area boundary is over water. This dose, which accounts for possible fishing activities in the vicinity, will then be added to the nearest residence dose computed with Equation 2.38 using an at-home occupancy factor of 0.95 rather than the usual 1.0. An occupancy factor of 0.05 is used for fishermen (0.025 at each of two locations at Quad Cities) and a boat shielding factor of 1.0.

At Dresden:

$$D(R,P) = (1.0)(0.05)\ 2.28 \times 10^{-5} \sum_{i=1}^{3} P_i \exp(-0.007 \times R_i) \tag{2.39}$$

$R_1 = 488$ m
$R_2, R_3 = 610$ m

P_i Electric power generated by each unit in the year (MWe-hr)

At Quad Cities:

$$D(R,P) = (1.0)(0.025)\ 2.28 \times 10^{-5}\ P \left[\exp(-0.007\ R_1) + \exp(-0.007\ R_2)\right] \tag{2.40}$$

$R_1 = 100$ m
$R_2 = 400$ m

P Electric power generated by the station (MWe-hr)

Table 2.3-1 shows the methodology for determining the maximum whole body dose from airborne releases and direct radiation.

2.3.2.1.2 Thyroid Dose

The maximum thyroid dose from airborne releases and direct radiation will be determined by adding, for each sector, the dose contributions from the various sources in a manner similar to that for the maximum whole body dose, as described above and in Table 2.3-1.

2.3.2.1.3 Any Other Organ Dose

In this class, the dose from airborne releases and direct radiation to the GI-LLI, bone, liver, kidney, lung, and skin will be determined separately in each sector, and the maximum value chosen to represent "any other organ" (AOO) for purposes of determining compliance. The maximum AOO dose will be determined in a manner similar to that for the maximum whole body dose, as described in Subsection 2.3.2.1.1 and in Table 2.3-1.

2.3.2.2 Radioactivity in Liquid Releases

The maximum whole body, thyroid, and AOO doses from radioactivity in individual station liquid releases will be determined using, for the fish pathway, the near-field estimate of dilution at the station; and using, for the drinking water pathway, the average flow of the receiving body of water at the nearest downstream community water system, if the water system is near the station. Otherwise, the drinking water pathway will not be considered. For situations involving combined-station releases, for the fish pathway, for releases from all upstream CECo facilities, the tissue doses will be determined using the average flow of the receiving body of water at the station. Table 2.3-1 shows the methodology for determining these doses.

2.3.3 Symbols Used in Section 2.3

SYMBOL	NAME	UNIT
D(R,P)	Dose Due to N-16 Skyshine	(mrem)
SF	Shielding Factor	
OF	Occupancy Factor	
P, P_i	Electric Power Generated by Station or Unit	(MWe-hr)
R	Distance	(m)

2.3.4 Constants Used in Section 2.3

NUMERICAL VALUE	NAME	UNIT
2.28×10^{-5}	Fitted Constant	(mrem/MWe-hr)
0.007	Fitted Constant	(m^{-1})
0.7	Shielding Factor at Home	
1.0	Shielding Factor on a Boat	
0.05	Occupancy Factor While Fishing	
0.95	Occupancy Factor at Home for Fishermen	
1.0	Occupancy Factor at Home for Everyone but Fishermen	

TABLE 2.3-1

NUMERICAL MODELS FOR COMPUTING RADIATION DOSE
FROM URANIUM FUEL CYCLE OPERATIONS[a]

FUEL CYCLE OPERATION	CLASSIFICATION OF RADIATION	WHOLE BODY	THYROID	ANY OTHER ORGAN						FOOT-NOTES
				GI-LLI	BONE	LIVER	KIDNEY	LUNG	SKIN	
REACTORS										
	1. Noble Gases	Equation 2.5	Equation 2.5	——— Equation 2.5 ———					Equation 2.7	-
	2. Airborne Iodine and Particulates	Equation 2.11	Equation 2.11	——— Equation 2.11 ———					Equation 2.11 WB Component	b
	3. Liquid Waste	Equation 2.22	Equation 2.22	——— Equation 2.22 ———					Equation 2.22 WB Component	c
	4. Direct Radiation	Equation 2.38	Equation 2.38	——— Equation 2.38 ———					Equation 2.38	d
FUEL STORAGE FACILITY										
	5. Noble Gases	N/A	N/A	Not Applicable					N/A	e
	6. Airborne Particulates	N/A	N/A	Not Applicable					N/A	e

a. The maximum sector doses for the whole body, thyroid, and any other organ, summed over all classifications of radiation, will be added to similar tissue doses received from radioactivity in liquid releases, or combined-station releases, if applicable. The maximum dose of each tissue class will be compared to the limits established in 40 CFR 190.10(a).

TABLE 2.3-1 (Cont'd)

b. The dose to all organs will be determined first with Equation 2.11 then adjusted through multiplication by a factor $0.5/fg \leq 1$ where fg is given in Table 7.1-2.

c. Only the fish pathway portion of Equation 2.22 will be used unless the community water system is near the station. For combined aquatic pathway doses from more than one station the dose from each upstream CECo station will be determined with Equation 2.22, using M^w/F^w instead of M^f/F^f at the individual station.

d. Except for special considerations of fishermen at Dresden and Quad Cities, direct radiation from BWR turbine N-16 will be computed at the nearest actual resident in each sector and not at the site boundary. A shielding and occupancy factor of 0.7 will be used.

e. So long as this plant remains a spent fuel storage facility and does not reprocess the fuel, its contribution to the total dose will not be considered further.

3.0 ATMOSPHERIC TRANSPORT, DIFFUSION, AND DOSE MODELS

TABLE OF CONTENTS

3.0 ATMOSPHERIC TRANSPORT, DIFFUSION, AND DOSE MODELS

3.1 METEOROLOGICAL DATA FOR MODELS

3.1.1 Current Record

Onsite meteorological data are used as input to all of the airborne dose calculations performed by a contractor. The data are obtained by means of an instrumented meteorological tower that measures wind speed and wind direction at several levels. The stability of the atmosphere is determined by means of the temperature lapse rate (differential temperature) between two levels on the tower. The contractor's analyses are used to supplement dose analyses performed with historical meteorological records.

For elevated releases, a joint frequency table (stability wind rose) of wind speed, wind direction, and stability is developed using the upper level wind data and the average lapse rate measured on the tower.

The mixed-mode model for vent stack releases requires two stability wind roses: one to represent the elevated part of the release and one to represent the ground level portion of the release.

These are developed jointly by considering the wind data hour by hour. The criteria for deciding how to proportion each hour's data between a vent release and ground level release depend on the ratio of the exit speed to the wind speed. When the criteria (Subsection 3.2.2.2) indicate part of the release should be considered as ground level, the 10-meter wind data are used.

For ground level releases, the stability wind rose is developed using the lower level wind data and lapse rate.

The wind direction, wind speed, and atmospheric stability classification schemes are described in Tables 7.1-5 and 7.1-8. Because the dispersion equations are very sensitive to low wind speeds, the hourly record may require editing to reflect the measuring limitations of the wind sensors at low speeds. If the reported wind speed is less than the anemometer's threshold (Table 7.1-6), it is assigned a value equal to one-half of threshold speed. If the reported speed is less than the vane's threshold (calm), Table 7.1-6, a direction is assigned in proportion to the observed wind direction distribution of the lowest noncalm speed class.

Diffusion estimates for monthly, calendar quarter, or annual releases are determined by combining hourly stability and wind data in the form of stability wind rose tables. Wind speed, direction, and stability classifications are used to group the data and calculate the joint occurrences of the groups.

3.1.2 Historical Record

Nuclear station operators will use the dispersion factors of Section 7.2 to demonstrate compliance with the Technical Specifications. Depending on the station, there may be three classes (elevated, mixed mode, and ground level) of effluent release, each with four types of dispersion factors: (1) χ/Q, (2) D/Q, (3) S_i, V_i, or G_i, and (4) $\overline{S_i}$, $\overline{V_i}$, or $\overline{G_i}$, where i = 1 to 15 which are wind direction dependent. The first two types of dispersion factors are used with the internal dose models; (χ/Q) and the last two types are used with the external dose models.

3.1.2.1 Internal Dose

The recipient of the internal dose can either be an adult

or an infant. If the recipient is an adult, the internal dose can consist of contributions from inhalation (X/Q), leafy vegetables or produce (D/Q), and milk or meat (D/Q). If the recipient is an infant, the total dose consists of contributions from inhalation (X/Q) and milk (D/Q). The dispersion factors for inhalation and leafy vegetable doses are calculated for the 16 wind directions. The dispersion factors for the milk cows and meat animals are only calculated for the direction(s) where these animals are located in the unrestricted area and at a distance no greater than 5 miles.

Historical dispersion factors used in the internal dose models are found in Section 7.2. There is a set of these tables for each station. Section 7.2 contains the dispersion factors for the three possible classes of release and the 16 wind directions for which X/Q (inhalation) and D/Q (leafy vegetables or produce) are calculated. The radius specifies the location at which the dose is calculated. Only maximum X/Q and D/Q values are used.

Also in Section 7.2 are the dispersion factors used to calculate the doses resulting from milk and meat consumption. Entries occur only for those directions where the nearby milk cows and meat animals are located.

The internal dose models are:

1. adult inhalation;
2. adult consuming leafy vegetables;
3. adult consuming produce;
4. adult consuming meat;
5. adult drinking milk;
6. any combination of 1, 2, 3, 4, and 5;
7. infant inhalation;
8. infant drinking milk; and
9. sum of 7 and 8.

3.1.2.2 External Dose

The wind direction dispersion factors used in the whole body and gamma air external dose models are found in Section 7.2. For each station, the 15 tables correspond to the 15 radionuclides used to determine total external dose, which is the sum of the dose contributions from each radionuclide. The whole body ($\overline{S}_i$, $\overline{V}_i$, or $\overline{G}_i$) and gamma air (S_i, V_i, or G_i) dose factors are computed for each of the 16 wind directions and each release class.

The dose factors for beta skin dose ($\overline{L}_i$) and beta air dose (L_i), two other types of external dose, are constants which do not vary with wind direction. However, they are combined in the dose models with χ/Q factors, which are wind direction dependent.

3.2 ATMOSPHERIC TRANSPORT AND DIFFUSION MODELS

3.2.1 Numerical Model

The model used is classed as a "constant mean wind direction model" by the NRC. Equation 3.1 shows how the concentration to emission ratio (χ/Q) at any downwind range and direction is calculated.

$$\frac{\chi(R,\theta)}{Q} = \frac{2.032}{R} \sum_{u} \sum_{s} f(u,\theta,s)\ (uS_z)^{-1} \exp\left[-1/2\left(\frac{h_e}{S_z}\right)^2\right] \quad (3.1)$$

This model assumes that the effluent is uniformally distributed within each downwind sector and that the release rate is constant during the time period modeled.

χ/Q Relative Effluent Concentration (sec/m^3)

The relative concentration within the cloud at point (R,θ).

R Downwind Range (m)

The distance downwind to point (R,θ).

θ Direction (degree or sector)

The downwind direction to point (R,θ).

u Wind Speed (m/sec)

The wind speed.

s Stability Class

The atmospheric stability class.

f Joint Frequency.

The observed frequency in which the wind blows with speed u, downwind direction θ, and atmospheric stability class s.

S_z Corrected Vertical Dispersion Coefficient (m)

The vertical dispersion coefficient, corrected for building wake effects.

h_e Effective Stack Height (m)

The effective height at which effluent is released.

3.2.2 Source Configuration Considerations

The location of the source with respect to the buildings affects how the airborne effluent will disperse. The following describes the criteria used to model airborne releases from nuclear power plants and describes how the model evaluates each case.

3.2.2.1 Elevated Releases

Release locations (chimneys, etc.) that are high enough to be out of the range of the effects caused by neighboring solid structures are classified as elevated releases. The concentrations at any range and direction can be calculated by Equation 3.1 when an appropriate value for the effective stack height (h_e) is used to represent the height of the plume centerline above the ground.

The effective stack height is calculated by the following equation:

$$h_e = h_s + h_r - h_t \qquad (3.2)$$

h_s Physical Stack Height (m)

The actual height of the stack above grade elevation.

h_r Plume Rise (m)

The additional rise of the plume due to its bouyancy and/or momentum.

h_t Terrain Correction Factor (m)

The elevation to account for ground points of interest being different than grade elevation near the stack.

This equation states that the effective stack height (h_e) is equal to the physical stack height (h_s) plus the plume rise due to buoyancy and momentum (h_r) less a correction for the variation in terrain (h_t).

3.2.2.1.1 Plume Rise (h_r)

The rise of an effluent plume is dependent on the stability of the atmosphere, the wind speed, the heat content of the plume, and the exit velocity of the plume. The procedure chosen has been selected to provide a conservative (low) estimate of the plume rise in order to maximize the resulting calculated doses.

Under neutral and unstable atmospheric conditions the momentum-dominated plume rise equations are used. Equation 3.3 shows the basic relationship between h_r and other parameters.

$$(h_r)_1 = 1.44d\ (W_o/u)^{2/3}\ (R/d)^{1/3} - C \qquad (3.3)$$

W_o Exit Velocity (m/sec)

The effluent stream velocity at the discharge point.

d Stack Diameter (m)

The diameter of the stack at the discharge point.

C Downwash Correction Factor (m)

The factor to account for stack downwash under certain atmospheric conditions.

Equation 3.3 would allow the plume to continue rising forever which is contrary to observation. In order to limit the rise, Equation 3.4 is evaluated and the lesser of Equations 3.3 and 3.4 is used in the calculation.

$$(h_r)_2 = 3\ (W_o/u)d \tag{3.4}$$

Therefore, h_r can be represented by the following formula for neutral and unstable conditions:

$$h_r = \text{Min}\left[(h_r)_1\ ,\ (h_r)_2\right] \tag{3.5}$$

Under stable atmospheric conditions, additional calculations are made as follows:

$$(h_r)_3 = 4\ (F/S)^{1/4} \tag{3.6}$$

$$(h_r)_4 = 1.5\ (F/u)^{1/3} S^{-1/6} \tag{3.7}$$

F Momentum Flux Parameter (m^4/sec^2)

$$F = W_o^{\ 2}\ (d/2)^2 \tag{3.8}$$

S Stability Parameter (sec^{-2})

See following table.

Table of Values for Stability Parameter (S) (Sec^{-2})

Stability Class	S
E	8.7×10^{-4}
F	1.75×10^{-3}
G	2.45×10^{-3}

The smaller value computed from Equations 3.6 and 3.7 is compared to the value obtained from Equation 3.5 and the smallest value is used to represent h_r under stable conditions. In other words,

$$h_r = \text{Min}\left[(h_r)_1, (h_r)_2, (h_r)_3, (h_r)_4\right] \quad (3.9)$$

3.2.2.1.2 Terrain Correction (h_t)

The topography of each site and immediate environs is characterized as relatively flat, little or no slope, and, with the exception of Zion, rural farmland. Zion terrain is comprised of marshy depressions and sandy ridges. Site-specific terrain correction factors, determined in the manner described below and used in the model to describe the offsite receptor points for each station, may be found in Table 7.2-5 of the site-specific data tables.

The average difference in elevation H_{rs} is computed for the point to be evaluated by subtracting the height of the terrain (H_s) at the release point from the height of the terrain at the receptor point (H_r). The correction factor, h_t, is computed by Equaitons 3.10 and 3.11.

$$H_{rs} = H_r - H_s \quad (3.10)$$

$$h_t = \begin{cases} H_{rs}; & H_{rs} > 0 \\ 0; & H_{rs} \leq 0 \end{cases} \quad (3.11)$$

H_{rs} Terrain Height Difference (m)
Net difference between grade elevation of source and receiver locations.

H_r Terrain Height At Receptor Point (m)
Grade elevation at the point of interest.

H_s Terrain Height At Source (m)
Grade elevation at the release.

3.2.2.1.3 Downwash Correction (C)

If the ratio of the exit velocity to the wind speed is less than 1.5, the effluent can get caught in the downwash of the stack and the plume rise would be inhibited. This reduction is accounted for by the term (C) in Equation 3.3 and this term is computed by Equation 3.12.

$$C = 3(1.5 - W_o/u)d \qquad (3.12)$$

3.2.2.2 Vent Stack Releases

The constant mean wind direction model has been modified into a "mixed-mode" model. In a mixed-mode model the height of the release is proportioned between an elevated release (stack height equal to the vent height plus momentum plume rise), and a ground level release (stack height equal to zero). Separate wind and stability data are used for each release height and the χ/Q ratios are calculated. Subsection 3.1.1 describes how the meteorological data are prepared for this calculation. This model is recommended by Regulatory Guide 1.111.

The fraction of the time that the plume is considered to be a ground level release (G_t) is determined, from the ratio of the exit velocity of the vent (W_o) to the wind speed (u), by the use of the following relationships:

$$G_t = \begin{cases} 1.00 & ; W_o/u \quad 1.0 \\ 2.58-1.58\ (W_o/u) & ; 1.0 \quad W_o/u \quad 1.5 \\ 0.3-0.06\ (W_o/u) & ; 1.5 \quad W_o/u \quad 5.0 \\ 0.00 & ; W_o/u \quad 5.0 \end{cases} \qquad (3.13)$$

G_t Ground Release Fraction

Fraction of time a vent release is considered a ground level release.

Therefore, the release can be considered as a ground level release $100G_t$ percent of the time and as an elevated release $100(1-G_t)$ percent of the time.

3.2.2.3 Ground Level Releases

To calculate the downwind concentrations resulting from ground level releases, Equation 3.1 is used with the effective stack height set to zero ($h_e=0$). If the release is from a structure of maximum height (D_z), a correction is made to the dispersion parameter to account for the increased mixing caused by the building's wake effect. Equation 3.14 shows how this is accounted for in the model.

$$S_z = \begin{cases} \sigma_z & \text{; no wake effect} \\ \left[\sigma_z^2 + D_z^2 / (2\pi) \right]^{\frac{1}{2}} & \text{; wake effect} \end{cases} \qquad (3.14)$$

σ_z Vertical Dispersion Coefficient (m)

The vertical dispersion coefficient for use in atmospheric dispersion models. See Table 7.1-7.

D_z Maximum Height Of Neighboring Structure (m)

The maximum height of any neighboring structure causing downwind building wake effects.

When the wake effect is used the factor S_z will be restricted by the condition:

$$S_z \leq \sqrt{3}\, \sigma_z \qquad (3.15)$$

3.2.3 Removal Mechanism Considerations

3.2.3.1 Radioactive Decay

The loss of activity with time, due to radioactive decay, is accounted for by adjusting the source term. This adjustment

takes the following form:

$$Q_i' = Q_i \exp(-\lambda_i t) = Q_i \exp(-\lambda_i R/3600u) \qquad (3.16)$$

Q_i' Corrected Release Rate (μCi/sec)

The release rate of radionuclide i corrected for radiodecay in transit.

Q_i Release Rate (μCi/sec)

The release rate of radionuclide i.

λ_i Radiodecay Constant (hr^{-1})

The radioactive decay constant for nuclide i. See Table 7.1-9.

t Transport Time (hr)

The time required to travel a distance R downwind.

3600 Conversion Constant (sec/hr)

Converts hours to seconds.

3.2.3.2 Plume Depletion and Deposition

As the plume travels downwind, the radioiodines and particulate material are deposited on the ground and thus removed from the plume. At all ranges (R) the model accounts for this depletion by multiplying the (χ/Q) ratios by a fraction that is a function of release height and stability.

$$(\chi/Q) = (\chi/Q)_o \; P_d(h_e, s) \qquad (3.17)$$

P_d Plume depletion coefficient

The function P_d recommended by the NRC (Regulatory Guide 1.111, Figures 2-5) is given in Section 7.1, Figures 7.1-1 to 7.1-4.

The plume depletion factors for the height closest to the actual release height are used.

3.2.3.3 Relative Deposition Factor (D/Q)

The value of D/Q is determined from one of the following equations:

$$D/Q = \frac{1}{R}\,\frac{16}{2\pi}\,D_r(s, R, h_s) \tag{3.18}$$

$$D/Q = \frac{1}{R}\,\frac{16}{2\pi}\sum_s f(\theta, s)\,D_r(s, R, h_s) \tag{3.19}$$

D/Q Relative Deposition Factor (m^{-2})

The calculated relative deposition factor in a given direction.

D_r Relative Deposition Rate (m^{-1})

The relative deposition rate is the deposition rate per unit downwind distance ($\mu Ci\ s^{-1}\ m^{-1}$) divided by the source strength ($\mu Ci\ s^{-1}$)

For time periods Δt < 8 hours, Equation 3.18 is used. For time period Δt > 8 hours, when the meteorological data are in the form of a stability wind rose, Equation 3.19 is used.

The values of D_r from Regulatory Guide 1.111, Figures 6-9, are reproduced in Section 7.1 as Figures 7.1-5 to 7.1-8. Choose the value of D_r closest to the release height (h_s).

For mixed mode releases, $(D_r)_v = G_t\,(D_r)_g + (1-G_t)\,(D_r)_s$. (3.19a)

3.2.4 Symbols Used In Section 3.2

SYMBOL	NAME	UNIT
χ/Q	Relative Effluent Concentration	(sec/m^3)
R	Downwind Range	(m)
θ	Direction	(degrees or sector)
u	Wind Speed	(m/sec)
s	Stability Class	
f	Joint Frequency	
S_z	Corrected Vertical Dispersion Coefficient	(m)
h_e	Effective Stack Height	(m)
h_s	Physical Stack Height	(m)
h_r	Plume Rise	(m)
h_t	Terrain Correction Factor	(m)
W_o	Exit Velocity	(m/sec)
d	Stack Diameter	(m)
C	Downwash Correction Factor	(m)
F	Momentum Flux Parameter	(m^4/sec^2)
S	Stability Parameter	(sec^{-2})
H_{rs}	Terrain Height Difference	(m)
H_r	Terrain Height at Receptor Point	(m)
H_s	Terrain Height at Source	(m)
G_t	Ground Release Fraction	
σ_z	Vertical Dispersion Coefficient	(m)
D_z	Maximum Height of Neighboring Structure	(m)
Q_i'	Corrected Release Rate	(μCi/sec)
Q_i	Release Rate	(μCi/sec)
λ_i	Radiodecay Constant	(hr^{-1})
t	Transport Time	(hr)
P_d	Plume Depletion Coefficient	

3.2.5 Constants Used In Section 3.2

NUMERICAL VALUE	NAME	UNIT
3600	Conversion Constant	(sec/hr)
$16/2\pi$	Sector Width^{-1}	(Radians^{-1})
2.032	Conversion Constant	

3.3 MODELS FOR CALCULATING DOSE FROM NOBLE GASES

3.3.1 Gamma Radiation

3.3.1.1 Gamma Air Dose - Finite Cloud Model

The gamma air dose (D^{γ}) is calculated from either of the following formulae:

$$D^{\gamma}(R,\theta) = \frac{260 \times 10^{-6} \times 86400}{R \times 2\pi/16} \times \sum_{m} t_r^m \sum_{u} \frac{1}{u} \sum_{i} \sum_{s} f(u,\theta,s) Q'_i \ \mu_{ai} \ \bar{E}_{\gamma i} \ (\bar{I}_1 + K_i \bar{I}_2)_i \qquad (3.20)$$

$$D^{\gamma}(R,\theta) = \frac{260 \times 10^{-6}}{R \ 2\pi/16} \sum_{u} \frac{1}{u} \sum_{i} \sum_{s} f(u,\theta,s) \times A'_i \ \mu_{ai} \ \bar{E}_{\gamma i} \ (\bar{I}_1 + K_i \bar{I}_2)_i \qquad (3.21)$$

$D^{\gamma}(R,\theta)$ — Gamma Air Dose (mrad)

The dose at (R,θ) due to gamma rays.

R — Downwind Range (m)

The distance downwind to point (R,θ).

θ — Direction (degree or sector)

The downwind direction to point (R,θ).

260 — Conversion Constant (mrad-radians-m^3-disintegration/sec-MeV-Ci)

Reconciles units of Equation 3.20.

10^{-6}	Conversion Constant	(Ci/μCi)
	Converts Ci to μCi.	
86400	Conversion Constant	(sec/day)
	Converts days to seconds.	
$2\pi/16$	Sector Width	(radians)
	The sector width over which the plume meanders.	
m	Index	
	An index identifying the release period of interest.	
t_r^m	Length of Release	(days)
	The time over which the m^{th} release occurred.	
u	Wind Speed	(m/sec)
	The wind speed.	
i	Index	
	An index identifying the nuclide of interest.	
s	Stability Class	
	The atmospheric stability class.	
f	Joint Frequency	
	The observed frequency in which the wind blows with speed u, downwind direction θ, and atmospheric stability class s.	
Q_i'	Corrected Release Rate	(μCi/sec)
	The release rate of nuclide i corrected for radiodecay in transit.	

μ_{ai} — Air Energy Absorption Coefficient (m^{-1})

The gamma ray energy absorption coefficient for air, for nuclide i (see Table 7.1-9).

$\bar{E}_{\gamma i}$ — Average Energy per Disintegration (MeV/disintegration)

The average gamma ray energy per disintegration of nuclide i (see Table 7.1-9).

$(\bar{I}_1 + K_i\bar{I}_2)$ — Dimensionless Numerical Integration Constant

The dimensionless parameter resulting from numerical integration over the cloud defined in Section 7.5 of Reference 6.7. (For K_i values, see Table 7.1-9)

A_i' — Corrected Release (μCi)

The release of nuclide i corrected for radiodecay in transit.

The basic form of the above equation was taken from Meteorology and Atomic Energy (Equation 7.63) and is equivalent to Equation 6 in Regulatory Guide 1.109. The summation over the index m represents the summing of the doses from all sources at the station (i.e., elevated releases and vent releases).

Equation 3.20 was used to compute the normalized gamma air dose factors (mrad/yr per μCi/sec) S_i (for stack releases); V_i (for vent releases); and G_i (for ground level releases). Site-specific values of S_i, V_i, and G_i, using historical meteorological data, are given in Section 7.2.

3.3.1.2 Whole Body Dose Factors

The whole body dose factors, $\overline{S_i}$ (for stack releases); $\overline{V_i}$ (for vent releases); and $\overline{G_i}$ (for ground level releases), in mrad/yr per μCi/sec, computed from $D^T(R,\theta) \div (1.11\ SF^\gamma\ 3.17 \times 10^{-8})$, evaluated one nuclide at a time, are given in Section 7.2.

The whole body dose $D^T(R,\theta)$, calculated for preselected ranges in each downwind sector, is given by the equation that follows:

$$D^T\ (R,\theta) = 1.11\ SF^\gamma \sum_i D_i^\gamma\ (R,\theta)\ \exp(-5\,\mu_{ti}) \qquad (3.22)$$

$D^T(R,\theta)$	Whole Body Dose The dose to the whole body at downwind point (R,θ).	(mrem)
1.11	Conversion Constant Converts mrad to mrem.	(mrem/mrad)
SF^γ	Shielding and Occupancy Factor for Gamma Radiation Accounts for reduction in gamma exposure to building shielding and occupancy at the point of interest.	
μ_{ti}	Tissue Energy Absorption Coefficient (Table 7.1-9) The gamma ray energy absorption coefficient in tissue for nuclide i.	(cm^2/g)
$D_i^\gamma(R,\theta)$	Gamma Air Dose The gamma air dose at (R,θ) due to nuclide i as evaluated from Equation 3.20.	(mrad)

For this calculation, the shielding factor SF^{γ} is set to 0.7 and dose is computed at a depth of 5 cm in the tissue. The factor 1.11 is the ratio of tissue to air energy absorption coefficients.

3.3.2 Beta Radiation

3.3.2.1 Beta Particle Air and Skin Dose Factors

The beta particle air dose factor L_i, (mrad/yr per $\mu Ci/m^3$) and skin dose factor $\bar{L}_i$, mrem/yr per $\mu Ci/m^3$, are given in Reference 6.5 and included in Table 7.1-13.

3.3.3 Symbols Used In Section 3.3

SYMBOL	NAME	UNIT
$D^{\gamma}(R,\theta)$	Gamma Air Dose	(mrad)
R	Downwind Range	(m)
θ	Direction	(degrees or sector)
m	Index	
t_r^m	Length of Release	(days)
u	Wind Speed	(m/sec)
i	Index	
s	Stability Class	
f	Joint Frequency	
Q_i'	Corrected Release Rate	(μCi/sec)
μ_{ai}	Air Energy Absorption Coefficient	(m^{-1})
$\overline{E}_{\gamma i}$	Average Energy per Disintegration	(MeV/disintegration)
$(\overline{I}_1+K_i\overline{I}_2)$	Dimensionless Numerical Integration Constant	
A_i'	Corrected Release	(μCi)
$D^T(R,\theta)$	Whole Body Dose	(mrem)
SF^{γ}	Shielding and Occupancy Factor for Gamma Radiation	
$D_i^{\gamma}(R,\theta)$	Gamma Air Dose	(mrad)
μ_{ti}	Tissue Energy Absorption Coefficient	(cm^2/g)

3.3.4 Constants Used in Section 3.3

NUMERICAL VALUE	NAME	UNIT
260	Conversion Constant	([mrad-radians-m^3-disintegration]/[sec-MeV-Ci])
10^{-6}	Conversion Constant	(Ci/μCi)
86400	Conversion Constant	(sec/day)
$2\pi/16$	Sector Width	(radians)
1.11	Conversion Constant	(mrem/mrad)

3.4 MODELS FOR CALCULATING DOSE FROM RADIOIODINES, "PARTICULATES", AND OTHER RADIONUCLIDES

The specific model for computing the dose to the various organs of an adult or infant is given in Equation 2.11. For the purpose of demonstrating compliance with the Technical Specifications, the dose to an infant who inhales air and drinks milk containing radioactive material shall be limiting. However, the dose model may be used to compute the dose to an adult who inhales radioactivity and ingests meat, milk, produce, or leafy vegetables containing radioactivity. The choice of the infant as the critical person is based on previous calculations of dose reported in semi-annual or annual reports. Annually, the dose to an adult will be computed to confirm the choice of an infant as "critical person".

In the inhalation model, using historical meteorological information, radioactive decay but not plume depletion was considered. Plume depletion was not considered at this time because depletion for the D atmospheric class, a class representative of average meteorology, reduces the inhalation dose by, at most, 10% within the 3 kilometer range considered.

4.0 AQUATIC TRANSPORT AND DOSE MODELS

TABLE OF CONTENTS

4.0 AQUATIC TRANSPORT AND DOSE MODELS

4.1 AQUATIC TRANSPORT

Dose via the aquatic pathway is discussed in Section 2.2. Two dilution factors are considered; F, the flow of the receiving body of water; and 1/M, an additional dilution factor.

4.1.1 River Model

For purposes of calculating the drinking water dose from liquid effluents discharged into a river, it is assumed that total mixing of the discharge in the river flow (F^w) occurs prior to consumption. No additional dilution is assumed to occur; thus $1/M^w$ equals 1.0. The river flow is taken as the long-term (generally 10 years) average. The nearest potable water intakes on the receiving bodies of water are described in a footnote to Table 7.2-1.

For the fish consumption pathway, a near-field dilution flow F^f is used; $1/M^f = 1.0$.

4.1.2 Lake Michigan Model

For purposes of calculating dose from liquid effluents discharged to Lake Michigan, it is assumed that the concentration of radioactivity is diluted initially in the condenser cooling water of flow (F^c) and then by an additional factor $1/M^w$ of 60 prior to consumption as potable water. The dilution factor of 60 is the product of the initial entrainment dilution (factor of 10); the plume dilution (factor of 3 over approximately 1 mile); and the current direction frequency (annual average factor of 2).

For the fish ingestion pathway only, it is assumed the radioactivity is diluted fully in a hypothetical river of flow F^f; $1/M^f = 1.0$. To determine F^f, it was assumed that the near shore lake current (which can vary in width from 2 to 10 miles) constitutes a "river" 5 miles wide, 50 feet deep (the average lake depth from shore to 5 miles near Zion), and flows at the offshore, measured average speed of 0.2 mile per hour. This results in $F^f = 4.0 \times 10^5$ ft^3/sec.

4.1.3 Symbols Used In Section 4.1

SYMBOL	NAME	UNIT
F	Flow of the Receiving Body of Water	
$1/M$	Additional Dilution Factor	
F^w	Average Flow Rate (Drinking Water Pathway)	(ft^3/sec)
$1/M^w$	Additional Dilution Factor (Drinking Water Pathway)	
F^f	Near-Field Flow Rate (Fish Ingestion Pathway)	(ft^3/sec)
$1/M^f$	Additional Dilution Factor (Fish Ingestion Pathway)	
F^c	Average Flow of the Condenser Cooling Water During the Period of Discharge	(gal/min)

4.2 AQUATIC DOSE MODEL

The general model used to calculate the dose from radioactive material released in liquid waste is given in Subsection 2.2.1. The maximum consumption rate of fish by an adult, $U^f = 2.4 \times 10^{-3}$ kg/hr (21 kg/yr), given in Reference 6.5 (USNRC Regulatory Guide 1.109), is assumed for all nuclear stations except those sited along the Illinois River. For these stations, because of this river's very low productivity of desirable fish, a consumption rate one-tenth the maximum is assumed.

4.2.1 Symbols Used in Section 4.2

SYMBOL	NAME	UNIT
U^f	Usage Factor	(kg/hr)

4.3 AQUATIC TRANSPORT DURING TANK OVERFLOW CONDITIONS

In Subsection 2.2.3, the limiting quantity of radionuclide i in tanks without overflow pipes connected to other storage tanks was determined to be a function of two dilution factors characteristic of the receiving body of water: F_o^w, the minimum flow of the receiving body of water during overflow conditions, and $1/M_o^w$, an additional dilution factor.

4.3.1 River Model

For purposes of calculating the limiting quantity of tank radioactivity spilled into a river of flow, F_o^w, and with a dam between the release point and the intake, it is assumed that total mixing of the discharge in the river occurs in the minimum river flow of the most recent past 10 years. No additional dilution is assumed to occur; thus $1/M_o^w$ equals 1.0.

4.3.2 Lake Michigan Model

For purposes of calculating the limiting quantity of tank radioactivity spilled into Lake Michigan, it is assumed that F_o^w, the initial dilution water, is zero and that the additional dilution factor, $1/M_o^w$, is 1000. The 1000 factor represents an estimate of the dilution experienced by a shoreline-spilled water mass as it moves north along the shore and east into the lake, having to cross the northward moving lake current to reach the nearest water intake which is 6500 feet northeast (1.1 miles north and 3000 feet out in the lake) at a depth of 35 feet.

4.3.3 Symbols Used in Section 4.3

SYMBOL	NAME	UNIT
F_o^w	Minimum Flow Rate, Receiving body of Water	(ft^3/sec)
$1/M_o^w$	Additional Dilution Factor	

5.0 SUMMARY

TABLE OF CONTENTS

5.0 SUMMARY

LIST OF TABLES

5.0 SUMMARY

5.1 AIRBORNE EFFLUENTS

5.1.1 10 CFR 50, Appendix I Design Objectives

The 10 CFR 50, Appendix I technical specification design objectives for the nuclear stations are summarized in Table 5.1-1. To demonstrate compliance with the Appendix I objectives, the dose for each time period of the quarter will be calculated using the dose equations noted in Table 5.1-1. The current quarter dose is the summation of the dose contribution from every effluent release during the quarter. The station will calculate the doses on a monthly basis. Each time the station evaluates the dose equations, the new contribution is added to the current total for the quarter, and the new total is compared with the objective. Next, the new total for the quarter is combined with the totals for the previous three quarters to determine the annual dose.

The results of each calculational run will be summarized in a format similar to that shown in Table 5.1-1. The maximum dose is printed with the associated wind direction. The values calculated for each wind direction and range must be stored for calculation of the maximum period, quarter, and annual dose. For the organ dose, the computer will calculate doses to seven organs for up to 73 radionuclides, and select the maximum period, quarter, and annual organ doses.

For each dose type and maximum value, the compliance status is calculated where the status (%) = 100 x maximum dose ÷ dose objective.

5.1.2 10 CFR 20 Release Rate Limits

The compliance status with respect to the 10 CFR 20 limits is determined in the following manner and reported in the format of Table 5.1-2 for periods of unusually high release rate Q.

$$C.S._{WB} = \frac{\text{(dose rate from Eq. 2.9)} \times 100}{500 \text{ mrem/yr}} \quad (\%) \quad \text{whole body} \qquad (5.1)$$

$$C.S._{S} = \frac{\text{(dose rate from Eq. 2.10)} \times 100}{3000 \text{ mrem/yr}} \quad (\%) \quad \text{skin} \qquad (5.2)$$

$$C.S._{O} = \frac{\text{(dose rate from Eq. 2.18)} \times 100}{1500 \text{ mrem/yr}} \quad (\%) \quad \text{organ} \qquad (5.3)$$

The value of C.S. must not exceed 100%. If it does, the station's release rate is too high and corrective action to reduce the release rate must be taken immediately.

TABLE 5.1-1

(Name) Unit (number)

MAXIMUM DOSES RESULTING FROM AIRBORNE RELEASES

(PERIOD OF RELEASE FROM (DATE) TO (DATE). DATE OF CALCULATION (DATE))

TYPE	CURRENT PERIOD	CURRENT QUARTER*	THIRD QUARTER	SECOND QUARTER	FIRST QUARTER	ANNUAL
Gamma Air (mrad)	Eq.2.1[Δ]	dose (dir.) - NOTE:	This format should appear in all 30 entries			
Beta Air (mrad)	Eq.2.3					
Whole Body (mrem)	Eq.2.5					
Skin (mrem)	Eq.2.7					
Organ (mrem)	Eq.2.11					

Last period of release from (date) to (date), calculated (date).

COMPLIANCE STATUS

TYPE	10 CFR 50 APP. I QUARTERLY OBJECTIVE	% OF APP. I	10 CFR 50 APP. I YEARLY OBJECTIVE	% OF APP. I
Gamma Air (mrad)	5		10	
Beta Air (mrad)	10		20	
Whole Body (mrem)	2.5		5	
Skin (mrem)	7.5		15	
Organ (mrem)	7.5	**	15	***

ΔThe equation number of the model used to compute the dose for the period is listed here for information only.

*Cumulative dose for the quarter including the current period.

**The critical organ is (Name).

***The critical organ is (Name).

TABLE 5.1-2

(Name) Station

MAXIMUM INSTANTANEOUS RELEASE RATES

(PERIOD OF RELEASE FROM (DATE/TIME) TO (DATE/TIME).
DATE OF CALCULATION (DATE))

ORGAN	DOSE RATE, mrem/year	10 CFR 20 LIMIT, mrem/year	COMPLIANCE STATUS*
Whole Body		500	Eq. 5.1
Skin		3000	Eq. 5.2
(Name) Organ$^{\Delta}$		1500	Eq. 5.3

$^{\Delta}$The organ with the maximum dose should be named.

*See text for definition. If C.S. $\geq$ 100, add this or similar footnote to the table:

"Corrective action must be taken immediately to reduce the release rate." Also, perhaps, at the bottom of this table on a separate sheet, the radionuclides and their release rate should be listed.

5.2 LIQUID RELEASES

5.2.1 10 CFR 50, Appendix I Design Objectives

The total quarterly and annual whole body or organ doses due to radioactivity discharged in liquid wastes are computed in a manner similar to that for airborne effluents. The results, based on doses computed with Equation 2.22, are summarized in the manner of Table 5.2-1.

5.2.2 10 CFR 20 Maximum Permissible Concentrations

5.2.2.1 Unrestricted Area

The concentration of nonnoble gas radioactive material released from the site to unrestricted areas (C_i) shall be limited to the concentrations specified in 10 CFR 20, Appendix B, Table II, Column 2 (MPC_i). The concentrations of dissolved or entrained noble gases shall be limited to the concentrations specified in Table 7.1-10. The sum of the fractional limits ($C_i \div MPC_i$) must not exceed 1.0 for each release.

Hence:

$$100 \times \sum_i \frac{C_i}{MPC_i} \leq 100\% \qquad (5.4)$$

5.2.2.2 Nearest Surface Water Supply

At Zion, the quantity of radionuclides, excluding tritium and dissolved or entrained noble gases, in outdoor tanks without overflow pipes connected to other storage tanks, shall be limited to ensure that in the case of an overflow, the annual average concentration of radioactivity in the potable water of the nearest surface water supply is less than the 10 CFR 20, Appendix B, Table II, Column 2 limits.

Hence:

$$\sum_i \frac{A_i^t}{MPC_i} \exp(-\lambda_i \times t_o^w) \leq 4 \left(\frac{F_o^w + F^t}{F^t}\right) \frac{V^t}{M_o^w} \tag{5.5}$$

and

$$\sum_i \frac{C_i^t}{MPC_i} \exp(-\lambda_i \times t_o^w) \leq \left(\frac{F_o^w + F^t}{F^t}\right) \frac{1100}{M_o^w} \tag{5.6}$$

TABLE 5.2-1

(Name) Unit (number)

MAXIMUM DOSES RESULTING FROM LIQUID EFFLUENTS

(PERIOD OF RELEASE FROM (DATE) TO (DATE). DATE OF CALCULATION (DATE))

TYPE	CURRENT PERIOD	CURRENT QUARTER*	THIRD QUARTER	SECOND QUARTER	FIRST QUARTER	ANNUAL
Whole Body (mrem)		dose - NOTE: This format should appear in all 12 entries				
Organ (mrem)		dose				
Critical Organ During Period		name				

Last period of release from (date) to (date), calculated (date).

COMPLIANCE STATUS

TYPE	10 CFR 50 QUARTERLY OBJECTIVE	% OF APP. I	10 CFR 50, APP. I YEARLY OBJECTIVE	% OF APP. I
Whole Body (mrem)	1.5		3	
Organ (mrem)	5	**	10	***

*Cumulative dose in quarter to date

**The critical organ is (name)

***The critical organ is (name)

5.3 URANIUM FUEL CYCLE

The compliance status, with respect to the 40 CFR 190 limits, is determined in the following manner and reported in the format of Table 5.3-1 at the end of each calendar year.

In accordance with the numerical models described in Subsection 2.3.2, the maximum whole body, thyroid, and any other organ (AOO) doses to a member of the public in the general environment, i.e., the unrestricted area, will be determined and compared to the 40 CFR 190 limits to determine the compliance status.

TABLE 5.3-1

______________(Name)______________ STATION(S)

COMPLIANCE STATUS: URANIUM FUEL CYCLE OPERATIONS: 40 CFR 190

Period of Release____________Date of This Calculation____________

ORGAN	DOSE RATE mrem/year	40 CFR 190 LIMIT (mrem/year)	COMPLIANCE STATUS(%)*
Whole Body		25	
Thyroid		75	
Any Other Organ (Name)		25	

*If ≥ 100%, this or a similar footnote must be added to the table.

"Corrective action might be needed to bring the facility into compliance with the regulations. If a variance for unusual operations is required, petition the NRC in accordance with the requirements of 40 CFR 190.11."

5.4 PRIMARY DRINKING WATER STANDARDS

The U.S. Environmental Protection Agency has promulgated regulations for the radioactivity content of community water systems (Reference 6.18). One part (40 CFR 141.16(a)) of these regulations involves man-made radioactivity, such as those in liquid waste from a reactor. It reads: "The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the whole body or any internal organ greater than 4 millirem per year." In 40 CFR 141.16(b) the method for calculating this dose is described. The EPA dose calculation method differs somewhat from that described in ODCM Subsection 2.2.1. Furthermore, the 40 CFR 141 regulation applies to the operator of the community water system and not to CECo.

If a special report defining corrective actions to reduce the releases of radioactive materials in liquid effluents is required by the technical specifications, it must include an analysis of the radiological impact on the downstream drinking water source also. This analysis may include the data of Table 5.4-1.

If confirmatory measurements of radioactivity attributable to plant operations found at the nearest community water system are available, the following concentrations, taken singularly or in combination (i.e., the sum of the ratios of concentration to limit are $\geq$ 1), shall define the 40 CFR 141 regulatory limit: strontium-90, 8 pCi/l; tritium, 20,000 pCi/l; gross beta activity, 50 pCi/l; and for any other nuclide, the concentration given in NBS Handbook 69 as amended in August 1963.

TABLE 5.4-1

(Name) Station

PROJECTED DOSE AT NEAREST COMMUNITY WATER SYSTEM*

(PERIOD OF RELEASE FROM (DATE) TO (DATE). DATE OF CALCULATION (DATE))

TYPE	CURRENT PERIOD	CURRENT QUARTER**	THIRD QUARTER	SECOND QUARTER	FIRST QUARTER	ANNUAL
Whole Body (mrem)	Dose		NOTE: This format should appear in all 12 entries			
Internal Organ (mrem)***	Dose					
Critical Organ During Period***	Name	Name	Name	Name	Name	Name

Last period of release from (date) to (date), calculated (date).

COMPLIANCE STATUS

TYPE	40 CFR 141 ANNUAL LIMIT	% OF LIMIT
Whole Body (mrem)	4	
Internal Organ (mrem)***	4	
Critical Organ During Year***	Name	

* This calculation of dose is based on techniques described in the Commonwealth Edison Offsite Dose Calculation Manual. These techniques differ from those described in 40 CFR 141. A projected dose of 2 mrem using CECo's techniques is approximately 4 mrem using EPA methods. Any planned action should be based on the requirements of the regulation and not this report.

** Cumulative dose in quarter to date.

*** Either thyroid, GI-LLI, bone, liver, kidney, or lung.

6.0 REFERENCES

TABLE OF CONTENTS

6.0 REFERENCES

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6.4 Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," U.S. Nuclear Regulatory Commission, Washington, D.C., Revision 1, July 1977.

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6.6 J. F. Sagendorf, "A Program for Evaluating Atmospheric Dispersion from a Nuclear Power Station," U.S. Department of Commerce, Report No. NOAA TM ERL ARL-42, Air Resources Laboratory, Idaho Falls, Idaho, 1974.

6.7 D. H. Slade, "Meteorology and Atomic Energy 1968," U.S. Atomic Energy Commission, 1968.

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6.14 EPA-520/9-73-003-B, "Environmental Analysis of the Uranium Fuel Cycle," Part I, Fuel Supply, October 1973.

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6.16 WASH-1248, "Environmental Survey of the Uranium Fuel Cycle," April 1974.

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7.0 DATA FOR DOSE ASSESSMENT MODELS

TABLE OF CONTENTS

7.0 DATA FOR DOSE ASSESSMENT MODELS

LIST OF TABLES

7.0 DATA FOR DOSE ASSESSMENT MODELS

LIST OF FIGURES

7.0 DATA FOR DOSE ASSESSMENT MODELS

Virtually all of the data to be used in the dose assessment models is contained in this section of the ODCM. This organization will permit easy reference and facilitate future changes, should they be necessary.

Section 7.1 contains data which is generically applicable to all stations.

Section 7.2 contains site descriptions and data (particularly meteorological data) which is relevant only to a specific site.

7.1 DATA COMMON TO ALL NUCLEAR STATIONS

This section contains data that is generically applicable to all stations.

TABLE 7.1-1

DOSE COMMITMENT FACTORS

PATHWAY	INFANT	ADULT
Inhalation	See Table 7.1-E-10	See Table 7.1-E-7
Ingestion	See Table 7.1-E-14	See Table 7.1-E-11

The following tables are from Tables E-7, E-10, E-11, and E-14 of Appendix E of Reference 6.5. Each table contains seven organ dose factors for 73 radionuclides. For radionuclides not found in these tables dose factors will be derived from ICRP 2 (1959) or NUREG-0172 (Reference 6.10).

TABLE 7.1-E-7

INHALATION DOSE FACTORS FOR ADULTS

(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-05	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

TABLE 7.1-E-7 (Cont'd)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
Y 93	1.18E-05	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
TC101	5.22E-15	7.52E-15	7.38E-14	NO DATA	1.35E-13	4.99E-08	1.36E-21
RU103	1.91E-07	NO DATA	8.23E-08	NO DATA	7.29E-07	6.31E-05	1.38E-05
RU105	9.88E-11	NO DATA	3.89E-11	NO DATA	1.27E-10	1.37E-06	6.02E-06
RU106	8.64E-06	NO DATA	1.07E-06	NO DATA	1.67E-05	1.17E-03	1.14E-04
AG110M	1.35E-06	1.25E-06	7.43E-07	NO DATA	2.46E-06	5.79E-04	3.78E-05
TE125M	4.27E-07	1.98E-07	5.84E-08	1.31E-07	1.55E-06	3.92E-05	8.83E-06
TE127M	1.58E-06	7.21E-07	1.96E-07	4.11E-07	5.72E-06	1.20E-04	1.87E-05
TE127	1.75E-10	8.03E-11	3.87E-11	1.32E-10	6.37E-10	8.14E-07	7.17E-06
TE129M	1.22E-06	5.84E-07	1.98E-07	4.30E-07	4.57E-06	1.45E-04	4.79E-05
TE129	6.22E-12	2.99E-12	1.55E-12	4.87E-12	2.34E-11	2.42E-07	1.96E-08
TE131M	8.74E-09	5.45E-09	3.63E-09	6.88E-09	3.86E-08	1.82E-05	6.95E-05
TE131	1.39E-12	7.44E-13	4.49E-13	1.17E-12	5.46E-12	1.74E-07	2.30E-09
TE132	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
CS134	4.66E-05	1.06E-04	9.10E-05	NO DATA	3.59E-05	1.22E-05	1.30E-06
CS136	4.88E-06	1.83E-05	1.38E-05	NO DATA	1.07E-05	1.50E-06	1.46E-06
CS137	5.98E-05	7.76E-05	5.35E-05	NO DATA	2.78E-05	9.40E-06	1.05E-06
CS138	4.14E-08	7.76E-08	4.05E-08	NO DATA	6.00E-08	6.07E-09	2.33E-13
BA139	1.17E-10	8.32E-14	3.42E-12	NO DATA	7.78E-14	4.70E-07	1.12E-07

TABLE 7.1-E-7 (Cont'd)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA140	4.88E-06	6.13E-09	3.21E-07	NO DATA	2.09E-09	1.59E-04	2.73E-05
BA141	1.25E-11	9.41E-15	4.20E-13	NO DATA	8.75E-15	2.42E-07	1.45E-17
BA142	3.29E-12	3.38E-15	2.07E-13	NO DATA	2.96E-15	1.49E-07	1.96E-26
LA140	4.30E-08	2.17E-08	5.73E-09	NO DATA	NO DATA	1.70E-05	5.73E-05
LA142	8.54E-11	3.88E-11	9.65E-12	NO DATA	NO DATA	7.91E-07	2.64E-07
CE141	2.49E-06	1.69E-06	1.91E-07	NO DATA	7.83E-07	4.52E-05	1.50E-05
CE143	2.33E-08	1.72E-08	1.91E-09	NO DATA	7.60E-09	9.97E-06	2.83E-05
CE144	4.29E-04	1.79E-04	2.30E-05	NO DATA	1.06E-04	9.72E-04	1.02E-04
PR143	1.17E-06	4.69E-07	5.80E-08	NO DATA	2.70E-07	3.51E-05	2.50E-05
PR144	3.76E-12	1.56E-12	1.91E-13	NO DATA	8.81E-13	1.27E-07	2.69E-18
ND147	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
NP239	2.87E-08	2.82E-09	1.55E-09	NO DATA	8.75E-09	4.70E-06	1.49E-05

TABLE 7.1-E-10

INHALATION DOSE FACTORS FOR INFANTS

(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	6.37E-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
[illegible]	9.69E-06	1.68E-05	6.77E-06	NO DATA	NO DATA	7.25E-04	1.77E-05
[illegible]	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-05
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

TABLE 7.1-E-10 (Cont'd)

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
TC101	4.65E-14	5.98E-14	5.80E-13	NO DATA	6.99E-13	4.17E-07	6.03E-07
RU103	1.44E-06	NO DATA	4.85E-07	NO DATA	3.03E-06	3.94E-04	1.15E-05
RU105	8.74E-10	NO DATA	2.93E-10	NO DATA	6.42E-10	1.12E-05	3.46E-05
RU106	6.20E-05	NO DATA	7.77E-06	NO DATA	7.61E-05	8.26E-03	1.17E-04
AG110M	7,13E-06	5.16E-06	3.57E-06	NO DATA	7.80E-06	2.62E-03	2.36E-05
TE125M	3.40E-06	1.42E-06	4.70E-07	1.16E-06	NO DATA	3.19E-04	9.22E-06
TE127M	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.68E-05	9.37E-04	1.95E-05
TE127	1.59E-09	6.81E-10	3.49E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
TE129M	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
TE129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
TE131M	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
TE131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-06
TE132	2.66E-07	1.69E-07	1.26E-07	1.99E-07	7.39E-07	2.43E-04	3.15E-05
I 130	4.54E-06	9.91E-06	3.98E-06	1.14E-03	1.09E-05	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	1.99E-06	4.97E-04	6.05E-06	NO DATA	1.31E-06
CS134	2.83E-04	5.02E-04	5.32E-05	NO DATA	1.36E-04	5.69E-05	9.53E-07
CS136	3.45E-05	9.61E-05	3.78E-05	NO DATA	4.03E-05	8.40E-06	1.02E-06
CS137	3.92E-04	4.37E-04	3.25E-05	NO DATA	1.23E-04	5.09E-05	9.53E-07
CS138	3.61E-07	5.58E-07	2.84E-07	NO DATA	2.93E-07	4.67E-08	6.26E-07
BA139	1.06E-09	7.03E-13	3.07E-11	NO DATA	4.23E-13	4.25E-06	3.64E-05

TABLE 7.1-E-10 (Cont'd)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA140	4.00E-05	4.00E-08	2.07E-06	NO DATA	9.59E-09	1.14E-03	2.74E-05
BA141	1.12E-10	7.70E-14	3.55E-12	NO DATA	4.64E-14	2.12E-06	3.39E-06
BA142	2.84E-11	2.36E-14	1.40E-12	NO DATA	1.36E-14	1.11E-06	4.95E-07
LA140	3.61E-07	1.43E-07	3.68E-08	NO DATA	NO DATA	1.20E-04	6.06E-05
LA142	7.36E-10	2.69E-10	6.40E-11	NO DATA	NO DATA	5.87E-06	4.25E-05
CE141	1.98E-05	1.19E-05	1.42E-06	NO DATA	3.75E-06	3.69E-04	1.54E-05
CE143	2.09E-07	1.38E-07	1.58E-08	NO DATA	4.03E-08	8.30E-05	3.55E-05
CE144	2.28E-03	8.65E-04	1.26E-04	NO DATA	3.84E-04	7.03E-03	1.06E-04
PR143	1.00E-05	3.74E-06	4.99E-07	NO DATA	1.41E-06	3.09E-04	2.66E-05
PR144	3.42E-11	1.32E-11	1.72E-12	NO DATA	4.80E-12	1.15E-06	3.06E-06
ND147	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
NP239	2.65E-07	2.37E-08	1.34E-08	NO DATA	4.73E-08	4.25E-05	1.78E-05

TABLE 7.1-E-11

INGESTION DOSE FACTORS FOR ADULTS

(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	1.08E-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

TABLE 7.1-E-11 (Cont'd)

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
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	6.09E-09	NO DATA	1.99E-07	NO DATA	9.42E-06
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	2.69E-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-0[illegible]
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-1[illegible]
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

TABLE 7.1-E-11 (Cont'd)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
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-0[illegible]	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	1.2[illegible]-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 187	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

TABLE 7.1-E-14

INGESTION DOSE FACTORS FOR INFANTS

(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

TABLE 7.1-E-14 (Cont'd)

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.[illegible]1E-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
TC101	2.27E-09	2.86E-09	2.83E-08	NO DATA	3.40E-08	1.56E-09	4.86E-07
RU103	1.48E-06	NO DATA	4.95E-07	NO DATA	3.08E-06	NO DATA	1.80E-05
RU105	1.36E-07	NO DATA	4.53E-08	NO DATA	1.00E-06	NO DATA	5.41E-05
RU106	2.41E-05	NO DATA	3.01E-06	NO DATA	2.85E-05	NO DATA	1.83E-04
AG110M	9.96E-07	7.27E-07	4.81E-07	NO DATA	1.04E-06	NO DATA	3.77E-05
TE125M	2.53E-05	7.79E-06	3.15E-06	7.84E-06	NO DATA	NO DATA	1.11E-05
TE127M	5.85E-05	1.94E-05	7.08E-06	1.69E-05	1.44E-04	NO DATA	2.36E-05
TE127	1.00E-06	3.35E-07	2.15E-07	8.14E-07	2.44E-06	NO DATA	2.10E-05
TE129M	1.00E-04	3.43E-05	1.54E-05	3.84E-05	2.50E-04	NO DATA	5.97E-05
TE129	2.84E-07	9.79E-08	6.63E-08	2.38E-07	7.07E-07	NO DATA	2.27E-05
TE131M	1.52E-05	6.12E-06	5.05E-06	1.24E-05	4.21E-05	NO DATA	1.03E-04
TE131	1.76E-07	6.50E-08	4.94E-08	1.57E-07	4.50E-07	NO DATA	7.11E-06
TE132	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	9.07E-06	NO DATA	2.62E-06
CS134	3.77E-04	7.03E-04	7.10E-05	NO DATA	1.81E-04	7.42E-05	1.91E-06
CS136	4.59E-05	1.35E-04	5.04E-05	NO DATA	5.38E-05	1.10E-05	2.05E-06
CS137	5.22E-04	6.11E-04	4.33E-05	NO DATA	1.64E-04	6.64E-05	1.91E-06
CS138	4.81E-07	7.82E-07	3.79E-07	NO DATA	3.90E-07	6.09E-08	1.25E-06
BA139	8.81E-07	5.84E-10	2.55E-08	NO DATA	3.51E-10	3.54E-10	5.58E-05

TABLE 7.1-E-14 (Cont'd)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA140	1.71E-04	1.71E-07	8.81E-06	NO DATA	4.06E-08	1.05E-07	4.20E-05
BA141	4.25E-07	2.91E-10	1.34E-08	NO DATA	1.75E-10	1.77E-10	5.19E-06
BA142	1.84E-07	1.53E-10	9.06E-09	NO DATA	8.91E-11	9.26E-11	7.59E-07
LA140	2.11E-08	8.32E-09	2.14E-09	NO DATA	NO DATA	NO DATA	9.77E-05
LA142	1.10E-09	4.04E-10	9.67E-11	NO DATA	NO DATA	NO DATA	6.86E-05
CE141	7.87E-08	4.80E-08	5.65E-09	NO DATA	1.48E-08	NO DATA	2.48E-05
CE143	1.48E-08	9.82E-06	1.12E-09	NO DATA	2.86E-09	NO DATA	5.73E-05
CE144	2.98E-06	1.22E-06	1.67E-07	NO DATA	4.93E-07	NO DATA	1.71E-04
PR143	8.13E-08	3.04E-08	4.03E-09	NO DATA	1.13E-08	NO DATA	4.29E-05
PR144	2.74E-10	1.06E-10	1.33E-11	NO DATA	3.84E-11	NO DATA	4.93E-06
ND147	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
NP239	1.11E-08	9.93E-10	5.61E-10	NO DATA	1.98E-09	NO DATA	2.87E-0

TABLE 7.1-2

MISCELLANEOUS DOSE ASSESSMENT FACTORS - ADULT

U_a^M = 310 liters/yr

R_a = 8000 m^3/yr

U_a^P = 520 kg/yr

U_a^V = 64 kg/yr

U_a^F = 110 kg/yr

f_p = .76

f_V = 1.0

t_h = 0 for pasture grass (milk and meat pathways)

t_h = 24 hr (1 day for leafy vegetables)

t_h = 1440 hr (60 days for produce)

t_h = 2160 hr for stored feed (milk and meat pathways)

t_e = 720 hr (30 days for milk and meat)

t_e = 1440 hr (60 days for produce or leafy vegetables)

f_f = 1.0 May-October

f_f = 0.0 November-April

f_g = 0.5

λ_w = .0021 hr^{-1}

TABLE 7.1-2 (Cont'd)

Y_v = 2.0 kg/m^2 for leafy vegetables and produce pathways

Y_v = 0.7 kg/m^2 for milk and meat pathways

t_s = 480 hr (20 days)

r = 1.0 (iodines)
0.2 (others)

W_f = 50 kg/day

t_M = 48 hr (2 days)

TABLE 7.1-3

MISCELLANEOUS DOSE ASSESSMENT FACTORS - INFANT

U_a^M	= 330 liters/yr
U_a^P, U_a^V, U_a^F	= 0
R_a	= 1400 m^3/yr
W_f	= 50 kg/day
r	= 1.0 (iodines)* 0.2 (others)
t_M	= 48 hr (2 days)
λ_w	= 0.0021 hr^{-1}
Y_v	= 0.7 kg/m^2
t_e	= 720 hours
t_h	= 0 for pasture grass (milk pathway)
t_h	= 2160 hr (stored feed and milk pathway)
f_f	= 1.0 May-October
f_f	= 0.0 November-April
f_g	= 0.5
K	= 0.5 May-October
K	= 0.0 November-April

*The r factor provides for the non-deposition on grass of the organic forms of iodine.

TABLE 7.1-4

STABLE ELEMENT TRANSFER DATA*

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

*Data presented in this table are from NRC Regulatory Guide 1.109, Revision 1, (Reference 6.5), October 1977.

**Used value for I (no literature available).

***W. C. Ng, "Transfer Coefficients for Prediction of the Dose to Man Via the Forage-Cow-Milk Pathway From Radionuclides Released to the Biosphere," UCRL-51939.

TABLE 7.1-5

ATMOSPHERIC STABILITY CLASSES

DESCRIPTION	PASQUILL STABILITY CLASS	σ_θ (SEE NOTE, BELOW)	TEMPERATURE CHANGE WITH HEIGHT (°C/100 m)
Extremely Unstable	A	>22.5°	<1.9
Moderately Unstable	B	17.5° to 22.5°	-1.9 to -1.7
Slightly Unstable	C	12.5° to 17.5°	-1.7 to -1.5
Neutral	D	7.5° to 12.5°	-1.5 to -0.5
Slightly Stable	E	3.8° to 7.5°	-0.5 to 1.5
Moderately Stable	F	2.1° to 3.8°	1.5 to 4.0
Extremely Stable	G	0° to 2.1°	>4.0

NOTE: σ_θ is the standard deviation of horizontal wind direction fluctuation over a period of 15 minutes to 1 hour.

TABLE 7.1-6

WIND SENSOR THRESHOLD

LOCATION	ANEMOMETER WIND SPEED (mph)	VANE WIND DIRECTION (mph)
Dresden	0.8	0.9
Quad Cities	0.6	0.8
Zion	0.5	0.7
LaSalle	0.5	0.7
Braidwood	0.8	0.8
Byron	0.8	0.8
Carroll County	0.5	0.7

TABLE 7.1-7

HORIZONTAL AND VERTICAL DISPERSION PARAMETERS*

Horizontal Dispersion Parameters, σ_y, meters**

$$\sigma_y = aR^b$$

R = downwind range, meters

STABILITY CLASS	a	b
A	0.3658	0.9031
B	0.2751	0.9031
C	0.2089	0.9031
D	0.1471	0.9031
E	0.1046	0.9031
F	0.0722	0.9031
G	0.0481	0.9031

Vertical Dispersion Parameters, σ_z, meters**

$$\sigma_z = aR^b+C$$

STABILITY CLASS	100 < R < 1000			R > 1000		
	a	b	c	a	b	c
A	0.00066	1.941	9.27	0.00024	2.094	- 9.6
B	0.0382	1.149	3.3	0.055	1.098	2.0
C	0.113	0.911	0.0	0.113	0.911	0.0
D	0.222	0.725	-1.7	1.26	0.516	-13.0
E	0.211	0.678	-1.3	6.73	0.305	-34.0
F	0.086	0.74	-0.35	18.05	0.18	-48.6
G	0.052	0.74	-0.21	10.83	0.18	-29.2

*From Reference 6.21.

**Values of σ_y and σ_z are also limited to a maximum of 1000 meters.

TABLE 7.1-8

WIND SPEED AND WIND DIRECTION CLASSES

Wind Direction Classes

WIND DIRECTION CLASS	(DEG)	N	WIND DIRECTION	GT	348.75	AND	LE	11.25
WIND DIRECTION CLASS	(DEG)	NNE	WIND DIRECTION	GT	11.25	AND	LE	33.75
WIND DIRECTION CLASS	(DEG)	NE	WIND DIRECTION	GT	33.75	AND	LE	56.25
WIND DIRECTION CLASS	(DEG)	ENE	WIND DIRECTION	GT	56.25	AND	LE	78.75
WIND DIRECTION CLASS	(DEG	E	WIND DIRECTION	GT	78.75	AND	LE	101.25
WIND DIRECTION CLASS	(DEG)	ESE	WIND DIRECTION	GT	101.25	AND	LE	123.75
WIND DIRECTION CLASS	(DEG)	SE	WIND DIRECTION	GT	123.75	AND	LE	146.25
WIND DIRECTION CLASS	(DEG)	SSE	WIND DIRECTION	GT	146.25	AND	LE	168.75
WIND DIRECTION CLASS	(DEG)	S	WIND DIRECTION	GT	168.75	AND	LE	191.25
WIND DIRECTION CLASS	(DEG)	SSW	WIND DIRECTION	GT	191.25	AND	LE	213.75
WIND DIRECTION CLASS	(DEG)	SW	WIND DIRECTION	GT	213.75	AND	LE	236.25
WIND DIRECTION CLASS	(DEG)	WSW	WIND DIRECTION	GT	236.25	AND	LE	258.75
WIND DIRECTION CLASS	(DEG)	W	WIND DIRECTION	GT	258.75	AND	LE	281.25
WIND DIRECTION CLASS	(DEG)	WNW	WIND DIRECTION	GT	281.25	AND	LE	303.75
WIND DIRECTION CLASS	(DEG)	NW	WIND DIRECTION	GT	303.75	AND	LE	326.25
WIND DIRECTION CLASS	(DEG)	NNW	WIND DIRECTION	GT	326.25	AND	LE	348.75

Wind Speed Classes

WIND SPEED CLASS	(MPH)	1	WIND SPEED	GE	0.0	AND	LT	ST*
WIND SPEED CLASS	(MPH)	2	WIND SPEED	GE	ST	AND	LE	3.5
WIND SPEED CLASS	(MPH)	3	WIND SPEED	GT	3.5	AND	LE	7.5
WIND SPEED CLASS	(MPH)	4	WIND SPEED	GT	7.5	AND	LE	12.5
WIND SPEED CLASS	(MPH)	5	WIND SPEED	GT	12.5	AND	LE	18.5
WIND SPEED CLASS	(MPH)	6	WIND SPEED	GT	18.5	AND	LE	24.5
WIND SPEED CLASS	(MPH)	7	WIND SPEED	GT	24.5	AND	LE	31.5
WIND SPEED CLASS	(MPH)	8	WIND SPEED	GT	31.5	AND	LE	38.5
WIND SPEED CLASS	(MPH)	9	WIND SPEED	GT	38.5	AND	LE	46.5
WIND SPEED CLASS	(MPH)	10	WIND SPEED	GT	46.5	AND	LE	99.8

* ST: Speed Threshold Value

TABLE 7.1-9

AIRBORNE ISOTOPE DATA

Isotope	Decay* Constant (1/hr) λ_i	Average Energy* Per Disintegration (Mev/dis) $\overline{E}_G$	$\overline{E}_B$	Linear Energy Absorption in air$^{\Delta}$ u_a (1/meter)	Linear Attenuation in air$^{\Delta}$ u (1/meter)	$K_i = \frac{u - u_a}{u_a}$	Tissue Energy Absorption Coeff.** u_t (cm^2/g)
Kr-83m	3.79E-1	2.58E-3	3.82E-2	37	37	0	4.87
Kr-85	7.38E-6	2.23E-3	2.51E-1	50	50	0	4.87
Kr-85m	1.55E-1	1.58E-1	2.55E-1	0.0033	0.017	4.15	0.0279
Kr-87	5.45E-1	8.04E-1	1.33	0.0037	0.0092	1.49	0.0318
Kr-88	2.44E-1	1.98	3.49E-1	0.0031	0.0058	0.87	0.0259
Kr-89	1.31E+1	1.71	1.31	0.0029	0.0054	0.86	0.0251
Kr-90	7.72E+1	1.26	1.3[illegible]	0.003	0.0056	0.87	0.0254
Xe-131^m	2.43E-3	2.00E-2	1.42E-1	0.065	0.09[illegible]	0.51	0.533
Xe-133	5.51E-[illegible]	4.60E-2	1.35E-1	0.0066	0.028	3.24	0.0566
Xe-133^m	1.32E-2	4.1[illegible]E-2	1.90E-1	0.0076	0.03	2.95	0.0674
Xe-135	7.63E-2	2.48E-1	3.17E-1	0.0036	0.015	3.17	0.0305
Xe-135^m	2.66E+0	4.31E-1	9.58E-2	0.0038	0.012	2.16	0.0326
Xe-137	1.09E+1	1.82E-1	1.78	0.0035	0.016	3.57	0.0293
Xe-138	2.93E+0	1.13	6.32E-1	0.0035	0.0075	1.14	0.0301
Ar-41	3.79E-1	1.28	4.64E-1	0.0034	0.0072	1.12	0.030

*Computed from data in Reference 6.8

**The Constants (u_t) were obtained from Radiation Dosimetry, Vol. I, Attix and Roesch, editors, 1968, Academic Press (Table XXII).

Δ Other values from Radiological Health Handbook, Revised Edition, January 1970.

TABLE 7.1-10

MAXIMUM PERMISSIBLE CONCENTRATION OF DISSOLVED OR ENTRAINED NOBLE GASES RELEASED FROM THE SITE TO UNRESTRICTED AREAS IN LIQUID WASTE

NUCLIDE	MPC(μCi/ml)*
Kr 85 m	2E-4
85	5E-4
87	4E-5
88	9E-5
Ar 41	7E-5
Xe 131 m	7E-4
133 m	5E-4
133	6E-4
135 m	2E-4
135	2E-4

*Computed from Equation 20 of ICRP Publication 2 (1959), adjusted for infinite cloud submersion in water, and R = 0.01 rem/week, ρ_w = 1.0 gm/cm^3, and P_w/P_t = 1.0.

TABLE 7.1-11

LISTING OF RADIOLOGICAL DECAY CONSTANTS (λ_i)$^{\Delta}$

ISOTOPE	DECAY CONSTANT λ_i (hrs^{-1})*
H-3	6.40E-6
C-14	1.38E-8
Na-24	4.62E-2
P-32	2.02E-3
Cr-51	1.04E-3
Mn-54	9.24E-5
Mn-56	2.69E-1
Fe-55	2.93E-5
Fe-59	6.47E-4
Co-58	4.08E-4
Co-60	1.50E-5
Ni-63	8.23E-7
Ni-65	2.75E-1
Cu-64	5.46E-2
Zn-65	1.18E-4
Zn-69	7.29E-1
Br-83	2.90E-1
Br-84	1.31E+0
Br-85	1.45E+1
Rb-86	1.55E-3
Rb-88	2.34E+0
Rb-89	2.74E+0
Sr-89	5.71E-4
Sr-90	2.77E-6
Sr-91	7.29E-2
Sr-92	2.56E-1
Y-90	1.08E-2
Y-91M	8.36E-1
Y-91	4.94E-4
Y-92	1.96E-1
Y-93	6.86E-2
Zr-95	4.51E-4
Zr-97	4.10E-2
Nb-95	8.21E-4
Mo-99	1.05E-2
Tc-99M	1.15E-1
Tc-101	2.93E+0
Ru-103	7.34E-4
Ru-105	1.56E-1

TABLE 7.1-11 (Cont'd)

ISOTOPE	DECAY CONSTANT λ_i (hrs^{-1})*
Ru-106	7.84E-5
Ag-110M	1.15E-4
Te-125M	4.98E-4
Te-127M	2.65E-4
Te-127	7.41E-2
Te-129M	8.59E-4
Te-129	5.97E-1
Te-131M	2.31E-2
Te-131	1.66E+0
Te-132	8.86E-3
I-130	5.61E-2
I-131	3.59E-3
I-132	3.01E-1
I-133	3.33E-2
I-134	7.90E-1
I-135	1.05E-1
Cs-134	3.83E-5
Cs-136	2.20E-3
Cs-137	2.62E-6
Cs-138	1.29E+0
Ba-139	5.03E-1
Ba-140	2.26E-3
Ba-141	2.28E+0
Ba-142	3.89E+0
La-140	1.72E-2
La-142	4.49E-1
Ce-141	8.88E-4
Ce-143	2.10E-2
Ce-144	1.02E-4
Pr-143	2.13E-3
Pr-144	2.41E+0
Nd-147	2.61E-3
W-187	2.90E-2
Np-239	1.23E-2
Sb-124	6.94E-4

* λ_i = Radiological Decay Constant
Ti = Radiological Half-life (from Reference 6.8)
$\lambda_i = .693 / Ti$
Δ For unlisted nuclides, see References 6.8 and 6.9.

TABLE 7.1-12

BIOACCUMULATION FACTORS TO BE USED IN THE ABSENCE OF SITE-SPECIFIC DATA (pCi/kg per pCi/liter)*

ELEMENT	FRESHWATER FISH
H	9.0E-01
C	4.[illegible]+03
Na	1.0E+02
P	1.0E+05
Cr	2.0E+02
Mn	4.0E+02
Fe	1.0E+02
Co	5.0E+01
Ni	1.0E+02
Cu	5.0E+01
Zn	2.0E+03
Br	4.2E+02
Rb	2.0E+03
Sr	3.0E+01
Y	2.5E+01
Zr	3.3E+00
Nb	3.0E+04
Mo	1.0E+01
Tc	1.5E+01
Ru	1.0E+01
Rh	1.0E+01
Te	4.0E+02
I	1.5E+01
Cs	2.0E+03
Ba	4.0E+00
La	2.5E+01
Ce	1.0E+00
Pr	2.5E+01
Nd	2.5E+01
W	1.2E+03
Np	1.0E+01
Ag	2.3E+00**

* Table A-1 of Reference 6.5.

** S. E. Thompson, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," UCRL-50564, Revision 1, 1972.

TABLE 7.1-13

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

NUCLIDE	BETA AIR DOSE FACTOR L_i (mrad/yr per $\mu Ci/m^3$)	BETA SKIN DOSE FACTOR $\bar{L}_i$ (mrem/yr per $\mu Ci/m^3$)	GAMMA AIR DOSE FACTOR X_i (mrad/yr per $\mu Ci/m^3$)	GAMMA WHOLE BODY DOSE FACTOR $\bar{X}_i$ (mrem/yr per $\mu Ci/m^3$)
Kr-83m	2.88E+02 **	---	1.93E+01	7.56E-02
Kr-85m	1.97E+03	1.46E+03	1.23E+03	1.17E+03
Kr-85	1.95E+03	1.34E+03	1.72E+01	1.61E+01
Kr-87	1.03E+04	9.73E+03	6.17E+03	5.92E+03
Kr-88	2.93E+03	2.37E+03	1.52E+04	1.47E+04
Kr-89	1.06E+04	1.01E+04	1.73E+04	1.66E+04
Kr-90	7.83E+03	7.29E+03	1.63E+04	1.56E+04
Xe-131m	1.11E+03	4.76E+02	1.56E+02	9.15E+01
Xe-133m	1.48E+03	9.94E+02	3.27E+02	2.51E+02
Xe-133	1.05E+03	3.06E+02	3.53E+02	2.94E+02
Xe-135m	7.39E+02	7.11E+02	3.36E+03	3.12E+03
Xe-135	2.46E+03	1.86E+03	1.92E+03	1.81E+03
Xe-137	1.27E+04	1.22E+04	1.51E+03	1.42E+03
Xe-138	4.75E+03	4.13E+03	9.21E+03	8.83E+03
Ar-41	3.28E+03	2.69E+03	9.30E+03	8.84E+03
Gr-999***	4.00E+03	4.00E+03	6.37E+03	5.43E+03

* From Table B-1 of Reference 6.5.
** 2.88E+02 = 2.88×10^2.
*** Parameters to assess a "gross" noble gas release, $\bar{E}_\gamma \sim 0.8$ MeV, $\bar{E}_\beta \sim 0.56$ MeV.

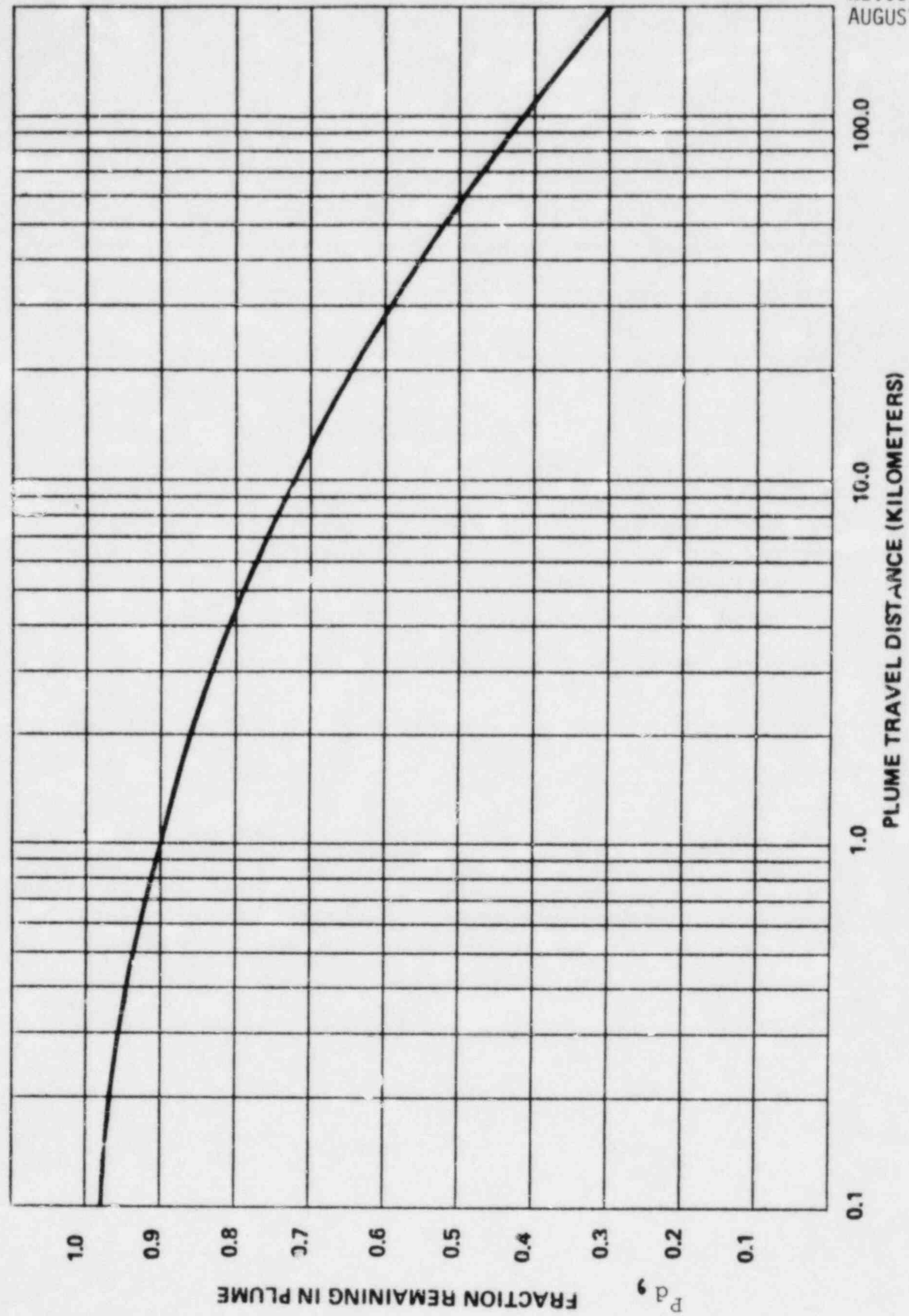


FIGURE 7.1-1

PLUME DEPLETION EFFECT FOR GROUND-LEVEL RELEASES
(ALL ATMOSPHERIC STABILITY CLASSES)
(FROM FIGURE 2 OF REFERENCE 6.4)

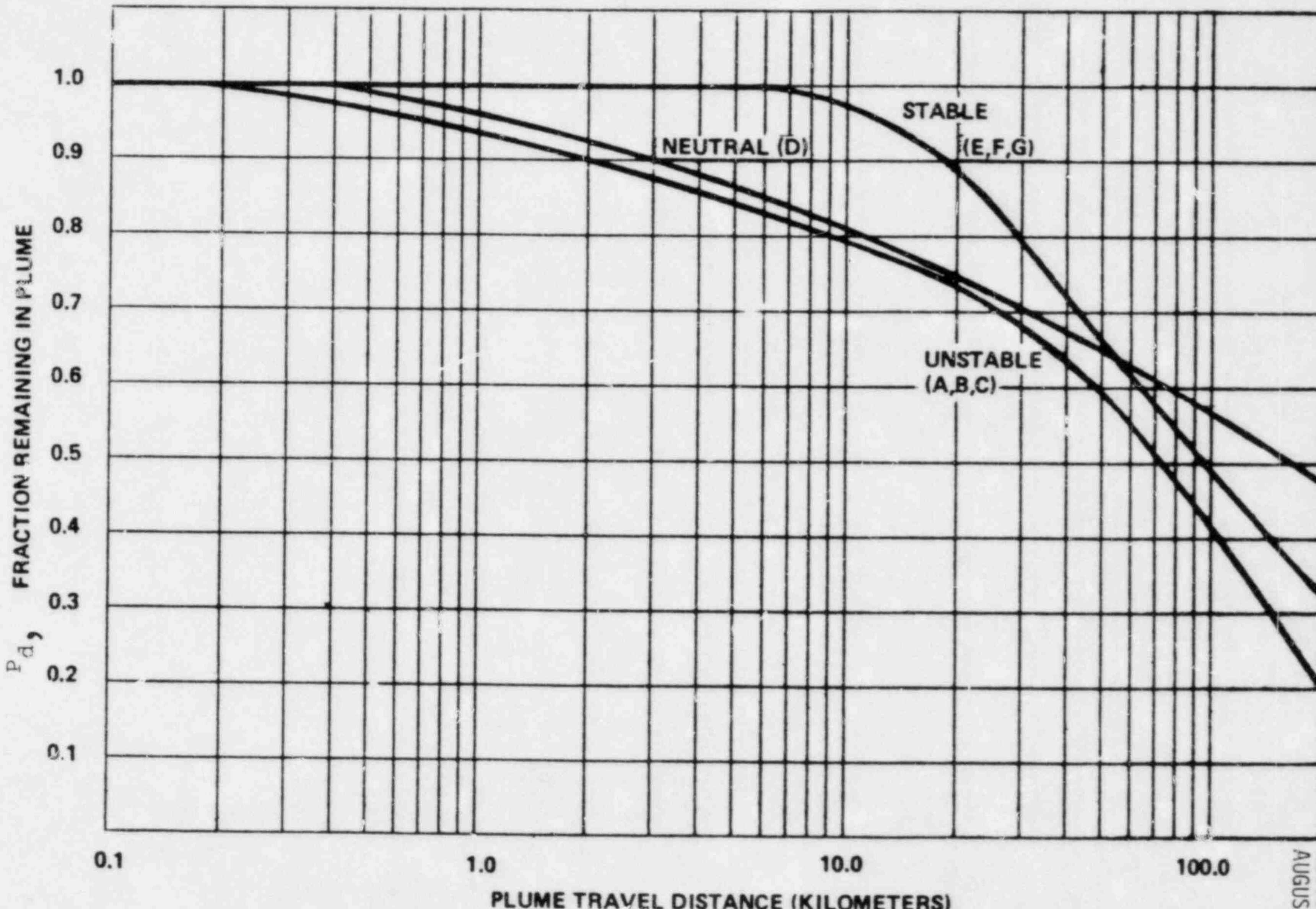


FIGURE 7.1-2

PLUME DEPLETION EFFECT FOR 30m RELEASES
(LETTERS DENOTE PASQUILL STABILITY CLASSES)
(FROM FIGURE 3 OF REFERENCE 6.4)

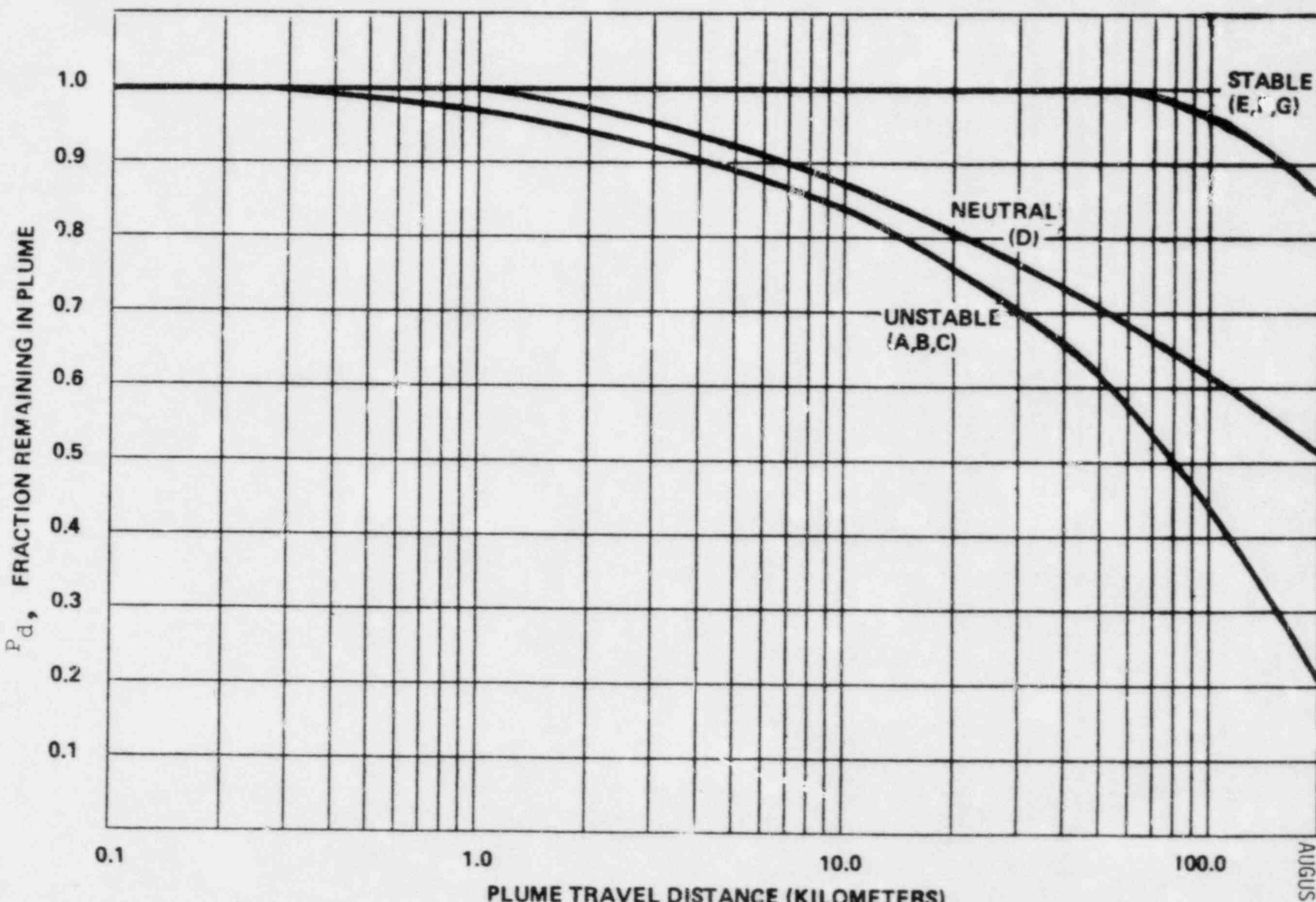


FIGURE 7.1-3

PLUME DEPLETION EFFECT FOR 60m RELEASES
(LETTERS DENOTE PASQUILL STABILITY CLASSES)
(FROM FIGURE 4 OF REFERENCE 6.4)

REVISION 2
AUGUST 1980

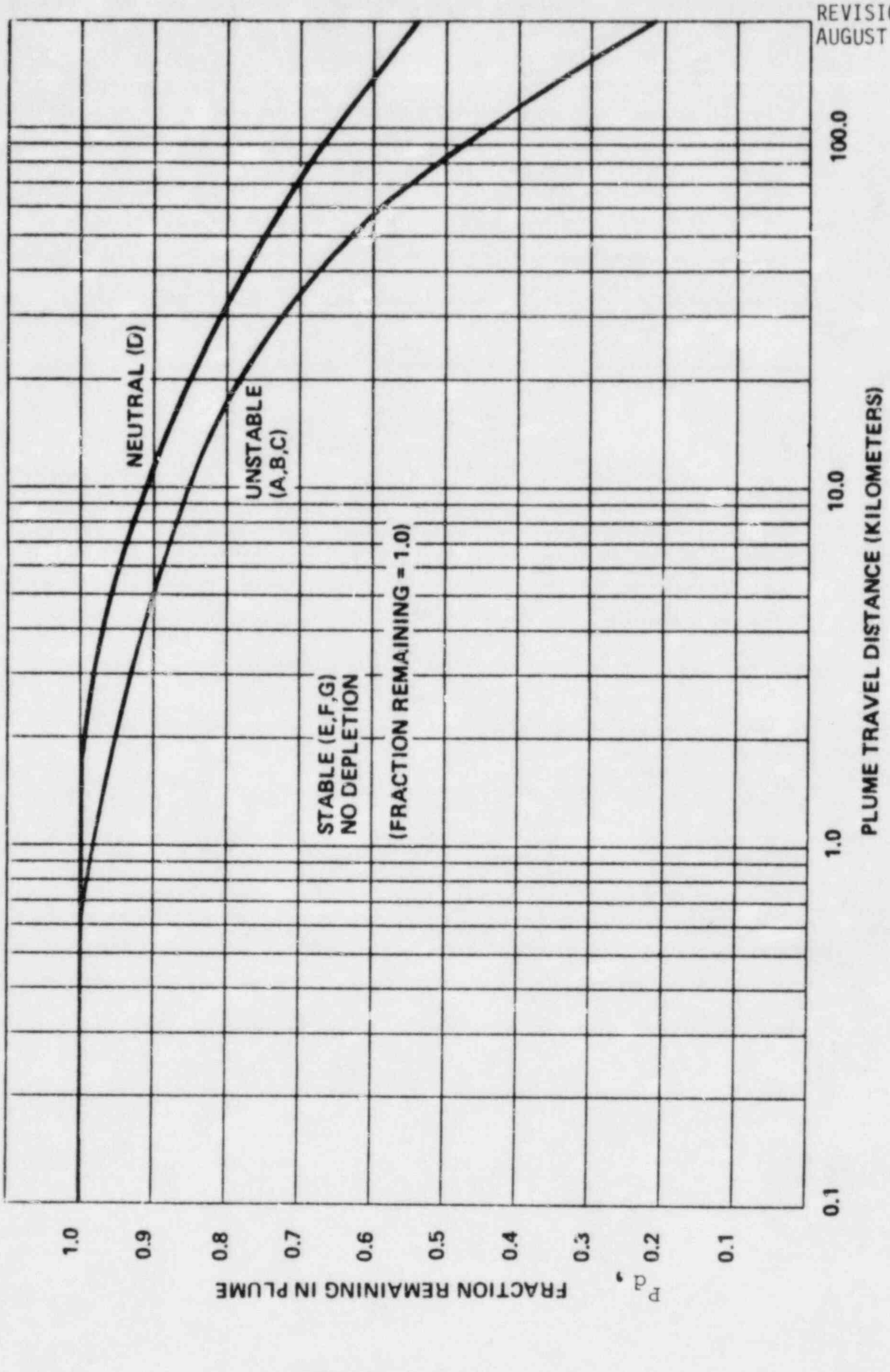


FIGURE 7.1-4

PLUME DEPLETION EFFECT FOR 100m RELEASES
(LETTERS DENOTE PASQUILL STABILITY CLASSES)
(FROM FIGURE 5 OF REFERENCE 6.4)

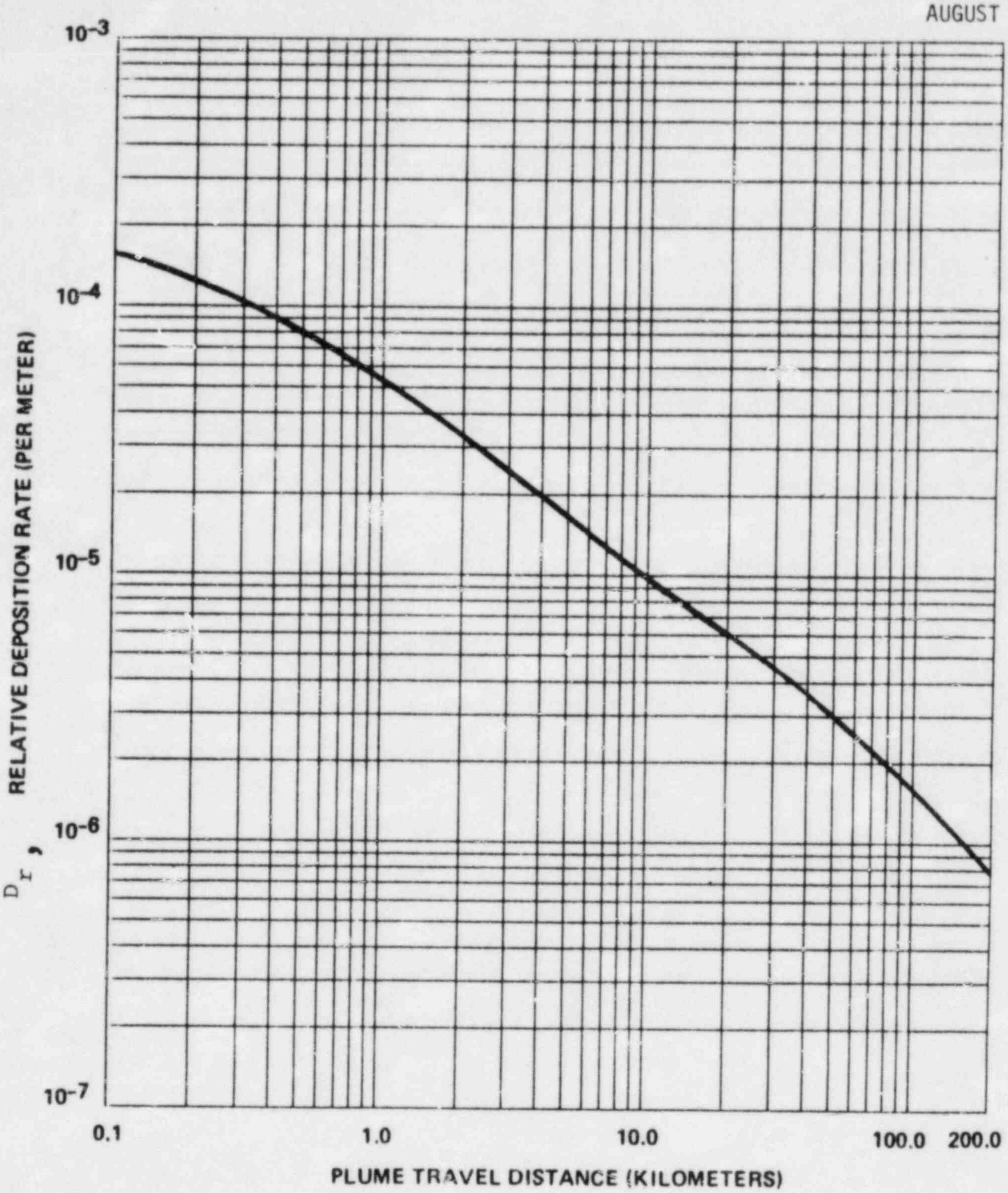


FIGURE 7.1-5

RELATIVE DEPOSITION FOR GROUND-LEVEL RELEASES
(ALL ATMOSPHERIC STABILITY CLASSES)
(FROM FIGURE 6 OF REFERENCE 6.4)

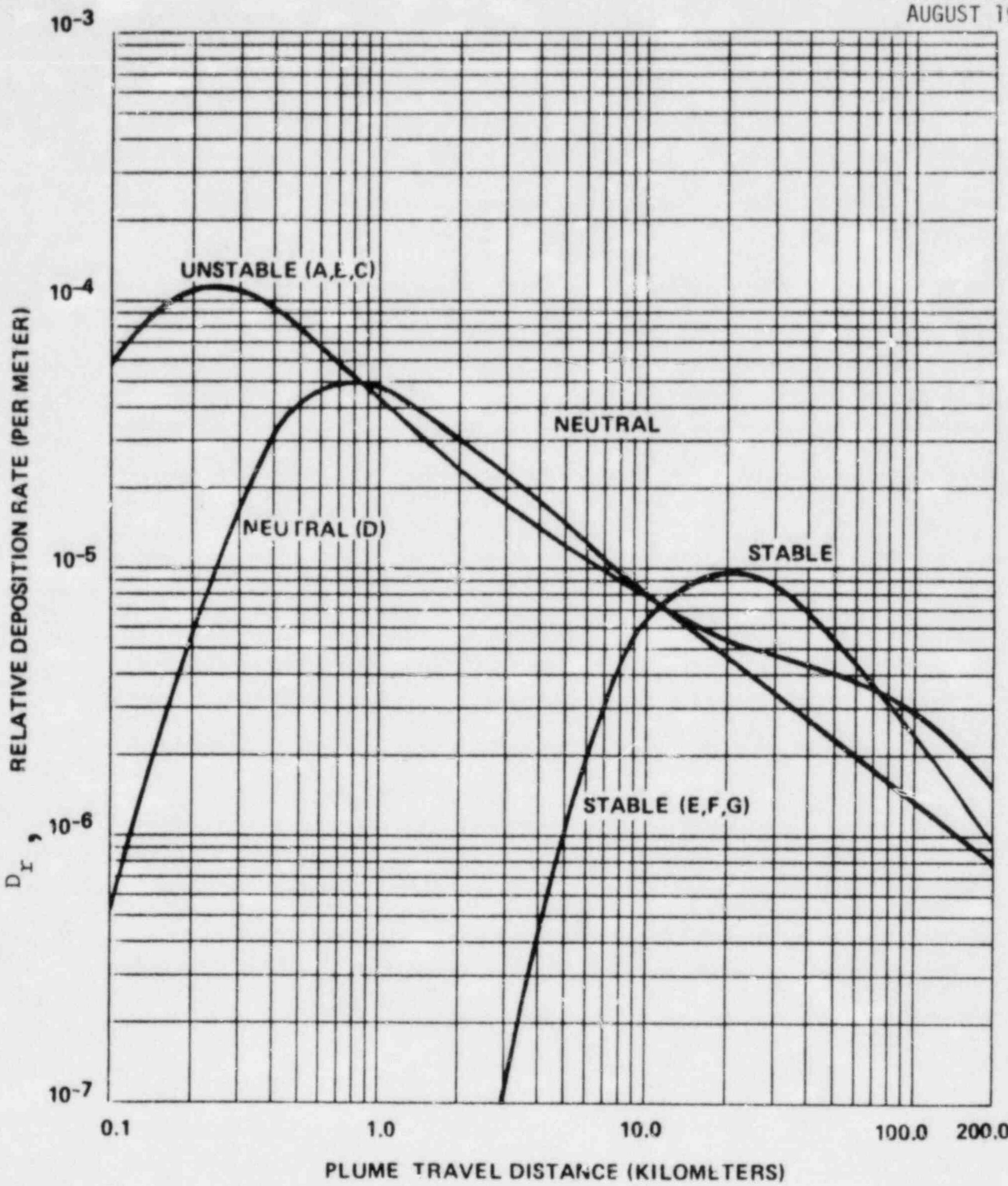


FIGURE 7.1-6

RELATIVE DEPOSITION FOR 30m RELEASES
(LETTERS DENOTE PASQUILL STABILITY CLASS)
(FROM FIGURE 7 OF REFERENCE 6.4)

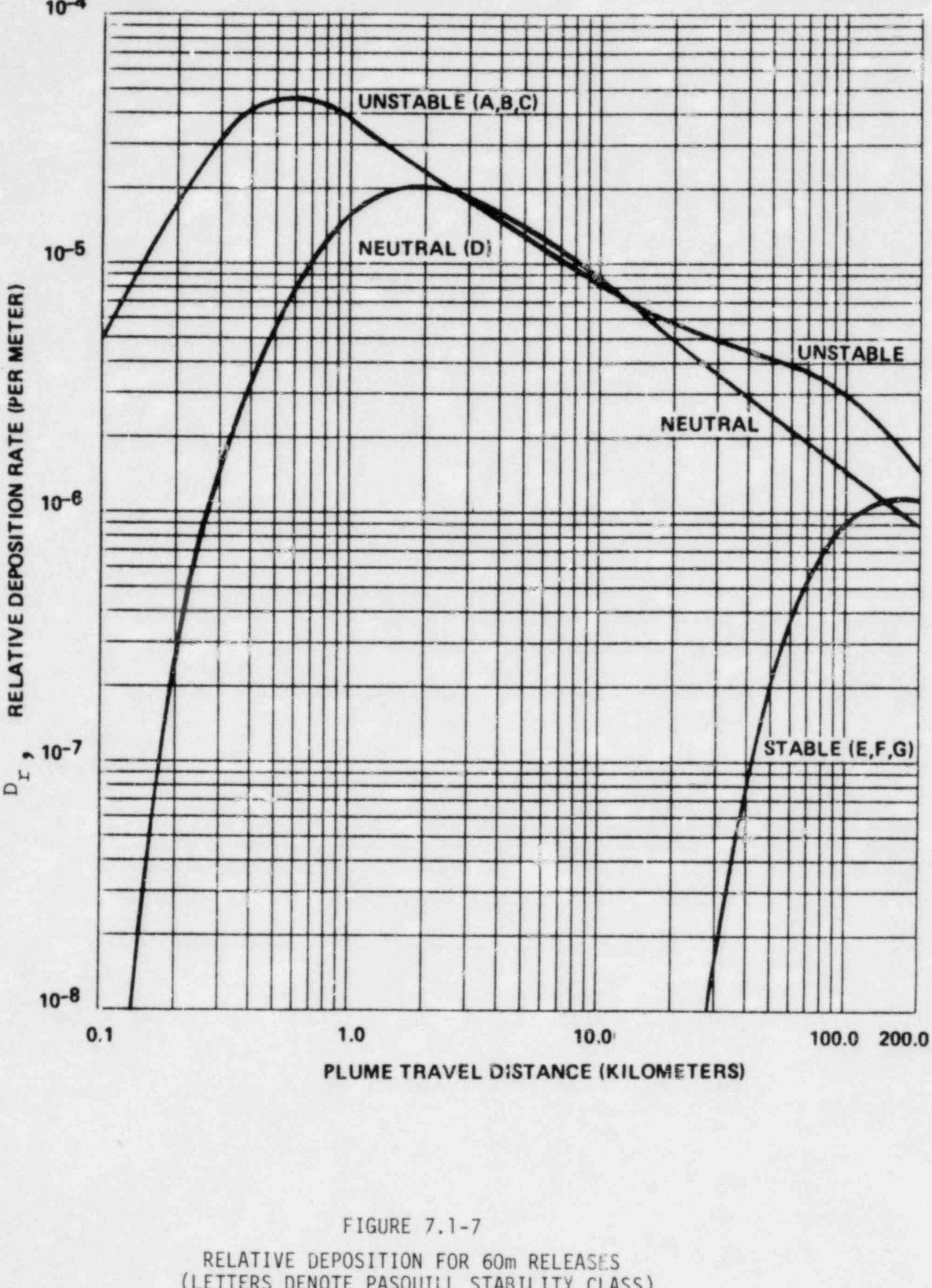


FIGURE 7.1-7

RELATIVE DEPOSITION FOR 60m RELEASES
(LETTERS DENOTE PASQUILL STABILITY CLASS)
(FROM FIGURE 8 OF REFERENCE 6.4)

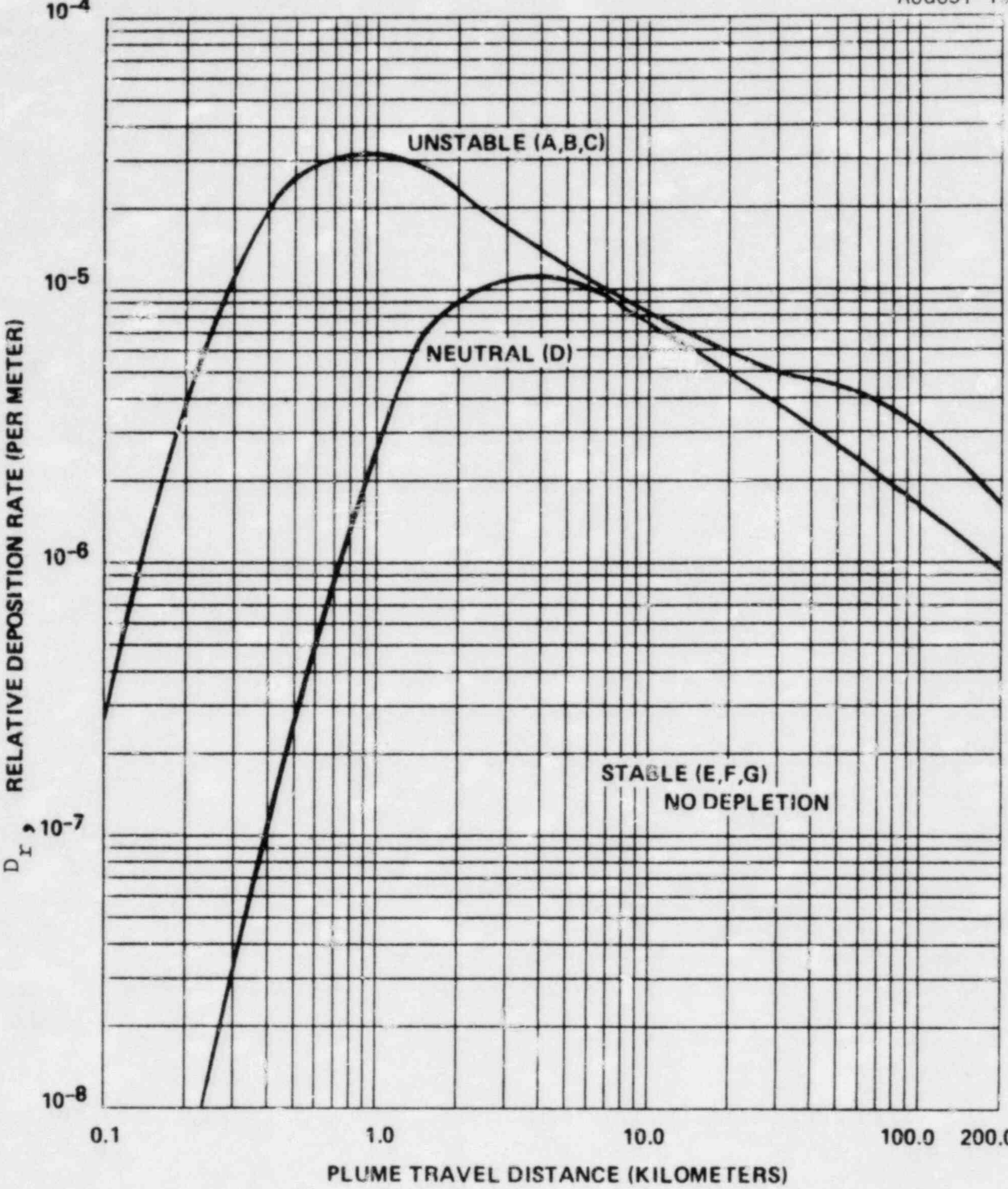


FIGURE 7.1-8

RELATIVE DEPOSITION FOR 100m RELEASES
(LETTERS DENOTE PASQUILL STABILITY CLASS)
(FROM FIGURE 9 OF REFERENCE 6.4)

LIST OF TABLES FOR SECTION 7.2

LIST OF FIGURES FOR SECTION 7.2

TABLE 7.2-1

AQUATIC ENVIRONMENTAL DOSE PARAMETERS

PARAMETER	BYRON
U^w, water usage, liters/hr	0.042
U^f, fish consumption, kg/hr	2.4×10^{-3}
$1/M^w$, $1/M^f$	1
F^w, cfs	5.2×10^{4}*
F^f, cfs	4.7×10^{3}
t^f, hr**	24
t^w, hr***	120

B_i - Regulatory Guide 1.109, Revision 1, October 1977, Table A-1, Column 2 for freshwater fish. See Table 7.1-12.

Parameter	
F^t, cfs	Not Applicable. No outdoor tanks without overflow pipes connected to other storage tanks.
F_o^w, cfs	
$1/M_o^w$	
t_o^w, hr	
V^t, gal	
t_o, hr	

---

* F^w = sum of average Mississippi River flow of 4.7×10^4 cfs plus the Rock River 5.0×10^3 cfs at Como, Illinois, 45 miles downstream. The average flow of the Rock River is 4.7×10^3 cfs at the site.

** t^f (hr) = 24 hr (all stations) for the fish ingestion pathway

*** t^w (hr) = 120 hr (distance to Mississippi River is approximately 120 miles; flow rate of 1 mph assumed)

TABLE 7.2-2

ANNUAL DESIGN OBJECTIVES SET BY 10 CFR 50,

APPENDIX I, FOR EACH REACTOR

TYPE OF DOSE	ANNUAL DESIGN OBJECTIVES
Airborne Releases	
Gamma Air Dose	10 mrad
Beta Air Dose	20 mrad
Whole Body Dose	5 mrem
Skin Dose	15 mrem
Infant Thyroid Dose	15 mrem
Liquid Releases	
Whole Body Dose	3 mrem
Thyroid Dose	10 mrem
Bone Dose	10 mrem
Skin Dose	10 mrem

TABLE 7.2-3

STATION CHARACTERISTICS

STATION: Byron

LOCATION: 3.7 miles SSW of Byron, Illinois

CHARACTERISTICS OF ELEVATED RELEASE POINT (NA)

1) Release Height = ______________ m   2) Diameter = ____________ m

3) Exit Speed = ______________ ms^{-1} 4) Heat Content = __________ $KCal\ s^{-1}$

CHARACTERISTICS OF VENT STACK RELEASE POINT

1) Release Height = 60.96 m   2) Diameter = 6.28 m

3) Exit Speed = 15.34 ms^{-1}

CHARACTERISTICS OF GROUND LEVEL RELEASE

1) Release Height = 0 m

2) Building Factor (D) = 60.6 m

METEOROLOGICAL DATA

A 250 ft. Tower is located 1036 m SW of elevated release point

---

Tower Data Used in Calculations

Release Point	Wind Speed and Direction	Differential Temperature
Elevated	(NA)	(NA)
Vent	250 ft	250 - 30 ft
Ground	30 ft	250 - 30 ft

TABLE 7.2-4

CRITICAL RANGES

DIRECTION	RESTRICTED AREA BOUNDARY* (m)	NEAREST** RESIDENT (m)	NEAREST DAIRY FARM RANGE*** (m)
N	1875	2240	----†
NNE	1829	2880	----†
NE	1585	1920	3058
ENE	1234	2080	2414
E	1227	1920	3862
ESE	991	2560	4989
SE	1006	2080	4828
SSE	800	1280	6437
S	945	1720	3701
SSW	975	960	3219
SW	1067	1280	----†
WSW	1212	2720	3219
W	1189	3040	4023
WNW	1227	3360	4989
NW	1128	1280	2253
NNW	1044	1920	----†

*FSAR Table 2.1-1a (Amendment 39, September 1982); ER Table 2.1-1 (Amendment 1, July 1981).

**Hazleton Environmental Sciences, Survey, December 27, 1982.

***Within 5 miles, ER Table 2.1-16 (Amendment 2, September 1981).

† Default range equal to 5 miles.

TABLE 7.2-5

TERRAIN CORRECTION FACTORS (h_t)*

(h_t = 0 to Stated Range, Then h_t = Given Value)

DIRECTION	RANGE (miles)	h_t (meters)
N	——	0.0
NNE	——	0.0
NE	——	0.0
ENE	——	0.0
E	9.0	3.0
ESE	——	0.0
SE	5.0	11.0
SSE	4.2	9.0
S	4.4	9.0
SSW	——	0.0
SW	5.0	9.0
WSW	6.5	12.0
W	7.6	14.0
WNW	——	0.0
NW	7.3	9.0
NNW	9.7	6.0

*Within 10 miles

TABLE 7.2-6

X/Q AND D/Q MAXIMA AT OR BEYOND THE UNRESTRICTED AREA BOUNDARY

DOWNWIND DIRECTION	ELEVATED(STACK) RELEASE RADIUS (METERS)	X/Q (SEC/M**3)	RADIUS (METERS)	D/Q (1/M**2)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	X/Q (SEC/M**3)	D/Q (1/M**2)	GROUND LEVEL RELEASE RADIUS (METERS)	X/Q (SEC/M**3)	D/Q (1/M**2)
N	1875.	9.557-08	1875.	9.680-10	1875.	2.102-07	1.666-09	1875.	1.007-06	4.937-09
NNE	1829.	1.083-07	1829.	1.048-09	1829.	1.683-07	1.582-09	1829.	9.936-07	4.682-09
NE	1585.	9.628-08	1585.	1.062-09	1585.	1.648-07	1.562-09	1585.	9.067-07	4.912-09
ENE	1609.	9.103-08	1234.	1.305-09	1234.	1.741-07	1.768-09	1234.	1.130-06	6.280-09
E	1400.	1.067-07	1227.	1.787-09	1227.	2.204-07	2.143-09	1227.	1.436-06	7.005-09
ESE	1400.	1.066-07	991.	2.199-09	991.	2.591-07	2.748-09	991.	1.706-06	9.462-09
SE	1500.	9.378-08	1006.	1.846-09	1006.	3.791-07	2.589-09	1006.	2.623-06	1.030-08
SSE	1500.	7.869-08	800.	1.558-09	800.	3.376-07	2.176-09	800.	2.622-06	1.146-08
S	1800.	6.347-08	945.	7.539-10	945.	1.775-07	1.377-09	945.	1.390-06	7.506-09
SSW	1609.	5.441-08	975.	8.453-10	975.	1.310-07	1.191-09	975.	9.962-07	5.632-09
SW	1609.	6.179-08	1067.	9.762-10	1067.	1.257-07	1.467-09	1067.	8.619-07	5.159-09
WSW	1609.	5.528-08	1212.	7.907-10	1212.	1.244-07	1.310-09	1212.	7.873-07	4.685-09
W	1609.	5.338-08	1189.	7.180-10	1189.	1.310-07	1.173-09	1189.	8.107-07	4.424-09
WNW	1400.	5.222-08	1227.	8.600-10	1227.	1.162-07	1.183-09	1227.	7.074-07	3.598-09
NW	1400.	5.652-08	1128.	1.028-09	1128.	1.380-07	1.405-09	1128.	8.763-07	4.804-09
NNW	1400.	8.117-08	1044.	1.591-09	1044.	2.769-07	2.540-09	1044.	1.492-06	8.173-09

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-6 (Cont'd)

BYRON 1&2

AVERAGE WIND SPEEDS FOR EACH RELEASE MODE

DOWNWIND DIRECTION	AVERAGE WIND SPEED (m/sec)		
	ELEVATED	MIXED MODE	GROUND LEVEL
N	7.6	6.6	4.5
NNE	7.4	6.6	4.7
NE	6.8	6.2	4.6
ENE	6.5	5.8	4.5
E	6.5	5.9	4.5
ESE	6.3	5.7	4.4
SE	6.0	5.4	4.0
SSE	6.0	5.2	3.9
S	5.9	5.2	4.1
SSW	6.0	5.4	4.0
SW	6.6	6.0	4.6
WSW	6.8	6.2	4.8
W	6.7	5.8	4.1
WNW	7.0	6.1	4.2
NW	7.0	6.0	3.9
NNW	7.2	6.2	4.2

TABLE 7.2-7

D/Q AT THE NEAREST MILK COW AND MEAT ANIMAL LOCATIONS WITHIN 5 MILES

DOWNWIND	NEAREST MILK COW D/Q(1/M**2)				NEAREST MEAT ANIMAL D/Q(1/M**2)			
DIRECTION	RADIUS (METERS)	ELEVATED RELEASE	MIXED RELEASE	GROUND RELEASE	RADIUS (METERS)	ELEVATED RELEASE	MIXED RELEASE	GROUND RELEASE
N	8045.	1.085-10	1.639-10	3.852-10	4667.	2.642-10	4.063-10	1.009-09
NNE	8045.	1.142-10	1.545-10	3.500-10	5150.	2.380-10	3.257-10	7.717-10
NE	3058.	4.693-10	6.152-10	1.570-09	3701.	3.478-10	4.573-10	1.128-09
ENE	2414.	6.255-10	7.321-10	1.983-09	2575.	5.743-10	6.682-10	1.770-09
E	3862.	4.274-10	4.455-10	9.650-10	2253.	9.275-10	9.791-10	2.472-09
ESE	4989.	2.699-10	2.962-10	5.818-10	5150.	2.566-10	2.813-10	5.496-10
SE	4828.	2.483-10	2.894-10	6.874-10	2575.	6.402-10	7.350-10	2.051-09
SSE	6437.	1.228-10	1.267-10	3.165-10	966.	1.406-09	1.752-09	8.483-09
S	3701.	1.632-10	2.121-10	7.181-10	3540.	1.749-10	2.268-10	7.757-10
SSW	3219.	2.282-10	2.471-10	7.214-10	2736.	2.867-10	3.113-10	9.581-10
SW	8045.	6.225-11	7.576-11	1.540-10	2414.	4.021-10	4.909-10	1.271-09
WSW	3219.	2.591-10	3.434-10	8.670-10	2736.	3.258-10	4.355-10	1.152-09
W	4023.	1.586-10	2.058-10	5.382-10	1126.	7.610-10	1.269-09	4.854-09
WNW	4989.	1.333-10	1.568-10	3.181-10	1287.	8.151-10	1.106-09	3.317-09
NW	2253.	4.738-10	5.492-10	1.469-09	2414.	4.317-10	4.961-10	1.301-09
NNW	8045.	9.382-11	1.156-10	2.351-10	2414.	6.107-10	7.736-10	1.941-09

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR KR 83M

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE			MIXED MODE(VENT) RELEASE			GROUND LEVEL RELEASE		
		RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	1.068-05	9.648-07	1875.	2.360-05	2.131-06	1875.	1.079-04	9.740-06
NNE	1829.	1829.	1.192-05	1.076-06	1829.	1.901-05	1.716-06	1829.	9.390-05	8.479-06
NE	1585.	1585.	1.074-05	9.697-07	1585.	1.846-05	1.667-06	1585.	9.516-05	8.593-06
ENE	1234.	1234.	1.132-05	1.022-06	1234.	2.034-05	1.836-06	1234.	1.229-04	1.110-05
E	1227.	1227.	1.281-05	1.157-06	1227.	2.482-05	2.241-06	1227.	1.536-04	1.387-05
ESE	991.	991.	1.432-05	1.[illegible]93-06	991.	3.026-05	2.733-06	991.	1.894-04	1.710-05
SE	1006.	1006.	1.251-05	1.130-06	1006.	4.172-05	3.767-06	1006.	2.811-04	2.539-05
SSE	800	800.	1.120-05	1.011-06	800.	3.735-05	3.372-06	800.	2.846-04	2.570-05
S	945.	945.	8.389-06	7.575-07	945.	2.134-05	1.927-06	945.	1.568-04	1.416-05
SSW	975.	975.	7.085-06	6.397-07	975.	1.572-05	1.420-06	975.	1.124-04	1.015-05
SW	1067.	1067.	8.135-06	7.346-07	1067.	1.503-05	1.357-06	1067.	9.529-05	8.605-06
WSW	1212.	1212.	6.862-06	6.196-07	1212.	1.470-05	1.327-06	1212.	8.648-05	7.809-06
W	1189.	1189.	6.732-06	6.079-07	1189.	1.549-05	1.399-06	1189.	9.002-05	8.129-06
WNW	1227.	1227.	5.640-06	[illegible].996-07	1227.	1.360-05	1.228-06	1227.	7.786-05	7.031-06
NW	1128.	1128.	7.413-06	6.694-07	1128.	1.635-05	1.476-06	1128.	9.772-05	8.824-06
NNW	1044.	1044.	1.074-05	9.694-07	1044.	3.265-05	2.948-06	1044.	1.696-04	1.531-05

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR KR 85M

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	1.731-04	9.137-05	1875.	2.312-04	1.209-04	1875.	6.971-04	3.601-04
NNE	1829.	1829.	1.929-04	1.018-04	1829.	2.179-04	1.143-04	1829.	6.266-04	3.240-04
NE	1585	1585.	1.809-04	9.554-05	1585.	2.117-04	1.111-04	1585.	6.368-04	3.293-04
ENE	1234.	1234.	2.207-04	1.168-04	1234.	2.398-04	1.259-04	1234.	7.650-04	3.948-04
E	1227.	1227.	2.297-04	1.214-04	1227.	2.644-04	1.385-04	1227.	9.340-04	4.814-04
ESE	991.	991.	2.964-04	1.569-04	991.	3.331-04	1.747-04	991.	1.103-03	5.681-04
SE	1006.	1006.	2.697-04	1.428-04	1006.	3.675-04	1.917-04	1006.	1.569-03	8.060-04
SSE	800.	800.	2.787-04	1.478-04	800.	3.457-04	1.806-04	800.	1.498-03	7.684-04
S	945.	945.	2.116-04	1.122-04	945.	2.348-04	1.232-04	945.	8.918-04	4.589-04
SSW	975.	975.	1.668-04	8.844-05	975.	1.800-04	9.449-05	975.	6.584-04	3.392-04
SW	1067.	1067.	1.795-04	9.508-05	1067.	1.803-04	9.473-05	1067.	5.698-04	2.937-04
WSW	1212.	1212.	1.345-04	7.119-05	1212.	1.579-04	8.276-05	1212.	5.225-04	2.694-04
W	1189.	1189.	1.363-04	7.215-05	1189.	1.653-04	8.663-05	1189.	5.437-04	2.803-04
WNW	1227.	1227.	1.280-04	6.773-05	1227.	1.442-04	7.557-05	1227.	4.705-04	2.426-04
NW	1128.	1128.	1.468-04	7.767-05	1128.	1.693-04	8.868-05	1128.	5.778-04	2.977-04
NNW	1044.	1044.	2.172-04	1.149-04	1044.	2.891-04	1.509-04	1044.	9.390-04	4.827-04

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR KR 85

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	2.036-06	1.260-06	1875.	2.723-06	1.686-06	1875.	7.846-06	4.857-06
NNE	1829.	1829.	2.270-06	1.405-06	1829.	2.598-06	1.608-06	1829.	7.093-06	4.390-06
NE	1585.	1585.	2.140-06	1.325-06	1585.	2.532-06	1.568-06	1585.	7.221-06	4.470-06
ENE	1234.	1234.	2.612-06	1.617-06	1234.	2.865-06	1.773-06	1234.	8.564-06	5.301-06
E	1227.	1227.	2.712-06	1.678-06	1227.	3.151-06	1.951-06	1227.	1.050-05	6.502-06
ESE	991.	991.	3.523-06	2.181-06	991.	3.971-06	2.458-06	991.	1.222-05	7.566-06
SE	1006.	1006.	3.204-06	1.983-06	1006.	4.330-06	2.680-06	1006.	1.749-05	1.082-05
SSE	800.	800.	3.322-06	2.057-06	800.	4.080-06	2.526-06	800.	1.654-05	1.024-05
S	945.	945.	2.530-06	1.566-06	945.	2.796-06	1.730-06	945.	9.827-06	6.083-06
SSW	975.	975.	1.989-06	1.231-06	975.	2.145-06	1.328-06	975.	7.266-06	4.498-06
SW	1067.	1067.	2.130-06	1.318-06	1067.	2.148-06	1.329-06	1067.	6.312-06	3.907-06
WSW	1212.	1212.	1.585-06	9.814-07	1212.	1.860-06	1.151-06	1212.	5.812-06	3.597-06
W	1189.	1189.	1.619-06	1.002-06	1189.	1.960-06	1.213-06	1189.	6.043-06	3.741-06
WNW	1227.	1227.	1.513-06	9.366-07	1227.	1.708-06	1.057-06	1227.	5.251-06	3.250-06
NW	1128.	1128.	1.733-06	1.073-06	1128.	1.999-06	1.238-06	1128.	6.410-06	3.968-06
NNW	1044.	1044.	2.568-06	1.590-06	1044.	3.374-06	2.089-06	1044.	1.032-05	6.390-06

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR KR 87

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	5.961-04	4.327-04	1875.	7.713-04	5.596-04	1875.	2.020-03	1.459-03
NNE	1829.	1829.	6.620-04	4.806-04	1829.	7.460-04	5.417-04	1829.	1.807-03	1.305-03
NE	1585.	1585.	6.270-04	4.551-04	1585.	7.268-04	5.278-04	1585.	1.848-03	1.335-03
ENE	1234.	1234.	7.768-04	5.640-04	1234.	8.465-04	6.151-04	1234.	2.256-03	1.629-03
E	1227.	1227.	8.045-04	5.841-04	1227.	9.119-04	6.623-04	1227.	2.713-03	1.958-03
ESE	991.	991.	1.053-03	7.646-04	991.	1.178-03	8.562-04	991.	3.265-03	2.357-03
SE	1006.	1006.	9.613-04	6.980-04	1006.	1.248-03	9.055-04	1006.	4.539-03	3.277-03
SSE	800.	800.	1.005-03	7.299-04	800.	1.214-03	8.819-04	800.	4.446-03	3.209-03
S	945.	945.	7.550-04	5.482-04	945.	8.365-04	6.079-04	945.	2.654-03	1.916-03
SSW	975.	975.	5.964-04	4.330-04	975.	6.421-04	4.666-04	975.	1.964-03	1.418-03
SW	1067.	1067.	6.390-04	4.639-04	1067.	6.471-04	4.703-04	1067.	1.696-03	1.225-03
WSW	1212.	1212.	4.785-04	3.474-04	1212.	5.538-04	4.021-04	1212.	1.555-03	1.123-03
W	1189.	1189.	4.779-04	3.469-04	1189.	5.759-04	4.182-04	1189.	1.620-03	1.170-03
WNW	1227.	1227.	4.526-04	3.286-04	1227.	5.040-04	3.660-04	1227.	1.388-03	1.002-03
NW	1128.	1128.	5.203-04	3.778-04	1128.	5.944-04	4.316-04	1128.	1.723-03	1.244-03
NNW	1044.	1044.	7.732-04	5.614-04	1044.	9.980-04	7.242-04	1044.	2.811-03	2.029-03

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR KR 88

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	1.463-03	1.122-03	1875.	1.915-03	1.466-03	1875.	5.038-03	3.836-03
NNE	1829.	1829.	1.629-03	1.249-03	1829.	1.856-03	1.423-03	1829.	4.538-03	3.456-03
NE	1585.	1585.	1.537-03	1.179-03	1585.	1.809-03	1.387-03	1585.	4.6[illegible]3-03	3.521-03
ENE	1234.	1234.	1.893-03	1.453-03	1234.	2.091-03	1.604-03	1234.	5.545-03	4.221-03
E	1227.	1227.	1.965-03	1.508-03	1227.	2.266-03	1.737-03	1227.	6.740-03	5.130-03
ESE	991.	991.	2.561-03	1.966-03	991.	2.906-03	2.228-03	991.	7.965-03	6.059-03
SE	1006.	1006.	2.334-03	1.792-03	1006.	3.087-03	2.364-03	1006.	1.123-02	8.540-03
SSE	800.	800.	2.426-03	1.863-03	800.	2.975-03	2.279-03	800.	1.078-02	8.193-03
S	945.	945.	1.835-03	1.410-03	945.	2.055-03	1.576-03	945.	6.429-03	4.890-03
SSW	975.	975.	1.448-03	1.112-03	975.	1.578-03	1.211-03	975.	4.760-03	3.621-03
SW	1067.	1067.	1.550-03	1.190-03	1067.	1.586-03	1.217-03	1067.	4.122-03	3.137-03
WSW	1212.	1212.	1.156-03	8.876-04	1212.	1.352-03	1.036-03	1212.	3.787-03	2.882-03
W	1189.	1189.	1.170-03	8.978-04	1189.	1.420-03	1.088-03	1189.	3.944-03	3.002-03
WNW	1227.	1227.	1.100-03	8.444-04	1227.	1.238-03	9.487-04	1227.	3.404-03	2.591-03
NW	1128.	1128.	1.263-03	9.695-04	1128.	1.455-03	1.115-03	1128.	4.196-03	3.193-03
NNW	1044.	1044.	1.874-03	1.439-03	1044.	2.432-03	1.862-03	1044.	6.779-03	5.155-03

BYRON SITE METEOROLOGICAL DATA 1/[illegible] - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR KR 89

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	[illegible].111-04	3.010-04	1875.	4.062-04	2.974-04	1875.	5.990-04	4.364-04
NNE	1829.	1829.	4.422-04	3.237-04	1829.	4.105-04	3.007-04	1829.	5.406-04	3.939-04
NE	1585.	1585.	4.341-04	3.178-04	1585.	4.221-04	3.093-04	1585.	6.219-04	4.532-04
ENE	1234.	1234.	6.185-04	4.529-04	1234.	5.854-04	4.292-04	1234.	9.721-04	7.080-04
E	1227	1227.	6.462-04	4.731-04	1227.	5.883-04	4.313-04	1227.	1.008-03	7.343-04
ESE	991.	991.	9.327-04	6.830-04	991.	8.838-04	6.482-04	991.	1.599-03	1.165-03
SE	1006.	1006.	8.489-04	6.216-04	1006.	8.077-04	5.923-04	1006.	1.616-03	1.177-03
SSE	800.	800.	9.994-04	7.319-04	800.	9.545-04	7.001-04	800.	2.238-03	1.630-03
S	945.	945.	6.409-04	4.693-04	945.	6.336-04	4.646-04	945.	1.433-03	1.043-03
SSW	975.	975.	5.305-04	3.885-04	975.	4.939-04	3.622-04	975.	1.049-03	7.640-04
SW	1067.	1067.	5.759-04	4.217-04	1067.	5.305-04	3.889-04	1067.	8.888-04	6.473-04
WSW	1212.	1212.	4.259-04	3.118-04	1212.	4.363-04	3.196-04	1212.	7.908-04	5.759-04
W	1189.	1189.	3.744-04	2.742-04	1189.	3.891-04	2.851-04	1189.	7.491-04	5.455-04
WNW	1227.	1227.	3.884-04	2.844-04	1227.	3.632-04	2.662-04	1227.	5.733-04	4.176-04
NW	1128.	1128.	4.680-04	3.427-04	1128.	4.492-04	3.292-04	1128.	8.016-04	5.839-04
NNW	1044.	1044.	7.275-04	5.327-04	1044.	7.938-04	5.812-04	1044.	1.573-03	1.145-03

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR KR 90

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	1.125-05	7.998-06	1875.	7.471-06	5.312-06	1875.	4.324-06	3.054-06
NNE	1829.	1829.	1.194-05	8.481-06	1829.	8.361-06	5.945-06	1829.	5.383-06	3.802-06
NE	1585.	1585.	1.460-05	1.038-05	1585.	1.163-05	8.268-06	1585.	9.069-06	6.405-06
ENE	1234.	1234.	3.604-05	2.562-05	1234.	2.752-05	1.957-05	1234.	2.745-05	1.938-05
E	1227.	1227.	4.020-05	2.857-05	1227.	3.081-05	2.190-05	1227.	3.305-05	2.334-05
ESE	991.	991.	8.655-05	6.154-05	991.	6.939-05	4.938-05	991.	7.290-05	5.146-05
SE	1006.	1006.	6.896-05	4.903-05	1006.	5.360-05	3.814-05	1006.	6.719-05	4.743-05
SSE	800	800.	1.246-04	8.864-05	800.	9.173-05	6.532-05	800.	1.368-04	9.654-05
S	945.	945.	5.623-05	3.999-05	945.	4.379-05	3.117-05	945.	6.024-05	4.250-05
SSW	975.	975.	4.486-05	3.190-05	975.	3.367-05	2.396-05	975.	3.851-05	2.717-05
SW	1067.	1067.	4.947-05	3.517-05	1067.	3.940-05	2.800-05	1067.	3.895-05	2.749-05
WSW	1212.	1212.	2.878-05	2.046-05	1212.	2.504-05	1.779-05	1212.	2.607-05	1.840-05
W	1189.	1189.	2.728-05	1.939-05	1189.	2.031-05	1.445-05	1189.	1.678-05	1.184-05
WNW	1227.	1227.	2.812-05	1.999-05	1227.	1.958-05	1.393-05	1227.	1.374-05	9.700-06
NW	1128.	1128.	3.999-05	2.844-05	1128.	2.696-05	1.919-05	1128.	1.820-05	1.285-05
NNW	1044.	1044.	7.876-05	5.601-05	1044.	5.964-05	4.241-05	1044.	4.889-05	3.450-05

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR XE131M

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	1.246-05	2.765-06	1875.	2.486-05	4.428-06	1875.	1.076-04	1.[illegible]28-05
NNE	1829.	1829.	1.390-05	3.085-06	1829.	2.061-05	3.925-06	1829.	9.491-05	1.450-05
NE	1585.	1585.	1.266-05	2.858-06	1585.	2.015-05	3.825-06	1585.	9.587-05	1.467-05
ENE	1234.	1234.	1.386-05	3.340-06	1234.	2.206-05	4.252-06	1234.	1.200-04	1.798-05
E	1227.	1227.	1.529-05	3.554-06	1227.	2.[illegible]69-05	4.907-06	1227.	1.516-04	2.245-05
ESE	991.	991.	1.790-05	4.420-06	991.	3.223-05	6.040-06	991.	1.817-04	2.663-05
SE	1006.	1006.	1.581-05	3.977-06	1006.	4.314-05	7.345-06	1006.	2.728-04	3.924-05
SSE	800.	800.	1.488-05	3.975-06	800.	3.820-05	6.675-06	800.	2.676-04	3.794-05
S	945.	945.	1.130-05	3.026-06	945.	2.253-05	4.237-06	945.	1.485-04	2.164-05
SSW	975.	975.	9.262-06	2.415-06	975.	1.677-05	3.205-06	975.	1.069-04	1.573-05
SW	1067.	1067.	1.036-05	2.632-06	1067.	1.612-05	3.147-06	1067.	9.124-05	1.352-05
WSW	1212.	1212.	8.352-06	2.022-06	1212.	1.541-05	2.870-06	1212.	8.326-05	1.237-05
W	1189.	1189.	8.405-06	2.053-06	1189.	1.626-05	3.022-06	1189.	8.633-05	1.284-05
WNW	1227.	1227.	8.095-06	1.941-06	1227.	1.428-05	2.642-06	1227.	7.531-05	1.118-05
NW	1128.	1128.	9.101-06	2.208-06	1128.	1.697-05	3.117-06	1128.	9.340-05	1.379-05
NNW	1044.	1044.	1.327-05	3.248-06	1044.	3.270-05	5.644-06	1044.	1.590-04	2.299-05

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR XE133M

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	3.363-05	1.394-05	1875.	5.333-05	1.932-05	1875.	1.943-04	6.113-05
NNE	1829.	1829.	3.752-05	1.556-05	1829.	4.741-05	1.800-05	1829.	1.731-04	5.498-05
NE	1585.	1585.	3.478-05	1.454-05	1585.	4.620-05	1.750-05	1585.	1.752-04	5.574-05
ENE	1234.	1234.	4.075-05	1.757-05	1234.	5.142-05	1.967-05	1234.	2.145-04	6.680-05
E	1227.	1227.	4.331-05	1.836-05	1227.	5.919-05	2.194-05	1227.	2.676-04	8.228-05
ESE	991.	991.	5.398-05	2.352-05	991.	7.295-05	2.740-05	991.	3.175-04	9.660-05
SE	1006.	1006.	4.861-05	2.135-05	1006.	8.827-05	3.089-05	1006.	4.672-04	1.392-04
SSE	800.	800.	4.869-05	2.190-05	800.	8.037-05	2.871-05	800.	4.516-04	1.323-04
S	945.	945.	3.706-05	1.669-05	945.	5.119-05	1.927-05	945.	2.580-04	7.798-05
SSW	975.	975.	2.955-05	1.317-05	975.	3.875-05	1.474-05	975.	1.877-04	5.737-05
SW	1067.	1067.	3.218-05	1.419-05	1067.	3.809-05	1.469-05	1067.	1.613-04	4.964-05
WSW	1212.	1212.	2.468-05	1.066-05	1212.	3.466-05	1.296-05	1212.	1.476-04	4.555-05
W	1189.	1189.	2.505-05	1.086-05	1189.	3.649-05	1.362-05	1189.	1.532-04	4.735-05
WNW	1227.	1227.	2.368-05	1.018-05	1227.	3.190-05	1.188-05	1227.	1.334-04	4.114-05
NW	1128.	1128.	2.695-05	1.165-05	1128.	3.763-05	1.394-05	1128.	1.645-04	5.042-05
NNW	1044.	1044.	3.966-05	1.722-05	1044.	6.793-05	2.403-05	1044.	2.741-04	8.213-05

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR XE133

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	3.840-05	1.340-05	1875.	5.939-05	1.898-05	1875.	2.194-04	6.492-05
NNE	1829.	1829.	4.286-05	1.496-05	1829.	5.269-05	1.731-05	1829.	1.959-04	5.833-05
NE	1585.	1585.	3.988-05	1.400-05	1585.	5.143-05	1.689-05	1585.	1.984-04	5.917-05
ENE	1234.	1234.	4.709-05	1.686-05	1234.	5.671-05	1.869-05	1234.	2.420-04	7.119-05
E	1227.	1227.	4.980-05	1.7[illegible]4-05	1227.	6.529-05	2.111-05	1227.	3.006-04	8.769-05
ESE	991.	991.	6.263-05	2.259-05	991.	8.019-05	2.611-05	991.	3.550-04	1.028-04
SE	1006.	1006.	5.653-05	2.049-05	1006.	[illegible].677-05	3.015-05	1006.	5.192-04	1.482-04
SSE	800.	800.	5.700-05	2.099-05	800.	8.759-05	2.759-05	800.	4.987-04	1.406-04
S	945.	945.	4.348-05	1.603-05	945.	5.614-05	1.829-05	945.	2.878-04	8.294-05
SSW	975.	975.	3.458-05	1.266-05	975.	4.257-05	1.397-05	975.	2.102-04	6.104-05
SW	1067.	1067.	3.747-05	1.362-05	1067.	4.193-05	1.389-05	1067.	1.812-04	5.290-05
WSW	1212.	1212.	2.855-05	1.024-05	1212.	3.836-05	1.248-05	1212.	1.660-04	4.857-05
W	1189.	1189.	2.899-05	1.042-05	1189.	4.030-05	1.309-05	1189.	1.724-04	5.046-05
WNW	1227.	1227.	2.729-05	9.752-06	1227.	3.529-05	1.145-05	1227.	1.500-04	4.385-05
NW	1128.	1128.	3.111-05	1.116-05	1128.	4.149-05	1.341-05	1128.	1.843-04	5.362-05
NNW	1044.	1044.	4.589-05	1.650-05	1044.	7.478-05	2.349-05	1044.	3.053-04	8.751-05

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR XE135M

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	2.796-04	1.722-04	1875.	3.384-04	2.079-04	1875.	8.143-04	4.977-04
NNE	1829.	1829.	3.068-04	1.890-04	1829.	3.264-04	2.007-04	1829.	7.058-04	4.315-04
NE	1585.	1585.	2.939-04	1.811-04	1585.	3.169-04	1.949-04	1585.	7.313-04	4.472-04
ENE	1234.	1234.	3.759-04	2.318-04	1234.	3.860-04	2.375-04	1234.	9.739-04	5.951-04
E	1227.	1227.	3.865-04	2.382-04	1227.	4.000-04	2.460-04	1227.	1.093-03	6.676-04
ESE	991.	991.	5.161-04	3.183-04	991.	5.411-04	3.329-04	991.	1.468-03	8.960-04
SE	1006.	1006.	4.750-04	2.930-04	1006.	5.507-04	3.383-04	1006.	1.848-03	1.127-03
SSE	800.	800.	5.132-04	3.167-04	800.	5.734-04	3.523-04	800.	2.056-03	1.254-03
S	945.	945.	3.686-04	2.275-04	945.	3.920-04	2.411-04	945.	1.245-03	7.597-04
SSW	975.	975.	2.949-04	1.820-04	975.	3.006-04	1.849-04	975.	9.205-04	5.619-04
SW	1067.	1067.	3.176-04	1.959-04	1067.	3.096-04	1.905-04	1067.	7.812-04	4.771-04
WSW	1212.	1212.	2.419-04	1.492-04	1212.	2.676-04	1.645-04	1212.	7.102-04	4.338-04
W	1189.	1189.	2.263-04	1.396-04	1189.	2.643-04	1.625-04	1189.	7.371-04	4.502-04
WNW	1227.	1227.	2.227-04	1.373-04	1227.	2.357-04	1.449-04	1227.	6.060-04	3.700-04
NW	1128.	1128.	2.585-04	1.594-04	1128.	2.829-04	1.739-04	1128.	7.847-04	4.791-04
NNW	1044.	1044.	3.874-04	2.390-04	1044.	4.860-04	2.984-04	1044.	1.358-03	8.285-04

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR XE135

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S	SBAR	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V	VBAR	GROUND LEVEL RELEASE RADIUS (METERS)	G	GBAR
			(MRAD/YR)/(UCI/SEC)			(MRAD/YR)/(UCI/SEC)			(MRAD/YR)/(UCI/SEC)	
N	1875.	1875.	2.405-04	1.297-04	1875.	3.197-04	1.721-04	1875.	9.558-04	5.129-04
NNE	1829.	1829.	2.681-04	1.446-04	1829.	3.023-04	1.628-04	1829.	8.615-04	4.624-04
NE	1585.	1585.	2.515-04	1.356-04	1585.	2.937-04	1.582-04	1585.	8.750-04	4.697-04
ENE	1234.	1234.	3.067-04	1.655-04	1234.	3.321-04	1.789-04	1234.	1.044-03	5.601-04
E	1227.	1227.	3.190-04	1.721-04	1227.	3.661-04	1.972-04	1227.	1.277-03	6.849-04
ESE	991.	991.	4.121-04	2.224-04	991.	4.604-04	2.480-04	991.	1.499-03	8.037-04
SE	1006.	1006.	3.749-04	2.024-04	1006.	5.064-04	2.724-04	1006.	2.135-03	1.144-03
SSE	800.	800.	3.875-04	2.092-04	800.	4.754-04	2.559-04	800.	2.025-03	1.085-03
S	945.	945.	2.948-04	1.591-04	945.	3.243-04	1.747-04	945.	1.208-03	6.479-04
SSW	975.	975.	2.322-04	1.253-04	975.	2.488-04	1.340-04	975.	8.930-04	4.789-04
SW	1067.	1067.	2.495-04	1.347-04	1067.	2.492-04	1.343-04	1067.	7.741-04	4.152-04
WSW	1212.	1212.	1.866-04	1.007-04	1212.	2.176-04	1.172-04	1212.	7.108-04	3.813-04
W	1189.	1189.	1.898-04	1.024-04	1189.	2.283-04	1.230-04	1189.	7.393-04	3.966-04
WNW	1227.	1227.	1.778-04	9.593-05	1227.	1.991-04	1.072-04	1227.	6.410-04	3.439-04
NW	1128.	1128.	2.038-04	1.100-04	1128.	2.333-04	1.257-04	1128.	7.849-04	4.210-04
NNW	1044.	1044.	3.015-04	1.627-04	1044.	3.966-04	2.134-04	1044.	1.270-03	6.806-04

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR XE137

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	ELEVATED(STACK) RELEASE S (MRAD/YR)/(UCI/SEC)	ELEVATED(STACK) RELEASE SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	MIXED MODE(VENT) RELEASE V (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	GROUND LEVEL RELEASE G (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	6.446-05	4.157-05	1875.	6.592-05	4.251-05	1875.	1.103-04	7.093-05
NNE	1829.	1829.	6.951-05	4.483-05	1829.	6.574-05	4.241-05	1829.	9.777-05	6.288-05
NE	1585.	1585.	6.795-05	4.382-05	1585.	6.656-05	4.294-05	1585.	1.097-04	7.055-05
ENE	1234.	1234.	9.459-05	6.101-05	1234.	8.954-05	5.779-05	1234.	1.663-04	1.069-04
E	1227.	1227.	9.821-05	5.335-05	1227.	8.967-05	5.787-05	1227.	1.718-04	1.105-04
ESE	991.	991.	1.392-04	8.980-05	991.	1.318-04	8.509-05	991.	2.672-04	1.718-04
SE	1006.	1006.	1.274-04	8.220-05	1006.	1.220-04	7.874-05	1006.	2.747-04	1.766-04
SSE	800.	800.	1.477-04	9.525-05	800.	1.416-04	9.140-05	800.	3.742-04	2.405-04
S	945.	945.	9.657-05	6.229-05	945.	9.542-05	6.158-05	945.	2.396-04	1.540-04
SSW	975.	975.	7.956-05	5.132-05	975.	7.406-05	4.780-05	975.	1.762-04	1.133-04
SW	1067.	1067.	8.635-05	5.570-05	1067.	7.944-05	5.126-05	1067.	1.488-04	9.566-05
WSW	1212.	1212.	6.460-05	4.167-05	1212.	6.650-05	4.290-05	1212.	1.335-04	8.585-05
W	1189.	1189.	5.686-05	3.667-05	1189.	6.009-05	3.876-05	1189.	1.295-04	8.323-05
WNW	1227.	1227.	5.870-05	3.786-05	1227.	5.565-05	3.591-05	1227.	9.980-05	6.416-05
NW	1128.	1128.	7.014-05	4.524-05	1128.	6.848-05	4.418-05	1128.	1.380-04	8.876-05
NNW	1044.	1044.	1.081-04	6.974-05	1044.	1.210-04	7.804-05	1044.	2.661-04	1.711-04

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR XE138

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	6.240-04	4.500-04	1875.	7.439-04	5.360-04	1875.	1.674-03	1.198-03
NNE	1829.	1829.	6.841-04	4.933-04	1829.	7.254-04	5.233-04	1829.	1.453-03	1.040-03
NE	1585.	1585.	6.543-04	4.719-04	1585.	7.055-04	5.091-04	1585.	1.503-03	1.076-03
ENE	1234.	1234.	8.415-04	6.071-04	1234.	8.693-04	6.278-04	1234.	2.004-03	1.434-03
E	1227.	1227.	8.652-04	6.242-04	1227.	8.955-04	6.465-04	1227.	2.238-03	1.601-03
ESE	991.	991.	1.159-03	8.362-04	991.	1.220-03	8.809-04	991.	3.025-03	2.163-03
SE	1006.	1006.	1.067-03	7.703-04	1006.	1.224-03	8.832-04	1006.	3.766-03	2.693-03
SSE	800.	800.	1.155-03	8.336-04	800.	1.288-03	9.298-04	800.	4.217-03	3.014-03
S	945.	945.	8.264-04	5.965-04	945.	8.839-04	6.382-04	945.	2.567-03	1.835-03
SSW	975.	975.	6.624-04	4.782-04	975.	6.789-04	4.903-04	975.	1.901-03	1.359-03
SW	1067.	1067.	7.136-04	5.150-04	1067.	7.000-04	5.055-04	1067.	1.613-03	1.154-03
WSW	1212.	1212.	5.430-04	3.917-04	1212.	5.991-04	4.322-04	1212.	1.466-03	1.048-03
W	1189.	1189.	5.063-04	3.653-04	1189.	5.893-04	4.251-04	1189.	1.520-03	1.087-03
WNW	1227.	1227.	4.997-04	3.605-04	1227.	5.270-04	3.802-04	1227.	1.246-03	8.911-04
NW	1128.	1128.	5.810-04	4.192-04	1128.	6.331-04	4.568-04	1128.	1.622-03	1.160-03
NNW	1044.	1044.	8.715-04	6.290-04	1044.	1.077-03	7.764-04	1044.	2.807-03	2.007-03

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76

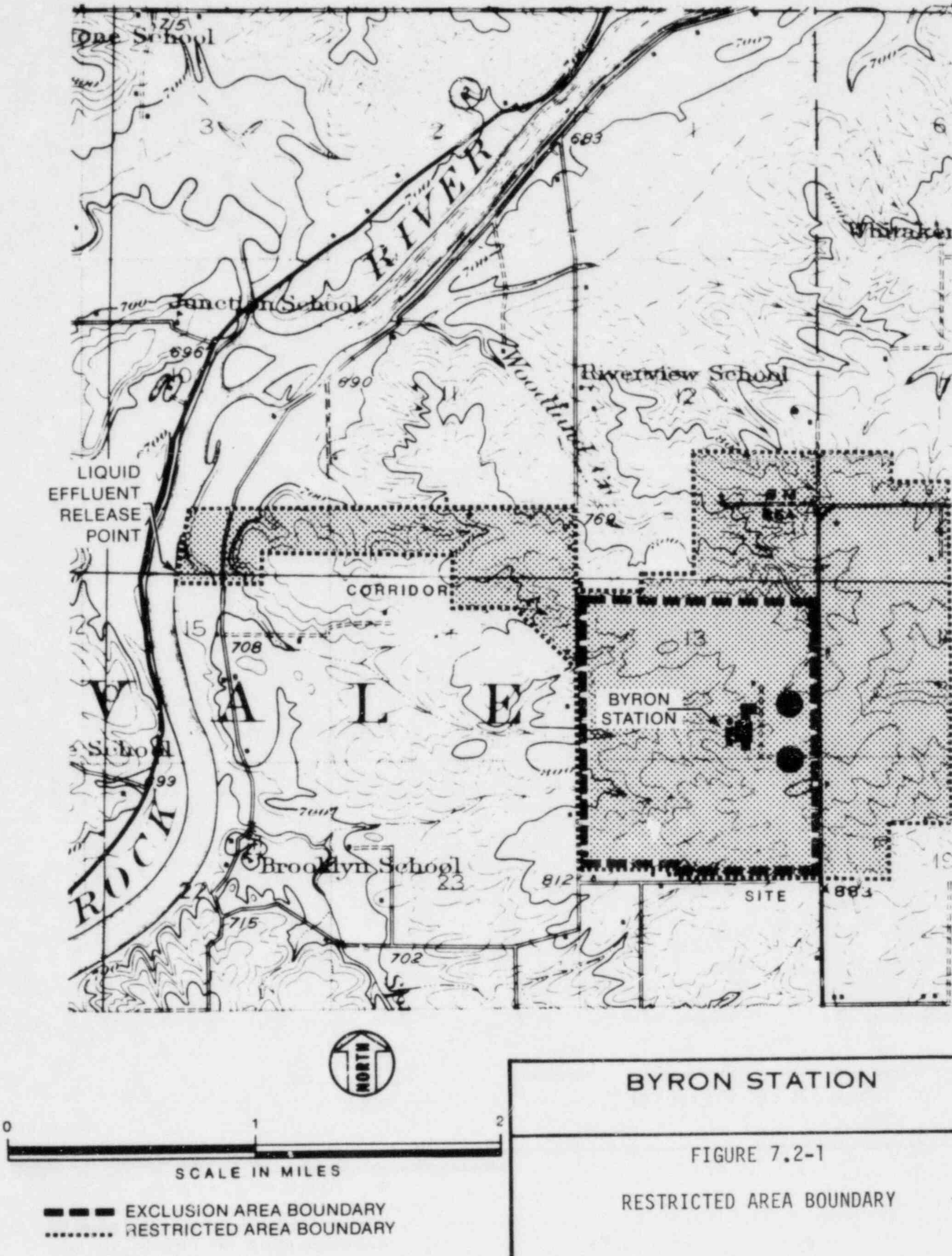
TABLE 7.2-8 (Cont'd)

BYRON 1&2

MAXIMUM OFFSITE FINITE PLUME GAMMA DOSE FACTORS FOR AR 41

DOWNWIND DIRECTION	RESTRICTED AREA BOUND (METERS)	ELEVATED(STACK) RELEASE RADIUS (METERS)	S (MRAD/YR)/(UCI/SEC)	SBAR (MRAD/YR)/(UCI/SEC)	MIXED MODE(VENT) RELEASE RADIUS (METERS)	V (MRAD/YR)/(UCI/SEC)	VBAR (MRAD/YR)/(UCI/SEC)	GROUND LEVEL RELEASE RADIUS (METERS)	G (MRAD/YR)/(UCI/SEC)	GBAR (MRAD/YR)/(UCI/SEC)
N	1875.	1875.	9.166-04	6.462-04	1875.	1.194-03	8.420-04	1875.	3.209-03	2.262-03
NNE	1829.	1829.	1.019-03	7.187-04	1829.	1.151-03	8.116-04	1829.	2.878-03	2.029-03
NE	1585.	1585.	9.617-04	6.780-04	1585.	1.121-03	7.903-04	1585.	2.936-03	2.070-03
ENE	1234.	1234.	1.186-03	8.362-04	1234.	1.299-03	9.155-04	1234.	3.564-03	2.512-03
E	1227.	1227.	1.232-03	8.687-04	1227.	1.406-03	9.914-04	1227.	4.311-03	3.039-03
ESE	991.	991.	1.602-03	1.130-03	991.	1.808-03	1.274-03	991.	5.133-03	3.619-03
SE	1006.	1006.	1.460-03	1.029-03	1006.	1.929-03	1.360-03	1006.	7.203-03	5.078-03
SSE	800.	800.	1.517-03	1.069-03	800.	1.863-03	1.313-03	800.	6.975-03	4.917-03
S	945.	945.	1.145-03	8.072-04	945.	1.281-03	9.034-04	945.	4.157-03	2.930-03
SSW	975.	975.	9.040-04	6.373-04	975.	9.832-04	6.931-04	975.	3.076-03	2.168-03
SW	1067.	1067.	9.698-04	6.837-04	1067.	9.888-04	6.971-04	1067.	2.663-03	1.877-03
WSW	1212.	1212.	7.269-04	5.125-04	1212.	8.472-04	5.973-04	1212.	2.445-03	1.724-03
W	1189.	1189.	7.302-04	5.148-04	1189.	8.847-04	6.237-04	1189.	2.547-03	1.795-03
WNW	1227.	1227.	6.903-04	4.867-04	1227.	7.726-04	5.447-04	1227.	2.190-03	1.544-03
NW	1128.	1128.	7.918-04	5.582-04	1128.	9.099-04	6.415-04	1128.	2.705-03	1.907-03
NNW	1044.	1044.	1.175-03	8.284-04	1044.	1.530-03	1.078-03	1044.	4.395-03	3.099-03

BYRON SITE METEOROLOGICAL DATA 1/74 - 12/76



BYRON STATION

FIGURE 7.2-1

RESTRICTED AREA BOUNDARY

8.0 RADIOACTIVE EFFLUENT TREATMENT SYSTEMS, MODELS FOR SETTING GASEOUS AND LIQUID EFFLUENT MONITOR ALARM AND TRIP SETPOINTS, AND ENVIRONMENT RADIOLOGICAL MONITORING

TABLE OF CONTENTS

8.0 RADIOACTIVE EFFLUENT TREATMENT SYSTEMS, MODELS FOR SETTING GASEOUS AND LIQUID EFFLUENT MONITOR ALARM AND TRIP SETPOINTS, AND ENVIRONMENTAL RADIOLOGICAL MONITORING

LIST OF TABLES

8.0 RADIOACTIVE EFFLUENT TREATMENT SYSTEMS, MODELS FOR SETTING GASEOUS AND LIQUID EFFLUENT MONITOR ALARM AND TRIP SETPOINTS, AND ENVIRONMENTAL RADIOLOGICAL MONITORING

LIST OF FIGURES

8.0 RADIOACTIVE EFFLUENT TREATMENT SYSTEMS, MODELS FOR SETTING GASEOUS AND LIQUID EFFLUENT MONITOR ALARM AND TRIP SETPOINTS, AND ENVIRONMENTAL RADIOLOGICAL MONITORING

8.1 GASEOUS RELEASES

8.1.1 System Design

8.1.1.1 Gaseous Radwaste Treatment System

A gaseous radwaste treatment system shall be any system designed and installed to reduce radioactive gaseous effluents by collecting primary coolant system off-gases from the primary system and providing for delay or holdup for the purpose of reducing the total radioactivity prior to release to the environment.

8.1.1.2 Ventilation Exhaust Treatment System

A ventilation exhaust treatment system shall be any system designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in effluents by passing ventilation or vent exhaust gases through charcoal adsorbers and/or HEPA filters for the purpose of removing iodines or particulates from the gaseous exhaust stream prior to the release to the environment (such a system is not considered to have any effect on noble gas effluents). Engineered Safety Feature (ESF) atmospheric cleanup systems are not considered to be ventilation exhaust treatment system components.

8.1.2 Alarm and Trip Setpoints

Alarm and trip setpoints of gaseous effluent monitors at the principal points of release of ventilation exhaust air

containing radioactivity are established to ensure that the release limits of 10 CFR 20 are not exceeded. The setpoints are found by solving Equations 2.9 and 2.10 for each class of releases.

For this equation, the radioactivity mixture in the exhaust air is assumed to have the composition of gases listed in Table 3.5-7 of the Environmental Report Operating License Stage. According to Subsection 3.5.3.4 of the report, releases of radionuclides in gaseous effluents were calculated using the PWR-GALE computer program and the parameters listed in Table 3.5-5.

Equation 2.9 is rewritten using the fractional composition of each nuclide, f_i, and a total release rate, Q_t, for station vent stack releases (the principal point of release of ventilation exhaust air containing radioactivity):

$$1.11 \sum_i \left[Q_{tv}(\bar{V}_i \times f_i) \right] < 500 \text{ mrem/yr} \qquad (8.1)$$

f_i Fractional Radionuclide Composition

The release rate of radionuclide i divided by the total release of all radionuclides.

Q_{tv} Total Release Rate, Vent Release (μCi/sec)

The release rate for all radionuclides due to a station vent stack release.

$$Q_{iv} = Q_{tv} f_i \qquad (8.2)$$

Equation 8.1 can be solved for Q_t for release limit determinations. Similarly, Equation 2.10 can be rewritten:

$$\sum_i \left[\bar{L}_i \, (\chi/Q)_v \, Q_{tv} \, f_i \exp\left(- \lambda_i R/3600 \, u_v\right) + 1.11 \, V_i \, Q_{tv} \, f_i \right] < 3000 \text{ mrem/yr} \qquad (8.3)$$

Equation 8.3 can be solved for Q_{tv} and a corresponding release limit can be determined. The most conservative release limit from Equations 8.1 and 8.3 will be used in selecting the appropriate alarm and trip setpoints for a vent release.

The exact settings will be selected to ensure that 10 CFR 20 limits are not exceeded.

Surveillance frequencies for gaseous effluent monitors will be as stated in Table 4.3-3 of the Technical Specifications. Calibration methods will be consistent with the definitions found in Section 1.0 of the Technical Specifications.

8.1.3 Station Vent Stack Monitor

Detectors 1RE-PR028 A, B, and C (air particulate, gas, and I_2 channels, respectively) and 2RE-PR028 A, B, and C monitor station stack effluent from the auxiliary building vent stacks of Units 1 and 2, respectively.

The two wide range monitors are installed on the auxiliary building vent stacks (final release points), one monitor per stack. The monitor has a range for radioactive gas concentration of 1 x 10^{-7} μCi/cc to 1 x 10^{5} μCi/cc. The monitor includes two isokinetic nozzles, one for normal conditions operating at 2 ft^3/min and one for high-range conditions operating at 0.06 ft^3/min; sampling rack; sample conditioner, operating only at high-range conditions to filter out large concentrations of radioiodine and particulates; and the wide-range gas detectors assembly, consisting of three radioactive gas detectors, a low-range detector, a mid-range detector, and a high-range detector.

In addition to the automatic isokinetic sampling system, additional features associated with these monitors include:

a. automatic grab sampling system,
b. tritium sampling system, and
c. low/high range gas monitors.

Each monitor system has a microprocessor which utilizes digital processing techniques to analyze data and control monitor functions. Control room readouts include a cathode ray tube display (RM-11), a recorder, and an RM-23 remote display module for all monitor parameters.

The monitor panels with associated pumps, detectors, and local controls, are located in the auxiliary building on the 477 ft and 463 ft elevations for Units 1 and 2, respectively.

A power supply unit furnishes the positive and negative voltages for the circuits, relays, and alarm lights and provides the high voltage for the detector. The power supply unit is located within the monitoring system cabinet. The monitors are powered from local 120-Vac instrumentation buses.

8.1.4 Containment Purge Effluent Monitors

Detectors 1RE-PR001 A, B, and C (air parti ulate, gas, and I_2 channels, respectively) and 2RE-P , B, and C monitor containment effluent for Units 1 an spectively.

The monitor has a range of radioactive gas concentration of 10^{-6} μCi/cc to 10^{-2} μCi/cc. High radiation is annunciated in the main control room.

Each monitor has a microprocessor which utilizes digital processing techniques to analyze data and control monitor functions. Control room readouts include a cathode ray

tube display (RM-11), a recorder, and an RM-23 remote display module for all monitor parameters.

The monitor panels and their associated pumps, detectors, and local controls, are located in the auxiliary building on the 451 ft elevation.

A power supply unit furnishes the positive and negative voltages for the circuits, relays, and alarm lights and provides the high voltage for the detector. The power supply unit is located within the monitoring system cabinet. The monitors are powered from local 120-Vac instrumentation buses.

8.1.5 Gas Decay Tank Monitors

Detectors 0RE-PR002 A and B (gas channel) monitor the radiation level of the gas decay tank discharge to the auxiliary building vent stack. Automatically, on high radiation and/or instrument failure signal from the detectors in the gas decay tank discharge, vent valve 0GWRCV014 between gas decay tanks 0GW01TA to 0GW01TF closes.

The monitor has a range for radioactive gas concentration of 10^{-6} μCi/cc to 10^{-2} μCi/cc. High radiation is annunciated in the main control room.

The monitor has a microprocessor which utilizes digital processing techniques to analyze data and control monitor functions. Control room readouts include a cathode ray tube display (RM-11), a recorder, and RM-23 remote display module for all monitor parameters.

The monitor panel and associated features, pumps, detectors, and local controls, are located in the auxiliary building on the 396 ft elevation.

A power supply unit furnishes the positive and negative voltages for the circuits, relays, and alarm lights and provides the high voltage for the detector. The power supply unit is located within the monitoring system cabinet. The monitor is powered from local 120-Vac instrumentation buses.

8.1.6 Radwaste Area Vent Exhaust

Detectors 0RE-PR026 A, B, and C (air particulate, gas, and I_2 channels, respectively) monitor the radwaste area vent exhaust. The radwaste area vent exhaust is ducted to the auxiliary building vent stack.

The monitor has a range for radioactive gas of 10^{-6} μCi/cc to 10^{-2} μCi/cc. High radiation is annunciated in the main control room.

The monitor has a microprocessor which utilizes digital processing techniques to analyze data and control monitor functions. Control room readouts include a cathode ray tube display (RM-11), a recorder, and an RM-23 remote display module for all monitor parameters.

The monitor panel and associated features, pumps, detectors, and local controls, are located in the auxiliary building on the 426 ft elevation.

A power supply unit furnishes the positive and negative voltages for the circuits, relays, and alarm lights and provides the high voltage for the detector. The power supply unit is located within the monitoring system cabinet. The monitor is powered from local 120-Vac instrumentation buses.

8.1.7 VR System Areas and Cubicles Ventilation Exhaust

Detectors 0RE-PR040 A, B, and C (air particulate, gas, and I_2 channels, respectively) monitor the ventilation exhaust from the volume reduction equipment areas and cubicles.

The radiation monitor is interlocked with the volume reduction ventilation exhaust fans 0VW10C and 0VW14C, associated bypass, and filter inlet and outlet dampers. Automatically on high radiation, the bypass dampers close and the fans start to route the exhaust through the filter unit. This system is interconnected with the radwaste building ventilation system.

8.1.8 SJAE/Gland Steam Exhaust

The steam jet air ejector (SJAE) monitor subsystem continually measures and records the gamma radiation in the off-gas as it is drawn from the main condenser by the steam jet air ejectors before it passes through the holdup line and carbon beds enroute to the station vent stacks.

Detectors 1RE-PR027 A, B, and C (air particulate, gas, and I_2 channels, respectively) and 2RE-PR027 A, B, and C monitor the off-gas system exhaust from Units 1 and 2, respectively. Automatically on high radiation in the off-gas exhaust stream, bypass valves and the off-gas vent filter system 0OG015 are energized.

The monitor has a microprocessor which utilizes digital processing techniques to analyze data and control monitor functions. Control room readouts include a cathode ray tube display (RM-11), a recorder, and an RM-23 remote display module for all monitor parameters. The monitor has a range for radioactive gas of 10^{-6} μCi/cc to 10^{-2} μCi/cc.

The monitor panel and associated features, pumps, detectors, and local controls, are located in the auxiliary building on the 401 ft elevation.

A power supply unit furnishes the positive and negative voltages for the circuits, relays, and alarm lights and provides the high voltage for the detector. The power supply unit is located within the monitoring system cabinet. The monitor is powered from local 120-Vac instrumentation buses.

8.1.9 Allocation of Effluents from Common Release Points

Radioactive gaseous effluents released from the auxiliary building, miscellaneous ventilation system, and the gas decay tanks are comprised of contributions from both units. Under normal operating conditions, it is difficult to apportion the radioactivity between the units. Consequently, allocation will normally be made evenly between units. During refueling outages or periods of known major in-plant leakage, the apportionment will be adjusted accordingly. The allocations of effluents will be estimated on a monthly basis.

8.1.10 Symbols Used in Section 8.1

SYMBOLS	NAME	UNIT
Q_{tv}	Total Release Rate, Vent Release	(μCi/sec)
$\overline{V}_i$	Gamma Whole Body Dose Constant, Vent Release	(mrad/yr per μCi/sec)
f_i	Fractional Radionuclide Composition	
$\overline{L}_i$	Beta Skin Dose Constant	(mrem/yr per $\mu Ci/m^3$)
$(\chi/Q)_v$	Relative Effluent Concentration, Vent Stack Release	(sec/m^3)
λ_i	Radiological Decay Constant	(hr^{-1})
R	Downward Range	(m)
u_v	Average Wind Speed, Vent Release	(m/sec)
Q_{iv}	Release Rate of Nuclide i, Vent Release	(μCi/sec)
V_i	Gamma Dose Constant, Vent Stack Release	(mrad/yr per μCi/sec)

8.1.11 Constants Used in Section 8.1

NUMERICAL VALUE	NAME	UNIT
1.11	Conversion Constant	(mrem/mrad)
3600	Conversion Constant	(sec/hr)

8.2 LIQUID RELEASES

8.2.1 System Design

A liquid radwaste treatment system shall be a system designed and installed to reduce radioactive liquid effluents by collecting the liquids, providing for retention or holdup, and providing for treatment by demineralizer or a concentrator for the purpose of reducing the total radioactivity prior to release to the environment.

8.2.2 Alarm Setpoints

Alarm setpoints of liquid effluent monitors at the principal release points are established to ensure that the limits of 10 CFR 20 are not exceeded in the unrestricted area. The concentration limit (C_{lim}) in the discharge line prior to dilution in the initial dilution stream is:

$$C_{lim} = MPC \left[\frac{F^{d}_{ave} + F^{r}_{max}}{F^{r}_{max}} \right] \qquad (8.4)$$

C_{lim} Limiting Concentration in Discharge Line (µCi/ml)

The maximum concentration in the discharge line permitted to be discharged to the initial dilution stream.

MPC Weighted Maximum Permissible Concentration (μCi/ml)

$$MPC = \frac{\sum_{i=1}^{n} C_i}{\sum_{i=1}^{n} \frac{C_i}{MPC_i}} \quad \text{or} \quad \frac{\sum_{i=1}^{n} A_i}{\sum_{i=1}^{n} \frac{A_i}{MPC_i}} \qquad (8.5)$$

where:

C_i = μCi/ml of nuclide i;

MPC_i = maximum permissible concentration μCi/ml of nuclide i; and

A_i = μCi of nuclide i released in time t.

F^r_{max} Maximum Flow Rate, Radwaste Discharge (ft^3/sec)

The maximum flow rate of radwaste from the discharge tank to the initial dilution stream.

F^d_{ave} Average Flow Rate Initial Dilution Stream (ft^3/sec

The average flow rate of the initial dilution stream which carries the radionuclides to the unrestricted area boundary.

Calibration methods will be consistent with the definitions found in Section 1.0 of the Technical Specifications.

8.2.3 Liquid Radwaste Effluent Monitor

Detector ORE-PR001 monitors liquid radwaste effluent and is interlocked with release tank discharge valve OWX353.

The release tank (OWX01T) holds 30,000 gallons and is located in the turbine building on the 401 ft elevation.

On high radiation in the liquid radwaste effluent, the release tank discharge valve is closed automatically. A high radiation level signal initiates automatic closure of the valve located in the component cooling surge tank vent line to prevent gaseous radiation release.

The monitor has a range for gamma radiation of 10^{-6} μCi/cc to 10^{-2} μCi/cc. The monitor panel and associated features are located in the turbine building on the 401 ft elevation.

The monitor has a microprocessor which utilizes digital processing techniques to analyze data and control monitor functions. Control room readouts include a cathode ray tube display (RM-11), a recorder, and an RM-23 remote display module for all monitor parameters.

A power supply unit furnishes the positive and negative voltages for the circuits, relays, and alarm lights and provides the high voltage for the detector. The power supply is located within the monitoring system cabinet. The monitor is powered from local 120-Vac instrumentation buses.

8.2.4 Component Cooling Water Monitors

Radiation detectors 1RE-PR009, 2RE-PR009, and 0RE-PR009 continuously monitor the component cooling system for leakage of reactor coolant from the reactor coolant system and/or the residual heat removal system.

Detector 1RE-PR009 is interlocked with the component cooling surge tank (1CC01T) vent valve 1CCRCV017, and detector 2RE-PR009 is interlocked with the component cooling surge tank (2CC01T)

vent valve 2CCRCV017. Detector 0RE-PR009 is interlocked with both vent valves, 1CCRCV017 and 2CCRCV017.

The component cooling surge tanks are located next to each other on the 426 ft elevation near the laundry room. They are each capable of holding 2,000 gallons.

The monitor has a range for gamma radiation of 10^{-6} μCi/cc to 10^{-2} μCi/cc. The monitor panels and associated features are located in the auxiliary building on the 364 ft elevation.

The monitor has a microprocessor which utilizes digital processing techniques to analyze data and control monitor functions. Control room readouts include a cathode ray tube display (RM-11), a recorder, and an RM-23 remote display module for all monitor parameters.

A power supply unit furnishes the positive and negative voltages for the circuits, relays, and alarm lights and provides the high voltage for the detector. The power supply is located within the monitoring system cabinet. The monitor is powered from local 120-Vac instrumentation buses.

8.2.5 Steam Generator Blowdown

Detectors 1RE-PR008 and 2RE-PR008 monitor steam generator blowdown for Units 1 and 2, respectively.

Steam generator blowdown sample flow is normally routed through the steam generator blowdown sample panel, 0PS01J, located on the 426 ft elevation in the chemistry hot lab, and on to the radiation monitor. Automatically on high radiation, detector 1RE-PR008 interlocks to close steam generator blowdown sample valves 1PS179A through D to terminate sample flow to the sample panel and radiation monitor.

A similar interlock exists between detector 2RE-PR008 and valves 2PS179A through D. Sequential isolation of steam generator blowdown can be used to determine which steam generator may be leaking.

The monitor has a range for gamma radiation of 10^{-6} μCi/cc to 10^{-2} μCi/cc. The monitor panels and associated features are located in the auxiliary building on the 426 ft elevation.

8.2.6 Blowdown Filters

The flow from the blowdown mixed-bed demineralizers is normally sent to the condensate storage tank. Detectors 0RE-PR016 through 19 are interlocked with the blowdown after-filter discharge valves 0WX119A through D and blowdown monitor tank inlet valves 0WX58A through D.

The two condensate storage tanks are located outside of the plant on the southeast corner. Each tank can hold 500,000 gallons. The three blowdown monitor tanks (0WX02T A, B, and C) are located on the 364 ft elevation. Each tank is capable of holding 20,000 gallons.

Automatically on high radiation, the flow from the blowdown mixed-bed demineralizers is redirected to the blowdown monitor tanks.

Monitors 0RE-PR016 and 0RE-PR017 are located in the auxiliary building on the 383 ft elevation. Monitors 0RE-PR018 and 0RE-PR019 are located in the auxiliary building on the 391 ft elevation. All four monitors have ranges for gamma radiation of 10^{-6} μCi/cc to 10^{-2} μCi/cc.

8.2.7 Administrative and Procedural Controls for Radwaste Discharges

Administrative and procedural controls have been designed to ensure proper control of radioactive liquid radwaste discharge in order to preclude a release in excess of 10 CFR 20 limits. The discharge rate for each batch is calculated by a technician and then independently verified by operating staff personnel. All liquid radwaste discharges will be from the release tank 0WX01T. On high radiation in the liquid radwaste effluent, the release tank discharge valve 0WX353 is closed automatically.

A documented valve checklist is prepared for each batch discharge. The proper valve lineup is made by the operator and rechecked by the radwaste foreman. The actual dischage is authorized by the shift engineer.

The system is equipped with a radiation trip point which alarms and initiates automatic valve closure on the radwaste discharge line to prevent the violation of 10 CFR 20 limits.

8.2.8 Determination of Initial Dilution Stream Flow Rates

For those release paths which have installed flow monitoring instrumentation, that instrumentation will be used to determine the flow rate of the initial dilution stream. This instrumentation will be operated and maintained as prescribed by the Technical Specifications. For those release paths which do not have installed flow monitoring instrumentation, flow rates will be determined by use of appropriate engineering data such as pump curves, differential pressures, or valve position indication.

8.2.9 Symbols Used In Section 8.2

SYMBOL	NAME	UNIT
C_{lim}	Limiting Concentration in Discharge Line	(μCi/ml)
MPC	Weighted Maximum Permissible Concentration	(μCi/ml)
C_i	Nuclide Concentration	(μCi/ml)
MPC_i	Maximum Permissible Concentration	(μCi/ml)
A_i	Nuclide Quantity Released	(μCi)
F^r_{max}	Maximum Flow Rate, Radwaste Discharge	(ft^3/sec)
F^d_{ave}	Average Flow Rate, Initial Dilution Stream	(ft^3/sec)

8.3 SOLIDIFICATION OF WASTE/PROCESS CONTROL PROGRAM

The process control program (PCP) shall contain the sampling, analysis, and formulation determination by which solidification of radioactive wastes from liquid systems is ensured.

8.4 ENVIRONMENTAL RADIOLOGICAL MONITORING

The environmental radiological monitoring program to be performed in the environs around Byron Station is given in Table 8.4-1 for the preoperational and first 2 years postoperational period. Table 8.4-2 describes the program for subsequent years.

Figure 8.4-1 shows the 8 fixed air sampling sites. Figure 8.4-2 shows the locations of the "inner ring" and "outer ring" TLD's (at an approximate distance of 5 miles from the station). The TLD's are code numbered as follows: XYY-N.

Where:

X = 1 means inner ring,

X = 2 means outer ring, and

YY-N is an identification code.

The practical lower limits of detection for this program are given in Table 8.4-3.

TABLE 8.4-1

RADIOLOGICAL MONITORING PROGRAM

(Preoperational and Two-Year Postoperational)

SAMPLE MEDIUM	TYPE AND FREQUENCY OF ANALYSIS*	COLLECTION SITES	FREQUENCY OF COLLECTING	NONROUTINE REPORTING LEVELS
1. Airborne				
a. Particulate Filter	Gross beta - W. Sr 89, 90 - Q. comp. Gamma Spec. - Q. comp.	Byron, Stillman Valley, Nearsite-East, Paines Point, Nearsite-South, Oregon, Mt. Morris, Leaf River	Continuous operation of a sampler for a week	Cs-134, 10 pCi/m^3 Cs-137, 20 pCi/m^3
b. Charcoal Cartridge	I-131	Same as for 1a	Continuous operation of a sampler for 2 weeks	0.9 pCi/m^3
2. TLD	Gamma Radiation	Same as for 1a, plus 40 other sites distributed near the site boundary and at 5 miles (see Figures 8.4-1 and 8.4-2) Minimum of 2 TLD's per packet	Quarterly	None
3. Surface Water	Sr-89, 90 - Q. comp. Gamma Spec. - M. comp. Gross beta - W. Tritium - Q. comp.	Woodland Creek, Rock River downstream of the station, Rock River upstream of the station	Weekly	**

TABLE 8.4-1 (Cont'd)

SAMPLE MEDIUM	TYPE AND FREQUENCY OF ANALYSIS*	COLLECTION SITES	FREQUENCY OF COLLECTING	NONROUTINE REPORTING LEVELS
4. Intake/Discharge pipes	Gross beta - W. Sr-89, 90 - M. comp. Tritium - M. comp. Gamma Spec. - M. comp.	I/D Pipes if pumping; if not pumping, collect in Rock River near I/D structures	Weekly	None
5. Precipitation	Gamma Spec. - Q. comp. Sr-89, 90 - Q. comp. Gross beta - M. Tritium - Q. comp.	Same four sites as milk collections	Monthly	None
6. Well Water: Offsite	Gamma Spec. Sr-89, 90 Gross beta Tritium	CECo Real Estate Office	Quarterly	**
7. Well Water: Onsite	Gamma Spec. - Q. comp. Sr-89, 90 - Q. comp. Gross beta - M. Tritium - Q. comp.	One onsite well (the one chosen for providing drinking water)	Monthly	**
8. Vegetables	Gross beta Sr-89, 90 Gamma Spec. I-131 (for green leafy vegetables only)	Farms within 10 miles	As available at harvest time	*
9. Cattle Feed and Grass	Gross beta Sr-89, 90 Gamma Spec.	Same four sites as milk collections	Quarterly: Grass: Summer Feed: Winter	None

TABLE 8.4-1 (Cont'd)

SAMPLE MEDIUM	TYPE AND FREQUENCY OF ANALYSIS*	COLLECTION SITES	FREQUENCY OF COLLECTING	NONROUTINE REPORTING LEVELS
10. Milk	Gamma Spec. Sr-89, 90 - M. I-131 (Pasture Season)	Four nearby dairies or private animals, including the nearest if possible	Monthly - November to April Weekly - May to October	Nuclide / pCi/l I-131 3 Cs-134 70 Cs-137 60 Ba/La-140 300
11. Sediment, Aquatic Plants	Gross beta Gamma Spec.	Just upstream of I/D structure Just downstream of I/D structure	Three times a year, if available	*
12. Fish	Gross beta Gamma Spec. Sr-89, 90	At discharge surface water sample site	Three times a year	*

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*If frequency of analysis is not given, it is the same as frequency of collection; W. - Weekly; M. - Monthly; Q. - Quarterly; Comp. - Composite.

*pCi/kg wet weight

Mn-54	3×10^4
Co-58	3×10^4
Zn-65	2×10^4
Cs-137	2×10^3
Fe-59	1×10^4
Co-60	1×10^4
Cs-134	1×10^3

** Nuclide	pCi/l	Nuclide	pCi/l
H-3	20,000	Zr-Nb-95	400
Mn-54	1,000	I-131	2
Fe-59	100	Cs-134	30
Co-58	600	Cs-137	50
Co-60	300	Ba/La-140	100
Zn-65	200		

TABLE 8.4-2

RADIOLOGICAL MONITORING PROGRAM

(Third Year and Later Operational Program)

SAMPLE MEDIA	COLLECTION SITE	TYPE OF ANALYSIS	FREQUENCY	NONROUTINE REPORTING LEVELS*
1. Air Monitoring	a. By-01 Byron By-02(a) Stillman Valley By-03 Nearsite-East By-04 Paines Point By-05 Nearsite-South By-06 Oregon By-07(a) Mt. Morris By-08(a) Leaf River	a. Filter - gross beta**	a. Continuous operation of a sampler for a week	Cs-134, 10; Cs-137, 20 pCi/m^3
		b. Charcoal - I-131	b. Continuous operation of a sampler for 2 weeks	0.9 pCi/m^3
		c. Sampling Train - Test and Maintenance	c. Weekly	Not Applicable
2. TLD	a. Same as Item 1, Air Monitoring Sites***	Gamma Radiation	Quarterly	None
	b. Plus 40 other sites distributed about the site boundary and at 5 miles***† (minimum of 2 TLD's per packet)			

TABLE 8.4-2 (Cont'd)

SAMPLE MEDIA	COLLECTION SITE	TYPE OF ANALYSIS	FREQUENCY	NONROUTINE REPORTING LEVELS*
3. Fish	By-12 Downstream	Gamma Isotopic	Semi-annual	pCi/kg wet weight Mn-54 3×10^4 Co-58 3×10^4 Zn-65 2×10^4 Cs-137 2×10^3 Fe-59 1×10^4 Co-60 1×10^4 Cs-134 1×10^3
4. Milk	a. Four nearby dairies or private animals including the nearest, if possible	I-131††	a. Weekly during grazing season, May to October	pCi/l I-131, 3 Cs-134, 70 Cs-137, 60 Ba-La-140, 300
			b. Monthly, November to April	Same as 4a
5. Surface Water	By-09 Woodland Creek By-12 Downstream By-13(a) Upstream	Gamma Isotopic	Monthly analysis of weekly composites	Nuclides — pCi/l H-3 20,000 Mn-54 1,000 Fe-59 100 Co-58 600 Co-60 300 Zn-65 200 Zr-Nb-95 400 I-131 2 Cs-134 30 Cs-137 50 Ba-La-140 100

TABLE 8.4-2 (Cont'd)

SAMPLE MEDIA	COLLECTION SITE	TYPE OF ANALYSIS	FREQUENCY	NONROUTINE REPORTING LEVELS*
6. Cooling Water Sample	a. Inlet ††† b. Discharge †††	Gross Beta	Weekly	None
7. Sediment	Downstream site	Gamma Isotopic	Annual	None

*Average concentration over calendar quarter.
**A gamma isotopic analysis shall be performed whenever the gross beta concentration in a sample exceeds by five times (5x) the average concentration of the preceding calendar quarter for the sample location.
***See Figure 8.4-1.
†See Figure 8.4-2.
††A gamma isotopic analysis shall be performed if I-131 from the plant is found above the LLD.
†††Provided by station personnel.

TABLE 8.4-3

PRACTICAL LOWER LIMITS OF DETECTION (LLD)

FOR ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

SAMPLE MEDIA	ANALYSIS	LLD (4.66σ)	UNITS
Airborne "Particulate"	Gross Beta*	0.01	pCi/m^3
	Gamma Isotopic	0.01	pCi/m^3
	Sr-89, 90	0.01	pCi/m^3
Airborne I-131	Iodine-131	0.10	pCi/m^3
Liquids	Sr-89	10	pCi/l
	Sr-90	2	pCi/l
	I-131	5**	pCi/l
	Cs-134	10	pCi/l
	Cs-137	10***	pCi/l
	Tritium	0.2	pCi/ml
	Gross Beta*	5	pCi/l
	Gamma Isotopic	<20	pCi/l/nuclide
Vegetation	Gross Beta*	2	pCi/g wet
	I-131	0.03	pCi/g wet
	Sr-89, 90	1	pCi/g wet
	Gamma Isotopic	0.2	pCi/g wet
Soil, Sediment	Gross Beta*	2	pCi/g dry
	Sr-89, 90	1	pCi/g dry
	Gamma Isotopic	0.2	pCi/g dry
Animal Tissue	Sr-89, 90	0.1	pCi/g wet
	I-131 - Thyroid	0.1	pCi/g wet
	Cs-134, 137	0.1	pCi/g wet
	Gross Beta*	1.0	pCi/g wet
	Gamma Isotopic	0.2	pCi/g wet

*Referenced to Cs-137.
**0.5 pCi/l on milk samples collected during the pasture season.
***5.0 pCi/l on milk samples.

TABLE 8.4-4

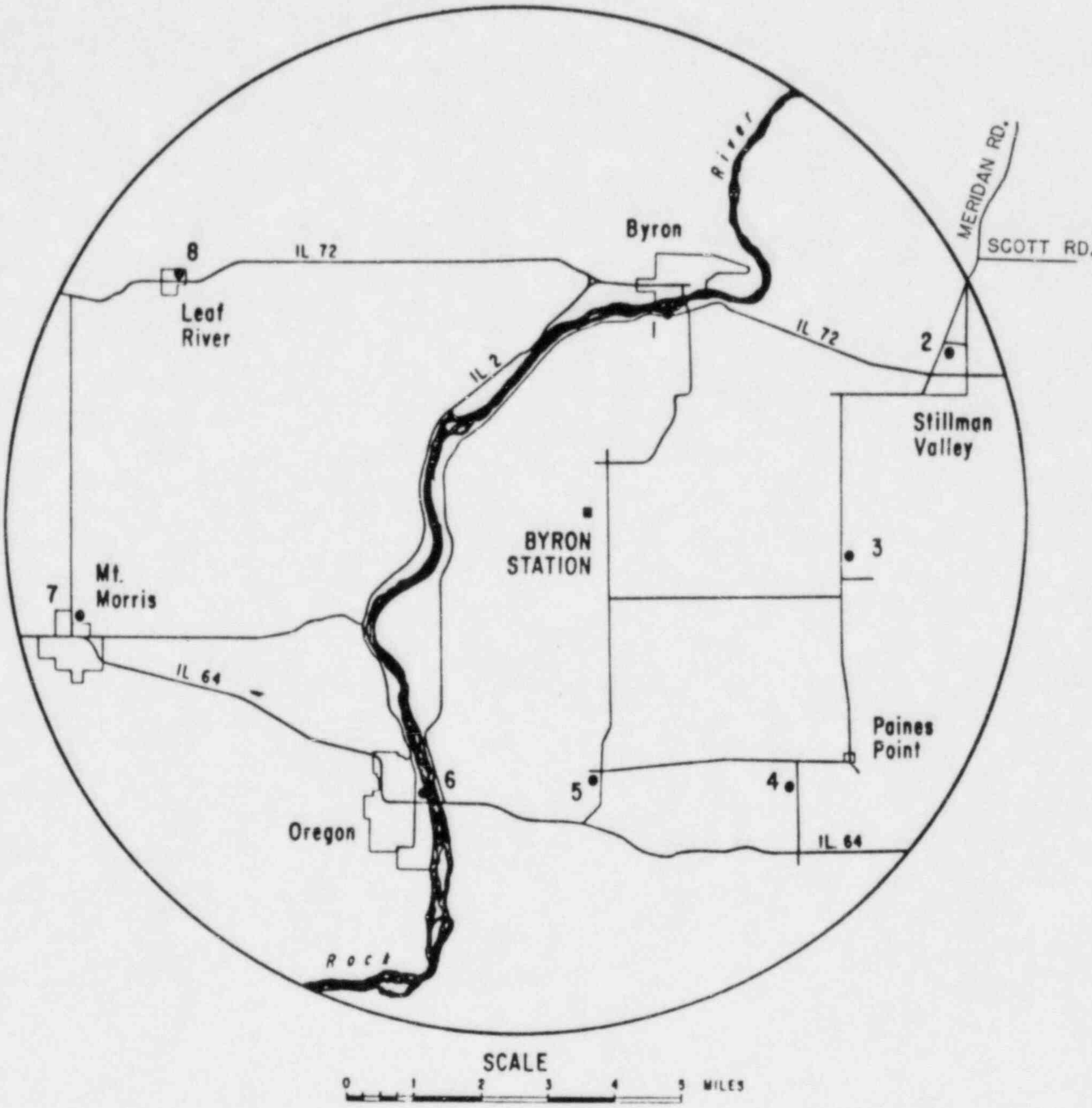
ENVIRONMENTAL RADIOLOGICAL MONITORING SAMPLING CODES

MONITORING SITES		AIR	TLD	SURFACE WATER	WELL WATER	FISH	AQUATIC PLANTS AND SEDIMENT	MILK	PRECIPITATION, FEED, GRASS	VEGETABLES
By-01	Byron	X	X							
By-02	Stillman Valley	X	X							
By-03	Nearsite-East	X	X							
By-04	Paines Point	X	X							
By-05	Nearsite-South	X	X							
By-06	Oregon	X	X							
By-07	Mt. Morris	X	X							
By-08	Leaf River	X	X							
By-09	Woodland Creek			X						
By-10	Intake Pipe			X						
By-11	Discharge Pipe			X						
By-12	Downstream			X			X			
By-12	Downstream (from Oregon Pool of Rock River)					X				
By-13	Upstream			X			X			
By-14	CECo Real Estate Office				X					
By-15	Groenhagen/Oltmann Dairy							X	X	
By-16	Ashelford Dairy Farm							X	X	
By-17	Bosecker/Lingre Dairy Farm							X	X	
By-18	Onsite Well				X					

REVISION 5
FEBRUARY 1983

TABLE 8.4-4 (Cont'd)

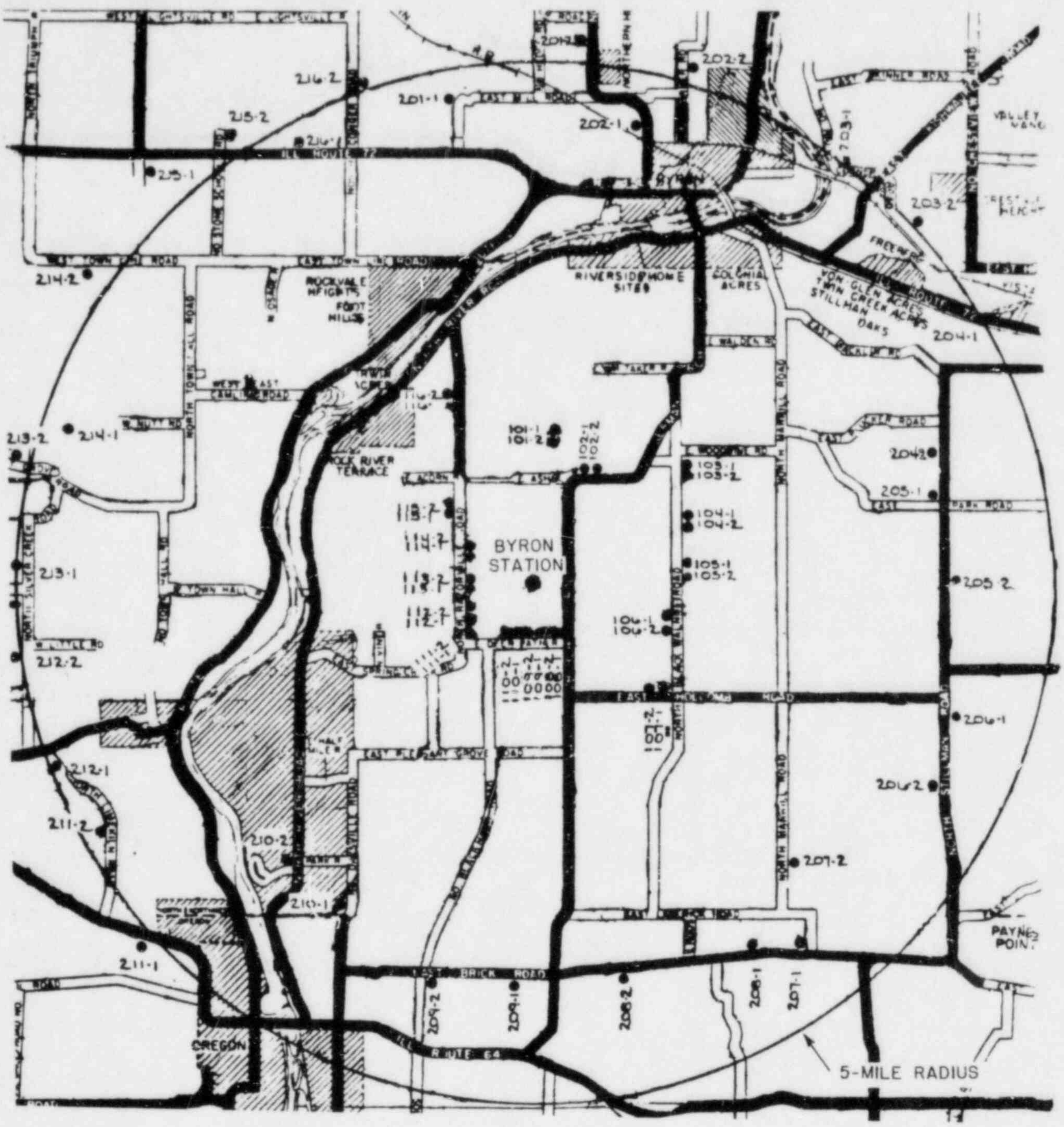
MONITORING SITES	AIR	TLD	SURFACE WATER	WELL WATER	FISH	AQUATIC PLANTS AND SEDIMENT	MILK	PRECIPITATION, FEED, GRASS	VEGETABLES
By-19-1 Oregon Stand									X
By-19-2 Oregon Stand									X
By-20 Meyers Dairy Farm							X	X	



BYRON STATION

FIGURE 8.4-1

FIXED AIR SAMPLING SITES



●=TLD

BYRON STATION

FIGURE 8.4-2

INNER RING AND
OUTER RING TLD LOCATIONS