OLD

H.B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
OFF-SITE DOSE CALCULATIONAL MANUAL
(ODCM)

Revision 1

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1.0 INTRODUCTION

The Off-Site Dose Calculation Manual (ODCM) provides the information and methodologies to be used by H. B. Robinson Steam Electric Plant Unit 2 (HBR) to assure compliance with Specifications 3.9.1, 3.9.2, 3.9.3, 3.9.4, 3.9.5, and 3.9.6 of the H. B. Robinson Technical Specification. These portions are those related to liquid and gaseous radiological effluents. They are intended to show compliance with 10CFR20, 10CFR50.36a, Appendix I of 10CFR50, and 40CFR190.

The ODCM is based on "Radiological Effluent Technical Specifications for PWRs (NUREG 0472, Rev. 3, Draft 7), "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants" (NUREG 0133), and guidance from the United States Nuclear Regulatory Commission (NRC). Specific plant procedures for implementation of this manual are presented in H. B. Robinson Unit 2 Plant Operating Manual. These procedures will be utilized by the operating staff of HBR to assure compliance with technical specifications.

The ODCM has been prepared as generically as possible in order to minimize the need for future revisions. However, some changes to the ODCM will be expected in the future. Any such changes will be properly reviewed and approved as indicated in the Administrative Control Section, Specification 6.16.2, of the HBR Technical Specifications.

2.0 LIQUID EFFLUENTS

2.1 MONITOR ALARM SETPOINT DETERMINATION

This methodology determines the monitor alarm setpoint that indicates if the concentration of radionuclides in the liquid effluent released from the site to unrestricted areas exceeds the concentrations specified in 10CFR20, Appendix B, Table II, Column 2, for radionuclides other than dissolved or entrained noble gases or exceeds a concentration 2×10^{-4} µCi/ml for dissolved or entrained noble gases. Two methodologies may be utilized to calculate monitor alarm setpoints. Section 2.1.1 determines a fixed setpoint based on the worst case assumptions that I-131 is the only nuclide being discharged. This is consistent with the limit of 10CFR20, Appendix B, Footnote 3.a. Section 2.1.2 methodology determines the setpoint based on the radionuclide mix via analysis prior to release to demonstrate compliance with 10CFR20, Appendix B, limits and may also be used as an alternative method for calculating setpoints.

2.1.1 Setpoint Based on Iodine-131

The following method applies to liquid releases via the discharge canal when determining the alarm/trip setpoint for the Waste Disposal System Effluent Monitor (RMS-18) and the Steam Generator Blowdown Monitor (RMS-19) during all operational conditions when the radwaste discharge flow rate is maintained constant. This methodology complies with Specification 3.9.1.1 of the RETS by satisfying the following equation:

$$\frac{cf}{F} \leq C$$

where:

C = The effluent concentration limit (Specification 3.9.1.1) implementing 10CFR20 for the site in µCi/ml.

c = The setpoint, in μCi/ml, of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release; the setpoint represents a value which, if exceeded, would result in concentrations exceeding the limits of 10CFR20 in the unrestricted area.

f = The waste effluent flow rate in gpm.

F = The dilution water flow rate in gpm.

2.1.1.1 Determine c (the effluent monitor setpoint) in μCi/ml for each of the dilution water flow rates.

where: $c = \frac{CF}{f}$

C = 3×10^{-7} μCi/ml, the effluent concentration limit based on 10CFR20, Appendix B, for I-131.

F = Dilution water flow rate (gpm).

= 160,000 gpm from one circulating water pump[1], Unit 2.
= 250,000 gpm from two circulating water pumps[1], Unit 2.
= 400,000 gpm from three circulating water pumps[1], Unit 2.

or

= 50,000 gpm from one circulating water pump[2], Unit 1.
= 80,000 gpm from two circulating water pumps[2], Unit 1.

f = The maximum acceptable discharge flow rate prior to dilution (gpm).

= 60 gpm for the Waste Disposal System Liquid Effluent Monitor[3].

- 750 gpm for the Steam Generator Blowdown Monitor.
- 450 gpm for the Steam Generator Blowdown Monitor while draining a steam generator.
- 390 gpm for the Condensate Polisher Liquid Waste Monitor.

2.1.1.2 Determine CR (calculated monitor count rate in corrected counts per minute [ccpm]). Attributed to the radionuclides for each of the dilution water flow rates.

$CR = (c)\ (E)$

E = The applicable effluent monitor efficiency located in the Plant Operating Manual, Volume 15, Curve Book. Use the radioactivity concentration "c" to find CR.

2.1.1.3 Determine SP (the monitor alarm/trip setpoint including background [cpm] for each of the dilution water flow rates.

$SP = (T_m CR + \text{Background})$

where: T_m = Fraction of the radioactivity from the site that may be released via the monitored pathway to ensure that the site boundary limit is not exceeded due to simultaneous releases from several pathways.

= .05 for the Waste Disposal System Liquid Effluent Monitor (RMS-18).

= .70 for the Steam Generator Blowdown Monitor (RMS-19).

= .25 for the Condensate Polisher Liquid Waste (RMC-37).

2.1.2 Setpoint Based on an Analysis of Liquid Prior to Discharge

The following method applies to liquid releases via the discharge canal when determining the alarm setpoint for the Waste Disposal System Liquid Effluent Monitor (RMS-18), the Steam Generator Blowdown Monitor (RMS-19), and the Condensate Polisher Liquid Waste Monitor (RMS-37) when an analysis of the activity of the principal gamma emitters has been made prior to each batch released.

2.1.2.1 Determine D (the minimum acceptable dilution factor):

$$D = S\sum_i \frac{C_i}{MPC_i}$$

$$C_i = \sum C_g + [C_a + C_s + C_t + C_{Fe-55}]$$

Radioactivity concentration of radionuclide "i" in the liquid effluent prior to dilution ($\mu Ci/ml$) from analysis of the liquid effluent to be released.

$\sum C_g$ = The sum of the concentrations of each measured gamma-emitting radionuclide observed by gamma spectroscopy.

C_a = The measured concentration of alpha-emitting radionuclides observed by gross alpha analysis of the monthly composite sample.

C_s = The measured concentration of Sr-89 and Sr-90 in liquid waste as determined by analysis of the quarterly composite sample.

C_t = The measured concentrations of H-3 in liquid waste as determined by analysis of the monthly composite sample.

C_{Fe-55} = The measured concentration of Fe-55 in liquid waste as determined by analysis of the quarterly composite sample.

MPC_i = The liquid effluent radioactivity limit for radionuclide "i" (μCi/ml) from 10CFR20, Appendix B.

S = 2, A safety factor used as a conservatism to assure that the radionuclide concentrations are less than the limits specified in 10CFR20, Appendix B, at the point of discharge.

2.1.2.3 Determine c (the monitor setpoint concentration [μCi/ml] attributed to the radionuclides for the dilution water flow rate available during the release.

$$c = (\sum_g C_g) (\frac{F}{D\ f}) (Tm)$$

where:

C_g = The total radioactivity concentration of gamma-emitting radionuclides in liquid effluent prior to dilution (μCi/ml).

f = The maximum approved discharged flow rate prior to dilution (gpm).

= 60 gpm for the Waste Disposal System Liquid Effluent Monitor[3].

= 750 gpm for the Steam Generator Blowdown Monitor.

= 450 gpm for the Steam Generator Blowdown Monitor while draining a steam generator.

= 390 gpm for the Condensate Polisher Liquid Waste Monitor.

F = Dilution water flow rate (gpm).

= 160,000 gpm from one circulating water pump[1], Unit 2.
= 250,000 gpm from two circulating water pumps[1], Unit 2.
= 400,000 gpm from three circulating water pumps[1], Unit 2.

or

= 50,000 gpm from one circulating water pump[2], Unit 1.
= 80,000 gpm from two circulating water pumps[2], Unit 1.

T_m = Fraction of the radioactivity from the site that may be released via the monitored pathway to ensure that the site boundary limit is not exceeded due to simultaneous releases from more than one pathway.

= .05 for the Waste Disposal System Liquid Effluent Monitor (RMS-18).

= .70 for the Steam Generator Blowdown Monitor (RMS-19).

= .25 for the Condensate Polisher Liquid Waste.

If it is determined that $\frac{F}{D\ f} < 1$, the release cannot be made. Reevaluate the discharge flow rate prior to dilution and/or the dilution flow rates.

If $\frac{F}{D\ f} > 1$, the release may be made.

2.1.2.4 Determine SP (the monitor alarm setpoint [ccpm].

$SP = (c)\ (E_m) + \text{background}.$

where:

E_m = The applicable effluent monitor efficiency based on "c," from the efficiency curves located in the Plant Operating Manual, Volume 15, Curve Book.

2.2 COMPLIANCE WITH 10CFR20 (LIQUIDS)

Liquid effluents from H.B. Robinson Unit 2 (HBR) will occur both continuously and on a batch basis. The following sections discuss the methodology which will be utilized by the HBR to show compliance with 10CFR20.

2.2.1 Continuous Releases

Steam generator blowdown is continuously released from HBR. Each operational working day grab samples will be taken of steam generator blowdown. These samples are composited at the rate of 100 ml/sgr. An aliquot of the SG composite is analyzed each week for I-131 and various other fission, activation, and corrosion products, as outlined in Table 4.10-1 of the technical specification for HBR. Samples are to be maintained until the end of the quarter and analyzed for strontium. Steam generator volumes are based on blowdown rates. In addition, a monthly analysis will be performed to determine the activity levels of tritium and dissolved and entrained gases. Compliance with 10CFR20 during actual release is established through the steam generator blowdown effluent monitor alarm setpoint. This setpoint is based upon I-131 as noted in Section 2.1. However, if a continuous release should occur in which the effluent monitor alarm setpoint is exceeded, then actual compliance with 10CFR20 may be determined utilizing the actual radionuclide mix and the following equation:

$$Conc_i = \frac{C_{ic} V_c}{V_{dc}} \qquad (2.2\text{-}1)$$

where:

$Conc_i$ = Concentration of radionuclide "i" at the unrestricted area, µCi/ml;

The mixture of radionuclides released must be of such concentrations that Equation 2.2-3 must be met.

For HBR, the liquid radwaste effluent line discharges to the circulating water system. Therefore, the dilution flow rate (D_{fr}) is a function of the number of circulating water pumps operating. Unit 2 of the H.B. Robinson Steam Electric Plant has three circulating water pumps. Pump curves show that with three pumps operating, the circulating water flow is 400,000 gpm, with two pumps--250,000 gpm, and with one pump--160,000 gpm. Unit 1 of the H.B. Robinson Steam Electric Plant has two circulating water pumps. The circulating water flow is 50,000 gpm with one pump and 80,000 gpm with two pumps. At least one circulating water pump must be operating during any liquid waste discharge.

Batch releases from the HBR liquid radwaste system may occur from the waste condensate tanks, the monitor tanks, the steam generators, and the Condensate Polisher Liquid Waste. The maximum release rate (R_b) is 750 gpm for the steam generators, 60 gpm from the monitor and waste condensate tanks, and 390 gpm for the Condensate Polisher Liquid Wastes.

2.2.2.2 Postrelease

The Steam Generation Blowdown Monitor (RMS-19), the Waste Disposal System Liquid Monitor (RMS-18), and the Condensate Polisher Liquid Waste Monitor (RMS-37) setpoint will each be limited to 50 percent of the 10CFR20 limits. These setpoints will ensure that 10CFR20 limits are met. However, because they are based upon a given mix, the possibility exists that the alarm trip setpoints may be exceeded, while 10CFR20 limits are not exceeded. The following methodology is provided to determine whether actual releases exceeded 10CFR20 limits.

The concentration of each radionuclide in the unrestricted area following release from a batch tank will be calculated in the following manner:

D_{fr} = Dilution flow rate from circulating water pumps during release k, gpm.

The circulating water pump flow rates were given in Section 2.2.2.1 above.

For the case where a batch release is occurring at the same time that a continuous release is occurring, the compliance with 10CFR20 limits may be determined by the following equation:

$$Conc_{ik} = \frac{C_{ikb} V_{kb} + C_{ikc} V_{kc}}{V_{kd}} \quad (2.2\text{-}8)$$

where:

C_{ikc} = Concentration of radionuclide "i" in continuous releases during release period k, μCi/ml;

V_{kc} = Volume of continuous release during period k, gal.

Calculated concentrations are to be compared to the concentration in Appendix B, Table II, Column 2, of 10CFR20.

2.3 COMPLIANCE WITH 10CFR50

2.3.1 Cumulation of Doses

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

$$D_{\tau b} = \sum_k \sum_i A_{i\tau} \; t_{kb} \; C_{ikb} \; F_{kb} \quad (2.3\text{-}1)$$

where:

$D_{\tau b}$ = The cumulative dose commitment to the total body or any organ τ, from batch liquid effluents, mrem;

t_{kb} = The length of time of batch release k over which C_{ikb} and F_{kb} are averaged for each batch liquid release, hours;

C_{ikb} = The average concentration of radionuclide "i" in undiluted batch liquid effluent during batch release k, μCi/ml;

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

F_{kb} = The near-field average dilution factor for C_{ikb} during any batch liquid effluent release k. Defined as the ratio of the volume of undiluted liquid waste released to the product of the dilution volume from the site discharge structure to unrestricted receiving waters times 1.0. (1.0 is the site-specific applicable factor for the mixing effect of the HBR discharge structure as defined in NUREG-0133, October 1978).

$$= \frac{V_{kb}}{V_{kd} \times 1.0}$$

Where V_{kb} and V_{kd} are as defined in Equation 2.2-5.

The dose factor $A_{i\tau}$ was calculated for an adult for each isotope using the following equation:

$$A_{i\tau} = 1.14 \times 10^5 \, (21BF_i) \, DF_{i\tau} \qquad (2.3\text{-}2)$$

where:

$$1.14 \times 10^5 = 10^6 \, \frac{pCi}{\mu Ci} \times 10^3 \, \frac{ml}{l} \times \frac{1 \, yr}{8760 \, hr}$$

21 = Adult fish consumption rate from Table E-5 of Regulatory Guide 1.109, Revision 1, kg/yr;

BF_i = Bioaccumulation factor for radionuclide "i" in fish from Table A-1 of Regulatory Guide 1.109, Revision 1, pCi/kg per pCi/l;

$DF_{i\tau}$ = Dose conversion factor for radionuclide "i" for adults for a particular organ τ from Table E-11 of Regulatory Guide 1.109, Revision 1, mrem/pCi.

The potable water pathway does not exist either within Lake Robinson or downstream of the Lake Robinson dam. Therefore, the potable water term was excluded from the calculation of $A_{i\tau}$ values. Table 2.3-1 presents $A_{i\tau}$ values for an adult at HBR.

As noted in Section 2.2.2, steam generator blowdown is continuously released from HBR. The dose from continuous releases will be calculated using the following equation:

$$D_{\tau c} = \sum_k \sum_i A_{i\tau} \, t_{kc} \, C_{ikc} \, F_{kc} \quad (2.3\text{-}3)$$

where:

$D_{\tau c}$ = The cumulative dose commitment to the total body or any organ τ, from liquid effluents for continuous releases, mrem;

t_{kc} = The length of time of continuous release period k over which C_{ikc} and F_{kc} are averaged for all continuous liquid releases, hours;

C_{ikc} = The average concentration of radionuclide "i" in undiluted liquid effluent during continuous release period k from any continuous liquid release, μCi/ml;

F_{kc} = The near-field average dilution factor for C_{ikc} during continuous liquid effluent release k. Defined as the ratio of the volume of undiluted liquid waste released to the product of the dilution volume from the site discharge structure to unrestricted receiving water times 1.0. (1.0 is the site-specific applicable factor for the mixing effect of the HBR discharge structure as defined in NUREG-0133, October 1978).

$$F_{kc} = \frac{V_{kc}}{V_{kd} \times 1.0}$$

Where V_{kc} and V_{kd} are, as defined in Equation 2.2-5, only now distinguished for continuous releases.

The sum of the cumulative dose from all batch and continuous releases for a quarter are compared to one half the design objectives for total body and any organ. The sum of the cumulative doses from all batch and continuous releases for a calendar year are compared to the design objective doses. The following relationships should hold for HBR to show compliance with Technical Specification 3.9.2.1 of the technical specifications for H.B. Robinson Unit 2.

For the calendar quarter,

$D_\tau \leq 1.5$ mrem total body (2.3-4)

$D_\tau \leq 5$ mrem any organ (2.3-5)

For the calendar year,

$D_\tau \leq 3$ mrem total body (2.3-6)

$D_\tau \leq 10$ mrem any organ (2.3-7)

where:

D_τ = Cumulative total dose to any organ τ or the total body from continuous and batch releases, mrem;

$$= D_{\tau b} + D_{\tau c}$$

The quarterly limits given above represent one half the annual design objective of Section II.A of Appendix I of 10CFR50. If any of the limits in Expressions 2.3-4 through 2.3-7 are exceeded, a special report pursuant to Technical Specification 6.9.3.2 must be filed with the NRC. This report complies with Section IV.A, of Appendix I of 10CRF50.

2.3.2 Projection of Doses

Doses resulting from the release of liquid effluents will be projected once per 31 days. These projections will include a safety margin, based upon expected operational conditions, which will take into consideration both planned and unplanned releases.

Projected dose will be calculated as follows:

$$PD = \frac{(DA)(TA)}{(TE)} + M \qquad (2.3\text{-}8)$$

where:

PD = projected doses in mrem.
DA = dose accumulated during current quarter in mrem.
TE = time elapsed in quarter in days.
TA = time in quarter in days.
M = safety margin in mrem.

If the projected doses exceed 0.2 mrem to the whole body or 0.6 mrem to any organ when averaged over a calendar quarter, the liquid radwaste equipment will be operated to reduce the radioactive materials in the liquid effluent.

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3.0 GASEOUS EFFLUENTS

3.1 MONITOR ALARM SETPOINT DETERMINATION

This methodology determines the monitor alarm setpoint that indicates if the dose rate in the unrestricted areas due to noble gas radionuclides in the gaseous effluent released from the site to areas at and beyond the site boundary exceeds 500 mrem/year to the whole body or exceeds 3000 mrem/year to the skin.

The methodology described in Section 3.1.2 provides an alternative means to determine monitor alarm setpoints that may be used when an analysis of batch releases is performed prior to release.

3.1.1 Setpoint Based on Conservative Radionuclide Mix (Ground and Mixed Mode Releases

Releases through the steam generator flash tank vent can only occur through this vent when significant primary-to-secondary leakage exists within the steam generators and the plant is operating below 30 percent power. Detection of primary-to-secondary leakage is accomplished most effectively by continuously monitoring the condenser vacuum pump vent (RMS-15). Steam generator blowdown is continuously monitored by RMS-19 as a liquid pathway.

The following method applies to gaseous releases via the plant vent and condenser vacuum pump vent when determining the high-alarm setpoint for the plant vent gas monitor (RMS-14) and condenser vacuum pump vent gas monitor (RMS-15) during the following operational conditions:

- Continuous release via the plant vent.
- Continuous release via the condenser vacuum pump vent.
- Batch release of containment purge via the plant vent.

- Batch release for containment pressure relief via the plant vent.
- Batch release of waste gas decay tanks via the plant vent.

3.1.1.1 Determine the "mix" (noble gas radionuclides and composition) of the gaseous effluent.

a. Determine the concentration (µCi/cc) of radioactive isotopes to be released in the gaseous effluent. This source term will be used for calculating the release rate.

If the concentration of radioactive isotopes listed in Table 3.1-1 (calculated using the Gale code) results in a more conservative release rate this may be used as the source term for calculating the release rate.

b. Determine S_i (the fraction of the total noble gas radioactivity in the gaseous effluent comprised by noble gas radionuclide "i") for each individual noble gas radionuclide in the gaseous effluent.

$$S_i = \frac{A_i}{\sum_i A_i} \qquad (3.1\text{-}1)$$

A_i = The radioactivity of noble gas radionuclide "i" in the gaseous effluent from Table 3.1-1 or from analysis of gaseous effluent to be released.

3.1.1.2 Determine the Q_m (the maximum acceptable total release rate of all noble gas radionuclides in the gaseous effluent [µCi/sec]) based upon the whole body exposure limit of 500 mrem/year by:

$$Q_m = \frac{500}{(\overline{X/Q}) \sum_i K_i S_i} \qquad (3.1\text{-}2)$$

$(\overline{X/Q})$ = The highest calculated annual average relative dispersion factor for any area at or beyond the unrestricted area boundary for all sectors (sec/m^3).

= 8.1 E-5 sec/m^3 (Continuous Ground Release) from Table A-1, Appendix A.

= 9.9 E-7 sec/m^3 (Continuous Mixed Mode Release) from Table A-10, Appendix A, only with upper wind speed $\geq$ 9 mph.

= 5.1 E-5 sec/m^3 (Batch Ground Release) from Table A-7, Appendix A.

= 2.9 E-6 sec/m^3 (Batch Mixed Mode Release) from Table A-16, Appendix A only with upper wind speed $\geq$ 9 mph.

K_i = The total whole body dose factor due to gamma emissions from noble gas radionuclide "i" ($mrem/yr/\mu Ci/m^3$) from Table 3.1-2.

3.1.1.3 Determine Q_m (the maximum acceptable release rate of all gas radionuclides in the gaseous effluent [$\mu Ci/sec$]) based upon the skin exposure limit of 3000 mrem/yr by:

$$Q_m = \frac{3000}{(\overline{X/Q}) \sum_i [(L_i + 1.1 M_i) S_i]} \qquad (3.1\text{-}3)$$

$L_i + 1.1M_i$ = The total skin dose factor due to emissions from noble gas radionuclide "i" ($mrem/yr/\mu Ci/m^3$) from Table 3.1-2.

3.1.1.4 Determine C_m (the maximum acceptable total radioactivity concentration of all noble gas radionuclides in the gaseous effluent [$\mu Ci/cc$]).

$$C_m = \frac{2.12\ E\text{-}3\ Q_m}{F} \qquad (3.1\text{-}4)$$

NOTE: Use the lower of the Q_m values obtained in Sections 3.1.1.2 and 3.1.1.3. This will protect both the skin and total body from being exposed to the limit.

where:

F = The maximum acceptable effluent flow rate at the point of release (cfm).

= 60,000 cfm for plant vent.

= 45 cfm for the condenser vacuum pump vent.

= 10,800 cfm for the fuel-handling building.

2.12 E-3 = Unit conversion constant to convert µCi/sec/cfm to µCi/cc.

3.1.1.5 Determine CR (the calculated monitor count rate above background attributed to the noble gas radionuclides [ccpm]) by:

$$CR = (C_m)\ (E_m)$$

E_m = Obtained from the applicable effluent monitor efficiency curve located in the Plant Operating Manual, Volume 15, Curve Book. Use the radioactivity concentration "C_m" to find CR.

3.1.1.6 Determine the HSP (the monitor high-alarm setpoint including background [cpm]) by:

$$HSP = T_m CR + \text{background (cpm)} \qquad (3.1\text{-}5)$$

where:

472 = A conversion factor to convert cfm to cc/sec.

C_i = The radioactivity concentration of noble gas radionuclide "i" in the gaseous effluent (μCi/cc) from the analysis of the gaseous effluent to be released.

F = The maximum acceptable effluent flow rate at the point of release (cfm).

= 45 for the condenser.

= 50,000 for the containment purge.

$$= \frac{2\ E6 \left(\frac{\Delta P_c}{14.7}\right) \left(\frac{273°}{T_c}\right)}{t}$$ for pressure relief.

$$= \frac{525 \left(\frac{\Delta P_t}{14.7}\right) \left(\frac{273°}{T_t}\right)}{t}$$ for a gas decay tank release.

where:

= 2 E6 and 525 are the volumes (ft^3) of the containment and decay tank respectively, and T_c, T_t, ΔP_c, and ΔP_t are the respective temperature and change in pressure (psig) following the release of the containment and decay tank.

t = Length of release (min).

0°C = 273°K.

T_c = 273°K + C°.

T_t = 273°K + C°

3.1.2.2 Determine the monitor alarm setpoint based on total body dose rate:

a. Determine CR_t (the monitor count rate per mrem/yr, total body).

$$CR_t = \frac{C}{(\overline{X/Q}) \sum_i K_i R_i}.$$

where:

C = The count rate of the monitor corresponding to the radioactivity concentration in the analyzed sample.

C = C_i (µCi/ml) x monitor efficiency (cpm/µCi/cc) = cpm.

$\overline{X/Q}$ = The highest calculated annual average relative dispersion factor for any area at or beyond the unrestricted area boundary for all sectors (sec/m^3) from Appendix A.

= 5.1 E-5 sec/m^3 (Batch Ground Release) from Table A-7, Appendix A.

= 2.9 E-6 sec/m^3 (Batch Mixed Mode Release) from Table A-16, Appendix A, only with upper wind speeds of $\geq$ 9 mph.

K_i = The total whole body dose factor due to gamma emissions from noble gas radionuclide "i" (mrem/yr/µCi/m^3) from Table 3.1-2.

b. Determine S_t (the count rate of the gaseous effluent noble gas monitor at the alarm setpoint based on total body dose rate [ccpm]):

$S_t = SF \times T_m \times D_t \times CR_t$

TABLE 3.1-1

GASEOUS SOURCE TERMS*

	Plant Vent Release[1]		Condenser Vacuum Pump Vent[2]		Containment Purge or Presure Relief		Gas Decay Tanks	
Radionuclide	A_i (Ci/yr)	S_i	A_i (Ci/yr)	S_i	A_i (Ci/yr)	S_i	A_i (Ci/yr)	S_i
Kr-85m	2.0E0	5.26E-2	1.0E0	4.35E-2	0.00	0.00	0.00	0.00
Kr-85	0.00	0.00	0.00	0.00	0.00	0.00	1.6E2	8.00E-1
Kr-87	1.0E0	2.63E-2	0.00	0.00	0.00	0.00	0.00	0.00
Kr-88	3.0E0	7.89E-2	2.0E0	8.70E-2	1.0E0	2.90E-3	0.00	0.00
Xe-131m	0.00	0.00	0.00	0.00	1.0E0	2.90E-3	9.0E0	4.50E-2
Xe-133m	0.00	0.00	0.00	0.00	4.0E0	1.16E-2	0.00	0.00
Xe-133	2.8E1	7.37E-1	1.8E+1	7.83E-1	3.1E2	8.99E-1	3.1E1	1.55E-1
Xe-135	4.0E0	1.05E-1	2.0E+1	8.70E-2	4.0E0	1.16E-2	0.00	0.00
Ar-41	0.00	0.00	0.00	0.00	2.5E1	7.25E-2	0.00	0.00
TOTAL	3.8E1		2.3E1		3.45E2		2.0E2	

*Source terms are based upon GALE Code and not actual releases from the evaluation of H.B. Robinson Unit 2 to demonstrate conformance to the design objectives of 10CFR50, Appendix I, Table 2-4. These values are only for routine releases and not for a complete inventory of gases in an emergency.

[1]These values are used to determine the monitor alarm setpoints for the Plant Vent Gas Monitor (RMS-14) and Fuel-Handling Basement Exhaust Monitor (RMS-20).

[2]These values are used to determine the monitor alarm setpoint for the Condenser Vacuum Pump Vent Monitor (RMS-15).

K_i = The total body dose factor due to gamma emissions for noble gas radionuclide "i," mrem/year per $\mu Ci/m^3$.

L_i = The skin dose factor due to beta emissions for noble gas radionuclide "i," mrem/year per $\mu Ci/m^3$.

M_i = The air dose factor due to gamma emissions for noble gas radionuclide "i," mrad/year per $\mu Ci/m^3$.

1.1 = The ratio of the tissue to air absorption coefficients over the energy range of the photon of interest, mrem/mrad (reference NUREG 0133, October 1978).

$\dot{Q}_{ie}$ = The release rate of noble gas radionuclide "i" in gaseous effluents from the condenser vacuum pump vent $\mu Ci/sec$.

$\dot{Q}_{iv}$ = The release rate of noble gas radionuclide "i" in gaseous effluents from the plant vent $\mu Ci/sec$.

The determination of limiting location for implementation of 10CFR20 for noble gases is a function of the radionuclide mix, release rate, and the meteorology. For the most limiting location, the radionuclide mix will be based on sample analysis of the effluent gases.

The X/Q value utilized in the equations for implementation of 10CFR20 is based upon the maximum long-term annual average ($\overline{X/Q}$) in the unrestricted area. Table 3.2-2 presents the distances from HBR to the nearest area for each of the 16 sectors as well as to the nearest residence, vegetable garden, cow, goat, and beef animal. Long-term annual average ($\overline{X/Q}$) values for the HBR release points to the special locations in Table 3.2-2 are presented in Appendix A. A description of their deriviation is also provided in this appendix.

To select the limiting location, the highest annual average $\overline{X/Q}$ value for the ground level releases and the mixed mode releases was used. Since mixed mode releases may not necessarily decrease with distance (i.e., the site boundary may not have the highest $\overline{X/Q}$ value), long-term annual average $(\overline{X/Q})$ values, calculated at the midpoint of 10 standard distances as given in Appendix A were also considered. For HBR, mixed mode release X/Q values decrease with distance for all directions except the WNW, NW, and NNW so that the maximum site boundary X/Q is usually greater at the site boundary than at distances greater than the site boundary. In addition, the maximum site boundary X/Q for both the ground level and mixed mode releases occurs at the SSE site boundary. Therefore, the limiting location for implementation of 10CFR20 for noble gases is the SSE site boundary.

Values for K_i, L_i, and M_i, which were used in the determination of the limiting location and which are to be used by HBR in Expressions 3.2-1 and 3.2-2 to show compliance with 10CFR20, are presented in Table 3.2-3. These values were taken from Table B-1 of NRC Regulatory Guide 1.109, Revision 1. The values have been multiplied by 1.0 E6 to convert microcuries to picocuries for use in Expressions 3.2-1 and 3.2-2.

3.2.2 Radioiodines and Particulates

The dose rate in an unrestricted area resulting from the release of radioiodines, tritium, and particulates with half-lives $\geq$ 8 days is limited to 1500 mrem/yr to any organ. Based upon NUREG 0133, the following is used to show compliance with 10CFR20.

$$\sum_i P_{i_I} \left[(\overline{X/Q})_v Q_{iv} + (\overline{X/Q})_e Q_{ie} \right] \leq 1500 \text{ mrem/yr} \qquad (3.2\text{-}3)$$

Q_{iv} = Release rate of radionuclide "i" from the plant vent, $\mu Ci/sec$.

Q_{ic} = Release rate of radionuclide "i" from the condenser vacuum pump vent, $\mu Ci/sec$.

$(\overline{X/Q})_v$ = Annual average relative dilution for plant vent releases at the site boundary, sec/m^3.

$(\overline{X/Q})_e$ = Annual average relative dilution for condenser vacuum pump vent releases at the site boundary, sec/m^3.

P_{i_I} = The dose parameter for Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days for the inhalation pathway only in the most restrictive sector in mrem/yr per $\mu Ci/m^3$. The dose factor is based on the most restrictive group (child) and most restrictive organ (thyroid) at the SITE BOUNDARY (see Table 3.3-18).

where:

In the calculation to show compliance with 10CFR20, only the inhalation is considered. A description of the methodology used in calculating the Pi values is presented in Appendix B. Compliance with 10CFR20 is achieved if the dose rate via inhalation pathway to a child is $\leq$ 1500 mrem/year.

TABLE 3.2-1

RELEASES FROM H.B. ROBINSON UNIT NO. 2*
(Ci/yr)

Isotope	Plant Vent (Q_v)	Condenser Vacuum Pump Vent (Q_e)	Total
Kr-85m	2.0E0	1.0E0	3.0E0
Kr-85	1.6E2	0.00	1.6E2
Kr-87	1.0E0	0.00	1.0E0
Kr-88	4.0E0	2.0E0	6.0E0
Xe-131m	1.0E1	0.00	1.0E1
Xe-133m	4.0E0	0.00	4.0E0
Xe-133	3.7E2	1.8E1	3.9E2
Xe-135	8.0E0	2.0E0	1.0E1
I-131	3.6E-2	2.3E-2	5.9E-2
I-133	5.4E-2	3.4E-2	9.8E-2
Mn-54	4.7E-3	0.00	4.7E-3
Fe-59	1.6E-3	0.00	1.6E-3
Co-58	1.6E-2	0.00	1.6E-2
Co-60	7.3E-3	0.00	7.3E-3
Sr-89	3.4E-4	0.00	3.4E-4
Sr-90	6.3E-5	0.00	6.3E-5
Cs-134	4.7E-3	0.00	4.7E-3
Cs-137	7.8E-3	0.00	7.8E-3

*Calculations based upon GALE Code and do not reflect actual release data from the Evaluation Comformance to the Design Objectives of 10CFR50, Appendix I. These values are only for routine releases and not for a complete inventory of gases in an emergency.

TABLE 3.2-2

DISTANCE TO SPECIAL LOCATIONS FOR THE
H.B. ROBINSON PLANT (MILES)

Sector	Site Boundary	Milk Cow	Milk Goat	Meat Animal	Nearest Resident	Nearest Garden
NNE	1.26	-	-	1.65	1.3	1.4
NE	1.01	-	-	1.16	1.2	1.3
ENE	0.86	-	-	2.41	0.9	2.2
E	0.61	4.2	-	3.12	0.8	2.8
ESE	0.50	-	-	1.99	0.6	0.6
SE	0.29	-	-	-	0.3	0.3
SSE	0.26	-	-	-	0.3	0.3
S	0.28	-	-	2.32	0.3	0.4
SSW	0.29	-	-	2.08	0.3	0.5
SW	0.36	-	2.5*	2.27	0.4	0.5
WSW	0.36	-	-	2.69	0.4	0.6
W	0.50	-	-	3.97	0.6	0.6
WNW	0.55	-	-	4.07	0.7	0.9
NW	1.23	-	-	1.60	1.3	1.3
NNW	1.89	-	-	2.84	2.9	3.0
N	1.94	-	-	2.93	2.9	2.9

*Milk is not presently used for human consumption.

TABLE 3.2-3

DOSE FACTORS FOR NOBLE GASES AND DAUGHTERS*

Radionuclide	Total Body Dose Factor K_i (mrem/yr per $\mu Ci/m^3$)	Skin Dose Factor L_i (mrem/yr per $\mu Ci/m^3$)	Gamma Air Dose Factor M_i (mrad/yr per $\mu Ci/m^3$)	Beta Air Dose Factor N_i (mrad/yr per $\mu Ci/m^3$)
Kr-83m	7.56E-02	---	1.93E+01	2.88E+02
Kr-85m	1.17E+03	1.46E+03	1.23E+03	1.97E+03
Kr-85	1.61E+01	1.34E+03	1.72E+01	1.95E+03
Kr-87	5.92E+03	9.73E+03	6.17E+03	1.03E+04
Kr-88	1.47E+04	2.37E+03	1.52E+04	2.93E+03
Kr-89	1.66E+04	1.01E+04	1.73E+04	1.06E+04
Kr-90	1.56E+04	7.29E+03	1.63E+04	7.83E+03
Xe-131m	9.15E+01	4.76E+02	1.56E+02	1.11E+03
Xe-133m	2.51E+02	9.94E+02	3.27E+02	1.48E+03
Xe-133	2.94E+02	3.06E+02	3.53E+02	1.05E+03
Xe-135m	3.12E+03	7.11E+02	3.36E+03	7.39E+02
Xe-135	1.81E+03	1.86E+03	1.92E+03	2.46E+03
Xe-137	1.42E+03	1.22E+04	1.51E+03	1.27E+04
Xe-138	8.83E+03	4.13E+03	9.21E+03	4.75E+03
Ar-41	8.84E+03	2.69E+03	9.30E+03	3.28E+03

*The listed dose factors are for radionuclides that may be detected in gaseous effluents.

TABLE 3.2-4

P_i VALUES FOR AN INFANT FOR THE H.B. ROBINSON UNIT NO. 2*

Isotope	Inhalation	Ground Plane	Cow Milk	Goat Milk
H-3	6.47E2	0.00	2.38E3	4.86E3
P-32	2.03E6	0.00	1.60E11	1.93E11
Cr-51	1.28E4	6.67E6	4.79E6	5.65E5
Mn-54	1.00E6	1.09E9	3.89E7	4.68E6
Fe-59	1.02E6	3.92E8	3.93E8	5.11E6
Co-58	7.77E5	5.29E8	6.06E7	7.28E5
Co-60	4.51E6	4.40E9	2.10E8	2.52E7
Zn-65	6.47E5	6.89E8	1.90E10	2.29E9
Rb-86	1.90E5	1.28E7	2.22E10	2.67E9
Sr-89	2.03E6	3.16E4	1.27E10	2.66E10
Sr-90	4.09E7	0.00	1.21E11	2.55E11
Y-91	2.45E6	1.52E6	5.26E6	6.32E5
Zr-95	1.75E6	3.48E8	8.28E5	9.95E4
Nb-95	4.79E5	1.95E8	2.06E8	2.48E7
Ru-103	5.52E5	1.55E8	1.05E5	1.27E4
Ru-106	1.16E7	2.99E8	1.44E6	1.73E5
Ag-110m	3.67E6	3.14E9	1.46E10	1.75E9
Te-127m	1.31E6	1.18E5	1.04E9	1.24E8
Te-129m	1.68E6	2.86E7	1.40E9	1.68E8
Cs-134	7.03E5	2.81E9	6.79E10	2.04E11
Cs-136	1.35E5	2.13E8	5.76E9	1.73E10
Cs-137	6.12E5	1.15E9	6.02E10	1.81E11
Ba-140	1.60E6	2.94E7	2.41E8	2.89E7
Ce-141	5.17E5	1.98E7	1.37E7	1.65E6
Ce-144	9.84E6	5.84E7	1.33E8	1.60E7
I-131	1.48E7	2.46E7	1.06E12	1.27E12
I-132	1.69E5	1.78E6	1.39E2	1.64E2
I-133	3.56E6	3.54E6	9.80E9	1.18E10
I-135	6.96E5	3.67E6	2.27E7	2.68E7

*Units are mrem/yr per μCi/m^3 for H-3 and the inhalation pathway and mrem/yr per μCi/sec per m^{-2} for the food and ground plane pathways.

3.3 COMPLIANCE WITH 10CRF50 (GASEOUS)

3.3.1 Noble Gases

3.3.1.1 Cumulation of Doses

Based upon NUREG 0133, the air dose in the unrestricted area due to noble gases released in gaseous effluents can be determined by the following equations:

$$D_\gamma = 3.17 \times 10^{-8} \sum_i M_i \left[(\overline{X/Q})_v \, \overline{Q}_{iv} + (\overline{X/q})_v \, \overline{q}_{iv} + (\overline{X/Q})_e \, \overline{Q}_{ie} \right] \qquad (3.3\text{-}1)$$

$$D_\beta = 3.17 \times 10^{-8} \sum_i N_i \left[(\overline{X/Q})_v \, \overline{Q}_{iv} + (\overline{X/q})_v \, \overline{q}_{iv} + (\overline{X/Q})_e \, \overline{Q}_{ie} \right] \qquad (3.3\text{-}2)$$

where:

D_γ = The air dose from gamma radiation, mrad.

D_β = The air dose from beta radiation, mrad.

M_i = The air dose factor due to gamma emissions for each identified noble gas radionuclide "i," mrad/ year per $\mu Ci/m^3$.

N_i = The air dose factor due to beta emissions for each identified noble gas radionuclide "i," mrad/year per $\mu Ci/m^3$.

$(\overline{X/Q})_v$ = The annual average dilution for areas at or beyond the unrestricted area boundary for long-term plant vent releases (> 500 hrs/year), sec/m^3.

= From Table A-1 for ground level releases.

- From Table A-10 for mixed mode releases to be used only with upper wind speeds $\geq$ 9 mph.

$(\overline{X/q})_v$ = The dilution for areas at or beyond the unrestricted area boundary for short-term vent releases ($\leq$ 500 hours/year), sec/m^3.

- From Table A-7 for ground level releases.

- From Table A-16 for mixed mode releases.

$(\overline{X/Q})_e$ = Annual average relative dilution for condenser vacuum pump vent releases at the site boundary, (> 500 hours/year), sec/m^3.

- From Table A-1 for ground level releases;

q_{iv} = The average release of noble gas radionuclide "i" in gaseous releases for short-term plant releases ($\leq$ 500 hours/year), μCi;

$\bar{Q}_{ie}$ = The average release of noble gas radionuclide "i" in gaseous releases for long-term condenser vacuum pump vent releases (> 500 hours/year), μCi;

$\bar{Q}_{iv}$ = The average release of noble gas radionuclide "i" in gaseous effluents for long-term vent releases (> 500 hours/year), μCi;

3.17×10^{-8} = The inverse of the number of seconds in a year $(sec/year)^{-1}$.

At HBR the limiting location is 0.26 miles SSE. Based upon the tables presented in Appendix A, substitution of the short-term X/Q value into Equation 3.3-1 yields lower dose value than the long-term X/Q values been used. In order to be conservative, for purposes of this document only, long-term annual average ($\overline{X/Q}$) values will be used. Should the calculated doses exceed 10CFR50 limits, recalculation of doses may be performed using short-term X/Q values for batch releases.

To select the limiting location, the highest annual average $\overline{X/Q}$ value for ground level and mixed mode releases and the highest short-term X/Q value for ground level and mixed mode releases were considered. Since mixed mode releases may increase and then decrease with distance (i.e., the site boundary may not have the highest X/Q value), long-term X/Q values were calculated at the midpoint of 10 standard distances as given in Appendix A. The calculated values decreased with the distance for all but the WNW, NW, and NNW sectors. The values for these sectors were not found to be limiting such that the maximum site boundary X/Q for both long-term and short-term ground level and mixed mode releases occurred at the SSE site boundary. The limiting location for implementation of 10CFR20 for noble gases is the SSE site boundary.

Values for M_i and N_i which are utilized in the calculation of the gamma air and beta air doses in Equation 3.3-1 to show compliance with 10CFR50 were presented in Table 3.2-3. These values originate from NUREG 0472, Revision 0, and were taken from Table B-1 of the NRC Regulatory Guide 1.109, Revision 1. The values have been multiplied by 1.0 E6 to convert from picocuries to microcuries.

The following relationship should hold for HBR to show compliance with HBR's Technical Specification 3.9.4.1.

For the calendar quarter:

$$D_\gamma \leq 5 \text{ mrad} \quad (3.3\text{-}3)$$

$$D_\beta \leq 10 \text{ mrad} \quad (3.3\text{-}4)$$

For the calendar year:

$$D_\gamma \leq 10 \text{ mrad} \quad (3.3\text{-}5)$$

$$D_\beta \leq 20 \text{ mrad} \quad (3.3\text{-}6)$$

The quarterly limits given above represent one-half of the annual design objectives of Section II.B.1 of Appendix I of 10CFR50. If any of the limits of quations 3.3-3 through 3.3-6 are exceeded, a special report pursuant to Technical Specification 6.9.4.a must be filed with the NRC. This report complies with Section IV.A of Appendix I of 10CFR50.

3.3.1.2 Projection of Doses

Doses resulting from the release of gaseous effluents will be projected once per 31 days. These projections will include a safety margin based upon expected operational conditions which will take into consideration both planned and unplanned releases.

Projected dose will be calculated as follows:

$$PD = \frac{(DA)\ (TA)}{(TE)} + M \quad (3.3\text{-}7)$$

where:

PD = Projected doses in mrem.

DA = Dose accumulated during current quarter in mrem.

TE = Time elapsed in quarter in days.

TA = Time in quarter in days.

M = Safety margin in mrem.

If the projected doses exceed 0.6 mrad for gamma radiation O2 1.3 mrad for beta radiation when averaged over a calendar quarter, the ventilation exhaust treatment system will be operated to reduce releases of radioactive materials.

3.3.2 Radioiodine and Particulates

3.3.2.1 Cumulation of Doses

Section II.C of Appendix I of 10CFR50 limits the release of radioiodines and radioactive material in particulate form from each reactor such that estimated dose or dose commitment to an individual in an unrestricted area from all pathways of exposure is not in excess of 15 mrem to any organ. Based upon NUREG 0133, the dose to an organ of an individual from radioiodines, tritium, and particulates with half-lives > 8 days in gaseous effluents released to unrestricted areas can be determined by the following equation:

$$D_\tau = 3.17 \times 10^{-8} \sum_i \Big[R_{i_I} [(\overline{X/Q})_v Q_{iv} + (\overline{X/Q})_e Q_{ie} + (\overline{X/Q})_e Q_{ie}] +$$

$$(R_{i_B} + R_{i_M} + R_{i_V} + R_{i_G}) \; [(\overline{D/Q})_v Q_{iv} + (\overline{D/q})_v q_{iv} + (\overline{D/Q})_e Q_{ie}] + \quad (3.3\text{-}8)$$

$$(R_{T_M} + R_{T_B} + R_{T_I} + R_{T_V}) \; [(\overline{X/Q})_v Q_{Tv} + (\overline{X/q})_v q_{Tv} + (\overline{X/Q})_e Q_{Te}] \Big]$$

where:

D_τ = Dose to any organ τ from radioiodines and particlates, mrem.

3.17×10^{-8} = The inverse of the number of seconds in a year, $(sec/year)^{-1}$.

$(\overline{X/Q})_v$ = Annual average relative concentration for plant vent releases (> 500 hrs/yr) sec/m^3.

= From Table A-1 for ground level releases.

= From Table A-10 for mixed mode releases only to be used with wind speeds > 9 mph.

$(\overline{X/Q})_e$ = Annual average dilution for condenser vacuum pump vent releases (> 500 hours/yr) sec/m^3.

= From Table A-1 for ground level releases.

$(\overline{D/Q})_v$ = Annual average deposition factor for plant vent releases (> 500 hrs/yr) m^{-2}.

= From Table A-3 for ground level releases.

= From Table A-12 for mixed mode releases only to be used with upper wind speeds > 9 mph.

$(D/q)_v$ = Relative deposition factor for short-term plant vent releases ($\leq$ 500 hrs/yr), m^{-2}.

= From Table A-9 for ground level releases.

= From Table A-18 for mixed mode releases only to be used with upper wind speeds > 9 mph.

$(D/Q)_e$ = Annual average relative deposition factor for condenser vacuum pump vent releases (> 500 hrs/ yr), m^{-2}.

= From Table A-3 for ground level releases.

Q_{ie} = Release of radionuclide "i" in gaseous effluents for long-term condenser vacuum pump vent releases (> 500 hrs/yr), μCi.

Q_{iv} = Release of radionuclide "i" in gaseous effluents for long-term plant vent releases (> 500 hrs/yr), µCi.

q_{iv} = Release of radionuclide "i" in gaseous effluents for short-term plant vent releases (≤ 500 hrs/yr), µCi.

R_{i_G} = Dose factor for an organ for radionuclide "i" for the ground plane exposure pathway, mrem/yr per µCi/sec per m^{-2}.

R_{i_I} = Dose factor for an organ for radionuclide "i" for the inhalation pathway, mrem/yr per µCi/m^3.

R_{i_V} = Dose factor for an organ for radionuclide "i" for the vegetable pathway, mrem/yr per µCi/m^{-2}.

R_{T_V} = Dose factor for an organ for tritium for the vegetable pathway, mrem/yr per µCi/m^3.

R_{T_I} = Dose factor for an organ for tritium for the inhalation pathway, mrem/yr per µCi/m^3.

Q_{TV} = Release of tritium in gaseous effluents for long-term vent releases (> 500 hrs/yr), µCi.

R_{i_M} = Dose factor for an organ for radionuclide "i" for the milk exposure pathway, mrem/yrµCi/sec/m^2.

R_{T_M} = Dose factor for an organ for tritium for the milk pathway, mrem/yr/µCi/m^3.

R_{T_B} = Dose factor for an organ for tritium for the meat pathway, mrem/yr/µCi/m^3.

R_{i_B} = Dose factor for an organ for radionuclide "i"for the meat exposure pathway, mrem/yr/μCi/sec/m^2.

Q_{Te} = Release of tritium in gaseous effluents for long-term condenser vacuum pump releases (> 500 hrs/ yr), μCi.

q_{TV} = Release of tritium in gaseous effluents for short-term plant vent releases (≤ 500 hrs/yr), μCi.

To show compliance with 10CFR50, Equation 3.3-8 is evaluated at the limiting pathway location. At HBR this location is the vegetable garden 0.3 miles in the SSE sector. The critical receptor is a child. Substitution of the appropriate X/Q and D/Q values from tables in Appendix A into Equation 3.3-8 would yield an equation with the short-term X/Q and D/Q values being less than the long-term values. Therefore, for this document, only long-term annual X/Q and D/Q values (i.e., more conservative values) are used.

The determination of a limiting location for implementation of 10CFR50 for radioiodines and particulates is a function of:

1. Radionuclide mix and isotopic release
2. Meteorology
3. Exposure pathway
4. Receptor's age

In the determination of the limiting location, the radionuclide mix of radioiodines and particulates was based upon the source terms calculated using the GALE Code. This mix is presented in Table 3.2-1 as a function of release point. The only source of short-term releases from the plant vent is containment purges.

In the determination of the limiting location, all of the exposure pathways, as presented in Table 3.2-2, were evaluated. These include cow milk, goat milk, beef and vegetable ingestion, and inhalation and ground plane exposure. An infant was assumed to be present at all milk pathway locations. A child was assumed to be present at all vegetable garden and beef animal locations. The ground plane exposure pathway was not considered a viable pathway for an infant. Naturally, the inhalation pathway was present everywhere an individual was present.HBR Technical Specification 4.20.2.1 requires that a land-use census survey be conducted on an annual basis. The age groupings at the various receptor locations are also determined during this survey; a new limiting location and receptor age group can result.

For the determination of the limiting location, the highest D/Q values for the vegetable garden, cow milk, and goat milk pathways were selected. The thyroid dose was calculated at each of these locations using the radionuclide mix and releases of Table 3.2-1. Based upon these calculations, it was determined that the limiting receptor pathway is the vegetable/child pathway.

In the determination of the limiting location, annual average D/Q and X/Q values are used. A description of the derivation of the various X/Q and D/Q values is presented in Appendix A.

Short-term and long-term X/Q and D/Q values for ground level releases and for long-term mixed mode releases are provided in tables in Appendix A. They may be utilized if an additional special location arises different from those presented in the special locations of Table 3.2-2.

Tables 3.3-1 through 3.3-19 present R_i values for the total body, GI-tract, bone, liver , kidney, thyroid, and lung organs for the ground plane, inhalation, cow milk, goat milk, vegetable, and meat ingestion pathways for the infant, child, teen, and adult age groups as appropriate to the pathways. These values were calculated using the methodology described in NUREG 0133 using a grazing period of eight months. A description of the methodology is presented in Appendix B.

The following relationship should hold for HBR to show compliance with HBR Technical Specification 3.9.5.1.

For the calendar quarter:

$$D_\tau \leq 7.5 \text{ mrem} \qquad (3.3\text{-}9)$$

For the calendar year:

$$D_\tau \leq 15 \text{ mrem} \qquad (3.3\text{-}10)$$

The quarterly limits given above represent one-half the annual design objectives of Section II.C of Appendix I of 10CFR50. If any of the limits of Equations 3.3-9 or 3.3-10 are exceeded, a special report pursuant to Technical Specification 6.9.4.a must be filed with the NRC. This report complies with Section IV.A of Appendix I of 10CFR50.

3.3.2.2 Projection of Doses

Doses resulting from release of radioiodines and particulate effluents will be projected once per 31 days. These projections will include a safety margin based upon expected operational conditions which will take into consideration both planned and unplanned releases.

Projected dose will be calculated as follows:

$$PD = \frac{(DA)\,(TA)}{(TE)} + M \qquad (3.3\text{-}11)$$

where:

PD = Projected doses in mrem.

DA = Dose accumulated during current quarter in mrem.

TE = Time elapsed in quarter in days.

TA = Time in quarter in days.

M = Safety margin in mrem.

If the projected doses exceed 1.0 mrem to any organ when averaged over a calendar quarter, the ventilation exhaust treatment system will be operated to reduce releases of radioactive materials.

TABLE 4.0-1

H. B. ROBINSON RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Sample Point	Sample Point Description, Distance, and Direction	Sampling and Collection Frequency	Analysis Frequency[1]	Analysis[1]
1. Airborne Particulates and Radioiodine	1.	Florence, S. C. (Control Station)[2] 26 miles ESE @ 119°	Continuous operating sampler with sample collection at least weekly	Weekly Weekly Quarterly	I-131 for Air Cartridges Gross Beta[3] Gamma Scan[4] of composite (by location)
	2.	Information Center 0.2 mile S @ 180°			
	3.	Microwave tower 0.7 mile N @ 5°			
	4.	Spillway 0.4 mile ESE @ 110°			
	5.	East Shore of lake across from plant intake Johnson's Landing 0.9 mile ENE @ 73°			
	6.	Information Center 0.3 mile SW @ 214°			
	7.	CP&L Hartsville substation, 6.3 miles ESE @ 109°			
2. Direct Radiation	1.	Florence, S.C. (Control Station)[2] 26 miles ESE @ 119°	Continuous measurement with readout at least once per quarter (TLDs)	Quarterly	Gamma Dose[5]

Table 4.0-1 (continued)

Exposure Pathway and/or Sample	Sample Point	Sample Point Description, Distance, and Direction	Sampling and Collection Frequency	Analysis[1] Frequency	Analysis[1]
2. Direct Radiation (continued)	2.	Information Center 0.2 mile S @ 180°	Continuous measurement with readout at least once per quarter (TLDs)	Quarterly	Gamma Dose[5]
	3.	Microwave tower 0.7 mile N @ 5°			
	4.	Spillway 0.4 mile ESE @ 110°			
	5.	East shore of lake across from plant intake Johnson's landing 0.9 mile ENE @ 73°			
	6.	Information Center 0.3 mile SW @ 214°			
	7.	CP&L Hartsville substation 6.3 miles ESE @ 109°			
	8.	On transmission poles intersecting with different transmission lines directly from HBR, approximately two pole sections down from railroad tracks 0.8 mile SSE.			
	9.	Second transmission pole from 151 Highway 1.0 mile S.			
	10.	Power pole at corner of The Church of God cemetary 1.0 mile WSW.			
	11.	Third power pole from the Old Camden Road 1.0 mile SW.			
	12.	Pine tree located at the second intersection of dirt road. Yellow mark on tree 1.2 miles SSW.			

Table 4.3-1 (continued)

Exposure Pathway and/or Sample	Sample Point	Sample Point Description, Distance, and Direction	Sampling and Collection Frequency	Analysis Frequency[1]	Analysis[1]
2. Direct Radiation (continued)	13.	Corner pine tree where dirt road splits 1.0 mile W.	Continuous measurement with readout at least once per quarter (TLDs)	Quarterly	Gamma Dose[5]
	14.	Power pole by Highway 151 on front of Pine Ridge Church 0.9 mile WNW.			
	15.	Pine tree down dirt road off Highway 151 directly adjacent to ash pond on CP&L property 1.0 miles NW.			
	16.	Southeast fence at Darlington County I.C. Turbine Plant 1.0 mile NNW.			
	17.	Small pine tree, right side of road, 1.0 mile down Discharge Canal road at Old Unit One Weir 1.1 miles N.			
	18.	Left side of train trestle over Black Creek 0.7 mile SE.			
	19.	Third power pole on Road #S-16-23 from intersection with 1.0 mile E.			
	20.	Power Pole #47 at right side of Road #S-16-39 going north 1.3 miles ENE.			
	21.	Power pole in the yard of A. Atkinson at Atkinson's boat landing.			
	22.	Shady Rest at light pole near the dock 1.9 miles NNE.			
	23.	Power Pole #41E-5 on Road #41E-5 on Road #S-16-39 1.2 miles ESE.			
	24.	151 north past peach farm, first paved Road #S-13-711 left. Fifth pole left side of road. Yellow marking 5.0 miles NW.			

Table 4.0-1 (continued)

Exposure Pathway and/or Sample	Sample Point	Sample Point Description, Distance, and Direction	Sampling and Collection Frequency	Analysis[1] Frequency	Analysis[1]
2. Direct Radiation (continued)	25.	Road #S-13-346 off 151 North. Cross railroad tracks and proceed 3/8 mile. Walk down right fence line into the woods towards pond. Badge on right pine tree ± 18 yards directly in front of fence marked "No Trespassing" 4.6 miles NNW.	Continuous measurement with readout at least once per quarter (TLDs)	Quarterly	Gamma Dose[5]
	26.	Power pole #32J-6 across old yellow house on Road #S-13-346 5.0 miles N.			
	27.	Road #S-13-763, ± 1.3 miles from intersection 5.0 miles NNE.			
	28.	Power Pole #30-4-A near dumpster on road #S-13-39 4.8 miles NE.			
	29.	Transmission pole nearest Road #S-16-20 ± 1/2 mile south of lookout tower.			
	30.	Located on Road #S-16-20, power pole in front yard of Johnson Fence and Awning 4.6 miles E.			
	31.	Lakeshore Drive, Pole #1122 right side of road. Yellow marking 4.6 miles ESE.			
	32.	Straight down the end of Kalber Drive, 12 feet up the transmission tower. Yellow marking 4.5 miles SE.			
	33.	Power Pole #25-4, left side of Road #S-16-493 near Harley Segar's driveway 4.6 miles SSE.			
	34.	Transmission pole nearest Road #S-16-772 4.6 miles S.			

Table 4.0-1 (continued)

Exposure Pathway and/or Sample	Sample Point	Sample Point Description, Distance, and Direction	Sampling and Collection Frequency	Analysis[1] Frequency	Analysis[1]
2. Direct Radiation (continued)	35.	Power pole at corner of Road #S-31-51 off Road #S-16-12 4.4 miles SSW.	Continuous measurement with readout at least once per quarter (TLDs)	Quarterly	Gamma Dose[5]
	36.	Power pole 1 3/4 mile down paved road off Road #S-16-85. Pole is in front of old house 4.7 miles SW.			
	37.	Transmission tower closest to Clay Road 5.0 miles WSW.			
	38.	Transmission pole right side of Road S-16-231 next to Union Church 4.9 miles W.			
	39.	Power pole, right side of road in middle of field. Yellow paint 5.0 miles WNW.			
3. Waterborne a. Surface Water	40.	Black Creek at Road 1623 0.6 mile ESE (indicator).	Composite sample[6] over one-month period	Monthly	Gamma Scan[4] H-3
	41.	Black Creek (Control Station[2] 7.2 miles NNW.			
b. Groundwater	40.	Artesian well 0.6 mile ESE.	Grab Sample	Monthly	Gamma Scan[4] H-3
	42.	Unit 1 deep well			
	43.	Unit 2 deep well			
c. Drinking Water		Not required[7].			
d. Shoreline Sediment	44.	East Shore of Lake, Shady Rest Club 1.9 miles NNE.	Semiannually	Semiannually	Gamma Scan[4]

Table 4.0-1 (continued)

Exposure Pathway and/or Sample	Sample Point	Sample Point Description, Distance, and Direction	Sampling and Collection Frequency	Analysis[1] Frequency	Analysis[1]
4. Ingestion a. Milk	53.	Lyndale Farm 9.0 miles SW (control station)	Semimonthly when animals are on pasture; monthly @ other times	Semimonthly when animals are on pasture; monthly @ other times	Gamma Scan[4] and I-131 analysis semi-monthly when animals are on pasture; monthly @ other times
	54.	Aurburndale Plantation[8] 10.1 miles E.			
b. Fish	45.	Site varies within Lake Robinson.	Semiannually (collect comparable species at all three locations)	Each sample	Gamma Scan[4] Edible portion
	46.	Prestwood Lake 4.9 miles ESE.			
	47.	Bee Lake (Control Station)[2] 13 miles NNW or May Lake 12.5 miles NW.			
c. Food Products leafy vege-tables	58.	One location within 3 miles of site in the sector with the highest de-position rate based on the latest information or historical data (location may vary).	Annual at Harvest	Each sample	Gamma Scan[4]
	49.	One location greater than 5 miles from plant site with the least de-position rate (Control Station)[2].			
	54.	Auburndale Plantation[8] 10.1 miles E.			
d. Broad-leaf vegetation	50.	0.25 mile SSE CP&L property[9].	Monthly when available (3 different kinds of broad-leaf vegetation)	Each sample	Gamma Scan[4] I-131
	51.	0.25 NNE CP&L property[9].			
	52.	10 miles W Bethune (Control Station)[2].			

FOOTNOTES:

1. The LLD for each analysis is specified in Table 3.17-3 of the HBR Technical Specifications.

2. Control stations are locations outside the influence of plant effluents.

3. Airborne particulate sample filter shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air particulate is greater than ten times the yearly mean of control samples, gamma isotopic analysis shall be performed on the individual samples.

4. Gamma scan means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

5. Thermoluminescent dosimeter (TLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters.

6. Composite sample aliquots shall be collected at time intervals that are short (5 or 6 times daily) relative to the compositing period (monthly in order to assure obtaining a representative sample).

7. Collection of drinking water samples is not required since there are no known reservoirs on Black Creek used for drinking purposes.

8. Water from Black Creek is used to irrigate feed and fodder for Arburndale Plantation's Dairy operation. This dairy is located ƒ 11 miles east @ 90° from plant.

9. Sample Points 50 and 51 are the highest and the second highest D/Q values, respectively. These locations are more restrictive than site boundary locations.

6.0 TOTAL DOSE (40CFR190 CONFORMANCE)

6.1 COMPLIANCE WITH 40CFR190

Compliance with 40CFR190 as prescribed by Specification 3.9.6 is to be demonstrated only when one or more of Specifications 3.9.2.1.a, 3.9.2.1.b, 3.9.4.1a, 3.9.4.1.b, 3.9.5.1.a, and 3.9.5.1.b is exceeded by a factor of 2. Once this occurs the Company has 30 days to submit this report in accordance with Specification 6.9.4(d).

6.2 CALCULATIONS EVALUATING CONFORMANCE WITH 40CFR190

To perform the calculations to evaluate conformance with 40CFR190, an effort is made to develop doses that are realistic by removing assumptions that lead to overestimates of dose to a MEMBER OF THE PUBLIC (i.e., calculations for compliance with 10CFR50, App. I). To accomplish this the following calculational rules are used:

(1) Doses to a MEMBER OF THE PUBLIC via the liquid release pathway will be calculated.

(2) Doses to a MEMBER OF THE PUBLIC due to a milk pathway will be evaluated only as can be shown to exist. Otherwise, doses via this pathway will be estimated as <1 mrem/yr.

(3) Environmental sampling data which demonstrate that no pathway exists may be used to delete a pathway to man from a calculation.

(4) To sum numbers represented as "less than" (<), use the value of the largest number in the group.

(i.e. <5 + <1 + <1 + <3 = 5)

(5) When doses via direct radiation are added to doses via inhalation pathway, they will be calculated for the same distance in the same sector.

(6) The calculational locations for a MEMBER OF THE PUBLIC will only be at residences or places of employment.

NOTE: Additional assumptions may be used to provide situation-specific parameters, provided they are documented along with their concomitant bases.

6.3 CALCULATIONS OF TOTAL BODY DOSE

Estimates will be made for each of the following exposure pathways to the same location by age class. Only those age classes known to exist at a location are considered.

6.3.1 Direct Radiation

The component of dose to a MEMBER OF THE PUBLIC due to direct radiation will be determined by:

(1) Determining the direct radiation dose at the plant boundary in each sector, $D_{B,\theta}$.

(2) Extrapolate that dose to the calculational location as follows:

$$D_{L,\theta} = \frac{D_{B,\theta}\,(1.49\ E{+}6)}{(X_{L,\theta})^2}$$

$D_{L,\theta}$ = dose at calculational location in sector θ.

1.49E+6 = square of mean distance to the site boundary (1220 m).

$X_{L,\theta}$ = Distance to calculational locations in sector θ in meters.

6.3.2 Inhalation Dose

The inhalation dose will be determined at the calculational locations for each age class at risk according to the methods outlined in Section 3.3 of this manual.

6.3.3 Ingestion Pathway

The dose via the ingestion pathway will be calculated at the consumer locations for the consumers at risk. If no milk pathway exists in a sector, the dose via this pathway will be treated as <1 mrem/yr.

6.3.4 Other Uranium Fuel Cycle Sources

The dose from other fuel cycle sources will be treated as <1 mrem/yr.

6.4 THYROID DOSE

The dose to the thyroid will be calculated for each sector as the sum of inhalation dose and milk ingestion dose (if existing). The calculational methods will be those identified in Section 3.3 of this manual.

6.5 DOSE PROJECTIONS

Dose projections are to incorporate planned plant operations such as power reduction or outages for the projected period.

TABLE A-1

X/Q Values for Long-Term Ground Level Releases at Special Locations (sec/m^3)*

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Ground Level

Variable: Relative Concentration (Sec./Cubic Meter)

Calculation Points: Special

Model: Straight Line (ANNX009)

Application of Terrain Correction Factors: Yes

Number of Observations: 8703

Affected Sector	Site Boundary	Meat	Dairy	Resident	Garden
NNE	6.67E-06	4.13E-06	0.00	6.26E-06	5.56E-06
NE	3.02E-06	2.56E-06	2.13E-06	2.44E-06	2.13E-06
ENE	4.41E-06	4.93E-07	0.00	4.18E-06	7.36E-07
E	6.39E-06	3.02E-07	1.44E-07	3.51E-06	3.68E-07
ESE	1.12E-05	1.18E-06	0.00	7.90E-06	7.90E-06
SE	3.28E-05	0.00	0.00	3.27E-05	3.27E-05
SSE	8.08E-05	0.00	0.00	6.01E-05	6.01E-05
S	3.29E-05	4.22E-07	0.00	2.78E-05	1.65E-05
SSW	2.10E-05	5.61E-07	0.00	2.04E-05	8.07E-06
SW	8.91E-06	2.61E-07	2.14E-07**	6.90E-06	5.38E-06
WSW	3.97E-06	1.16E-07	0.00	3.22E-06	1.83E-06
W	2.11E-06	3.89E-08	0.00	1.38E-06	1.38E-06
WNW	1.62E-06	5.32E-08	0.00	1.03E-06	6.06E-07
NW	7.93E-07	5.06E-07	0.00	7.39E-07	7.39E-07
NNW	1.31E-06	4.78E-07	0.00	4.42E-07	3.82E-07
N	1.45E-06	6.44E-07	0.00	6.67E-07	6.67E-07

* Zeroes indicate that this point was not calculated

** A milk goat is located here

TABLE A-2

Depleted X/Q Values for Long-Term Ground Level Releases at Special Locations (sec/m^3)*

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Ground Level

Variable: Relative Depleted Concentration (Sec./Cubic Meter)

Calculation Points: Special

Model: Straight Line (ANNXOQ9)

Application of Terrain Correction Factors: Yes

Number of Observations: 8703

Affected Sector	Site Boundary	Meat	Dairy	Resident	Garden
NNE	5.84E-06	3.38E-06	0.00	5.25E-06	4.77E-06
NE	2.68E-06	2.21E-06	1.79E-06	2.09E-06	1.79E-06
ENE	3.95E-06	3.99E-07	0.00	3.72E-06	5.93E-07
E	5.79E-06	2.42E-07	1.08E-07	3.12E-06	2.86E-07
ESE	1.01E-05	9.72E-07	0.00	7.11E-06	7.11E-06
SE	3.08E-05	0.00	0.00	3.05E-05	3.05E-05
SSE	7.46E-05	0.00	0.00	5.61E-05	5.61E-05
S	3.11E-05	3.42E-07	0.00	2.61E-05	1.53E-05
SSW	1.91E-05	4.55E-07	0.00	1.96E-05	7.35E-06
SW	8.25E-06	2.14E-07	2.44E-07**	6.44E-06	4.88E-06
WSW	3.68E-06	8.92E-08	0.00	2.94E-06	1.68E-06
W	1.98E-06	2.96E-08	0.00	1.26E-06	1.26E-06
WNW	1.47E-06	4.07E-08	0.00	9.26E-07	5.42E-07
NW	6.71E-07	4.19E-07	0.00	6.31E-07	6.31E-07
NNW	1.09E-06	3.80E-07	0.00	3.48E-07	2.98E-07
N	1.24E-06	5.11E-07	0.00	5.24E-07	5.24E-07

* Zeroes indicate that this point was not calculated

** A milk goat is located here

TABLE A-4

X/Q Values for Long-Term Ground Level Releases at Standard Distances (sec/m^3)

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Ground Level

Variable: Relative Concentration (Sec./Cubic Meter)

Calculation Points: Standard

Model: Straight Line (ANNXOQ9)

Application of Terrain Correction Factors: Yes

Number of Observations: 8703

BASE DISTANCE IN MILES/KILOMETERS

Aftd Sect	Design Dist MI	.25 .40	.75 1.21	1.25 2.01	1.75 2.82	2.25 3.62	2.75 4.42	3.25 5.23	3.75 6.03	4.25 6.84	4.75 7.64
NNE	0.	8.8E-05	1.5E-05	6.4E-06	3.5E-06	2.3E-06	1.7E-06	1.1E-06	8.0E-07	5.5E-07	3.7E-07
NE	0.	3.9E-05	4.6E-06	2.0E-06	1.1E-06	6.9E-07	4.6E-07	3.5E-07	2.8E-07	2.2E-07	1.7E-07
ENE	0.	3.2E-05	5.2E-06	1.8E-06	9.7E-07	5.3E-07	3.8E-07	2.6E-07	2.1E-07	1.7E-07	1.5E-07
E	0.	2.9E-05	4.5E-06	1.6E-06	8.3E-07	6.2E-07	3.3E-07	2.7E-07	1.9E-07	1.3E-07	9.5E-08
ESE	0.	3.6E-05	5.4E-06	2.3E-06	1.3E-06	9.2E-07	6.2E-07	5.1E-07	3.6E-07	2.7E-07	1.9E-07
SE	0.	4.0E-05	5.4E-06	2.6E-06	1.3E-06	8.5E-07	4.8E-07	3.6E-07	2.1E-07	1.9E-07	1.6E-07
SSE	0.	8.2E-05	1.2E-05	5.0E-06	2.6E-06	1.5E-06	9.2E-07	6.5E-07	5.5E-07	4.5E-07	4.0E-07
S	0.	3.6E-05	4.4E-06	1.7E-06	9.1E-07	4.2E-07	3.3E-07	2.6E-07	2.1E-07	1.7E-07	1.4E-07
SSW	0.	2.5E-05	4.6E-06	1.9E-06	7.9E-07	4.5E-07	3.0E-07	2.1E-07	1.6E-07	1.2E-07	9.8E-08
SW	0.	1.5E-05	2.2E-06	8.3E-07	3.7E-07	2.3E-07	1.6E-07	1.2E-07	8.8E-08	7.1E-08	5.9E-08
WSW	0.	6.5E-06	1.0E-06	3.7E-07	2.0E-07	1.6E-07	1.0E-07	6.9E-08	5.8E-08	4.8E-08	3.7E-08
W	0.	6.5E-06	8.3E-07	3.2E-07	1.7E-07	1.3E-07	8.8E-08	6.7E-08	4.3E-08	3.0E-08	2.4E-08
WNW	0.	6.1E-06	7.8E-07	3.0E-07	1.8E-07	1.3E-07	9.6E-08	7.1E-08	5.4E-08	4.0E-08	3.0E-08
NW	0.	1.1E-05	1.6E-06	7.4E-07	4.2E-07	2.4E-07	1.3E-07	8.0E-08	6.7E-08	5.3E-08	4.4E-08
NNW	0.	2.0E-05	3.6E-06	1.9E-06	1.4E-06	9.4E-07	5.2E-07	2.7E-07	1.8E-07	1.2E-07	9.2E-08
N	0.	5.2E-05	8.0E-06	3.3E-06	1.6E-06	1.0E-06	7.1E-07	4.9E-07	3.7E-07	2.9E-07	2.4E-07

Number of Valid Observations	=	8703
Number of Invalid Observations	=	57
Number of Calms Lower Level	=	398
Number of Calms Upper Limit	=	0

TABLE A-5

Depleted X/Q Values for Long-Term Ground Level Releases at Standard Distances (sec/m^3)

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Ground Level

Variable: Relative Concentration (Sec./Cubic Meter)

Calculation Points: Standard

Model: Straight Line (ANNXOQ9)

Application of Terrain Correction Factors: Yes

Number of Observations: 8703

BASE DISTANCE IN MILES/KILOMETERS

Aftd Sect	Design Dist MI	.25 .40	.75 1.21	1.25 2.01	1.75 2.82	2.25 3.62	2.75 4.42	3.25 5.23	3.75 6.03	4.25 6.84	4.75 7.64
NNE	0.	8.3E-05	1.3E-05	5.4E-06	3.0E-06	2.0E-06	1.3E-07	8.3E-06	6.2E-07	4.1E-07	2.7E-07
NE	0.	3.6E-05	4.1E-06	1.7E-06	9.2E-07	5.6E-07	3.6E-07	2.7E-07	2.1E-07	1.6E-07	1.3E-07
ENE	0.	3.1E-05	4.6E-06	1.5E-06	8.3E-07	4.3E-07	3.0E-07	2.0E-07	1.6E-07	1.3E-07	1.1E-07
E	0.	2.7E-05	4.1E-06	1.3E-06	6.9E-07	5.0E-07	2.7E-07	2.1E-07	1.4E-07	9.4E-08	7.2E-08
ESE	0.	3.4E-05	4.9E-06	2.0E-06	1.1E-06	7.4E-07	5.0E-07	4.0E-07	2.9E-07	2.1E-07	1.5E-07
SE	0.	3.8E-05	4.9E-06	2.2E-06	1.1E-06	7.0E-07	3.8E-07	2.8E-07	1.7E-07	1.4E-07	1.2E-07
SSE	0.	7.8E-05	1.1E-05	4.4E-06	2.2E-06	1.3E-06	7.6E-07	5.1E-07	4.3E-07	3.3E-07	2.9E-07
S	0.	3.5E-05	3.9E-06	1.4E-06	7.6E-07	3.5E-07	2.6E-07	2.0E-07	1.6E-07	1.3E-07	1.1E-07
SSW	0.	2.3E-05	4.1E-06	1.6E-06	6.6E-07	3.7E-07	2.4E-07	1.7E-07	1.2E-07	8.9E-08	6.9E-08
SW	0.	1.4E-05	1.9E-06	7.1E-07	3.1E-07	1.9E-07	1.2E-07	9.8E-08	6.7E-08	5.0E-08	4.3E-08
WSW	0.	6.2E-06	9.2E-07	3.2E-07	1.7E-07	1.3E-07	8.0E-08	5.4E-08	4.4E-08	3.6E-08	2.7E-08
W	0.	6.1E-06	7.5E-07	2.8E-07	1.4E-07	1.1E-07	6.8E-08	5.2E-08	3.3E-08	2.3E-08	1.8E-08
WNW	0.	5.8E-06	7.0E-07	2.6E-07	1.5E-07	1.1E-07	7.6E-08	5.5E-08	4.2E-08	3.0E-08	2.2E-08
NW	0.	1.1E-05	1.4E-06	6.4E-07	1.4E-07	2.0E-07	1.0E-07	6.1E-08	5.0E-08	4.0E-08	3.3E-08
NNW	0.	1.9E-05	3.1E-06	1.6E-06	1.1E-06	7.6E-07	4.2E-07	2.0E-07	1.3E-07	8.8E-08	7.1E-08
N	0.	4.9E-05	7.2E-06	2.8E-06	1.4E-06	8.1E-07	5.6E-07	3.8E-07	2.9E-07	2.2E-07	1.8E-07

Number of Valid Observations	=	8703
Number of Invalid Observations	=	57
Number of Calms Lower Level	=	398
Number of Calms Upper Limit	=	0

TABLE A-18

D/Q Values for Short-Term Mixed Mode Releases at Special Locations (m^{-2})*

Carolina Power & Light Company - Robinson
Release Type: Purge
Release Mode: Mixed Mode
Variable: Relative Deposition Rate (Meter^{-2})
Calculation Points: Special
Model: Purge (ACNPURG2)
Application of Terrain Correction Factors: No
Number of Observations: 8703
Purge Time: 100 Hours

Affected Sector	Site Boundary	Meat	Dairy	Resident	Garden
NNE	5.77E-09	3.45E-09	0.00	5.70E-09	4.68E-09
NE	7.18E-09	5.72E-09	4.70E-09	5.20E-09	4.70E-09
ENE	1.04E-08	1.16E-09	0.00	9.77E-09	1.74E-09
E	2.08E-08	8.36E-10	5.32E-10	1.06E-08	9.36E-10
ESE	2.12E-08	2.22E-09	0.00	1.73E-08	1.73E-08
SE	2.99E-08	0.00	0.00	2.88E-08	2.88E-08
SSE	1.81E-08	0.00	0.00	1.64E-08	1.64E-08
S	3.04E-08	9.84E-10	0.00	2.80E-08	2.48E-08
SSW	3.66E-08	2.33E-09	0.00	3.72E-08	2.78E-08
SW	2.20E-08	1.48E-09	1.18E-09**	2.14E-08	1.97E-08
WSW	2.83E-08	1.23E-09	0.00	2.55E-08	2.07E-08
W	2.09E-08	4.69E-10	0.00	1.62E-08	1.62E-08
WNW	2.01E-08	6.45E-10	0.00	1.38E-08	8.18E-09
NW	4.98E-09	3.00E-09	0.00	4.53E-09	4.53E-09
NNW	2.32E-09	9.15E-10	0.00	8.99E-10	8.09E-10
N	1.36E-09	5.75E-10	0.00	6.24E-10	6.24E-10

* Zeroes indicate that this point was not calculated

** A milk goat is located here

The concentration of tritium in milk is based on the airborne concentration rather than the deposition. Therefore, the R_i is based on X/Q:

$$R_{T_M} = K'K'''F_m Q_F U_{ap} (DFL_i)_a \, 0.75(0.5/H) \qquad (B.2\text{-}4)$$

where:

R_{T_M} = Dose factor for the cow or goat milk pathway for tritium for the organ of interest, mrem/yr per $\mu Ci/m^3$;

K''' = A constant of unit conversion;
= 10^3 gm/kg;

H = Absolute humidity of the atmosphere, gm/m^3;

0.75 = The fraction of total feed that is water;

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

and other parameters and values are given above. A value of H = 8 grams/meter^3, was used in lieu of site-specific information.

B.2.4 Grass-Cow-Meat Pathway

The integrated concentration in meat follows in a similar manner to the development for the milk pathway, therefore:

$$R_{i_B} = I_i K' Q_F U_{ap} F_f \, (DFL_i)_a \, e^{-\lambda_i t_s} \left[f_p f_s \left[\frac{r(1-e^{-\lambda_{E_i} t_e})}{Y_p \, \lambda_{E_i}} + \frac{B_{iv} \, (1-e^{-\lambda_i t_b})}{P \lambda_i} \right] + \right.$$

$$\left. (1-f_p f_s) \left[\frac{r(1-e^{-\lambda_{E_i} t_e})}{Y_s \, \lambda_{E_i}} + \frac{B_{iv} \, (1-e^{-\lambda_i t_b})}{P \lambda_i} \right] e^{-\lambda_i t_h} \right] \qquad (B.2\text{-}5)$$

where:

R_{i_B} = Dose factor for the meat ingestion pathway for radionuclide "i" for any organ of interest, mrem/yr per $\mu Ci/sec$ per m^{-2};

F_f = The stable element transfer coefficients, pCi/Kg per pCi/day;

U_{ap} = The receptor's meat consumption rate for age group a, kg/yr;

t_s = The transport time from slaughter to consumption, sec;

t_h = The transport time from harvest to animal consumption, sec;

t_e = Period of pasture grass and crop exposure during the growing season, sec;

I_i = Factor to account for fractional deposition of radionuclide "i."

For radionuclides other than iodine, I_i is equal to one. For radioiodines, the value of I_i may vary. However, a value of 1.0 was used in calculating the R values in Tables 3.3-6 through 3.3-8.

All other terms remain the same as defined in Equation B.2-3. Table B-2 contains the values which were used in calculating R_i for the meat pathway.

The concentration of tritium in meat is based on its airborne concentration rather than the deposition. Therefore, the R_i is based on X/Q.

$$R_{T_B} = K'K'''F_f Q_F U_{ap} (DFL_i)_a \; 0.75(0.5/H) \qquad (B.2\text{-}6)$$

where:

R_{T_B} = Dose factor for the meat ingestion pathway for tritium for any organ of interest, mrem/yr per $\mu Ci/m^3$.

All other terms are defined in Equations B.2-4 and B.2-5.

B.2.5 Vegetation Pathway

The integrated concentration in vegetation consumed by man follows the expression developed in the derivation of the milk factor. Man is considered to consume two types of vegetation (fresh and stored) that differ only in the time period between harvest and consumption, therefore:

$$R_{i_V} = I_i K' (DFL_i)_a \left[U_a^L f_L \, e^{-\lambda_i t_L} \left[\frac{r(1-e^{-\lambda_{E_i} t_e})}{Y_v \lambda_{E_i}} + \frac{B_{iv}(1-e^{-\lambda_i t_b})}{P \lambda_i} \right] + U_a^S f_g \, e^{-\lambda_i t_h} \left[\frac{r(1-e^{-\lambda_{E_i} t_e})}{Y_v \lambda_{E_i}} + \frac{B_{iv}(1-e^{-\lambda_i t_b})}{P \lambda_i} \right] \right] \quad (B.2\text{-}7)$$

where:

R_{i_V} = Dose factor for vegetable pathway for radionuclide "i" for the organ of interest, mrem/yr per μCi/sec per m^{-2};

K' = A constant of unit conversion;
= 10^6 pCi/μCi;

U_a^L = The consumption rate of fresh leafy vegetation by the receptor in age group a, kg/yr;

U_a^S = The consumption rate of stored vegetation by the receptor in age group a, kg/yr;

f_L = The fraction of the annual intake of fresh leafy vegetation grown locally;

f_g = The fraction of the annual intake of stored vegetation grown locally;

t_L = The average time between harvest of leafy vegetation and its consumption, sec;

TABLE D-1
Liquid Process Monitors

Name	RMS #	ID #	Drawing #
Containment Vessel Fan Cooling Water	16	R-16	C997261
Component Cooling Water	17	R-17	C997246
Liquid Waste Disposal	18	PI 871109	NRC Industries 4PI Liquid Sample Manual
Condensate Polisher Liquid Waste	37	R-37	Plant Mod.-723 H.B.R.-2-9065
Steam Generator Blowdown	19	R-19	997261

Liquid Radwaste Flow Measurement Devices

Liquid Radwaste Flow (ITT Barton Flow Integrator)	N/A	FT 1064	