

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

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CAROLINA POWER & LIGHT COMPANY

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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 Specification 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 1 of 10CFR50, and 40CFR190.

The ODCM is based on "Radiological Effluent Technical Specifications for PWRs (NUREG 0472, Rev. 3, Draft 6), "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 and the H. B. Robinson Unit 2 Standing Orders. 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 Administration Control Section, Specification 6.16.2, of the HBR Technical Specifications.

2.0 LIQUID EFFLUENTS

2.1 MONITOR ALARM SETPOINT DETERMINATION

This procedure 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} $\mu\text{Ci/ml}$ for dissolved or entrained noble gases. The methodology described in Section 2.1.2 provides an alternate means to determine monitor high alarm setpoints that may be used when an analysis is performed prior to release.

2.1.1 Setpoint Based on a Conservative Radionuclide Mix

The following method applies to liquid releases via the discharge canal when determining the high alarm 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 at the maximum design flow rate.

2.1.1.1 Determine the "mix" (radionuclides and composition) of the liquid effluent by the following:

- a. Determine the liquid source terms that are representative of the "mix" of the liquid effluent. Liquid source terms are the radionuclides and the radioactivity levels of the radionuclides in the effluent from Table 2.1-1 or from analysis of the liquid effluent to be released.
- b. Determine S_i (the fraction of the total radioactivity in the liquid effluent comprised by radionuclide "i") for each individual radionuclide in the liquid effluent by:

$$S_i = \frac{A_i}{\sum_i A_i} \quad (2.1-1)$$

A_i = The radioactivity of radionuclide "i" in the liquid effluent from Table 2.1-1 or from analysis of the liquid effluent to be released.

2.1.1.2 Determine C_d (the maximum acceptable diluted radioactivity concentration of all radionuclides in the liquid effluent [$\mu\text{Ci/ml}$]) by:

$$C_d = \frac{1}{\sum_i \left(\frac{S_i}{MPC_i} \right)} \quad (2.1-2)$$

MPC_i = The liquid effluent radioactivity concentration limit for radionuclide "i" ($\mu\text{Ci/ml}$) from Table 2.1-1 or if not listed in Table 2.1-1, obtained from Reference 1.

2.1.1.3 Determine C_u (the maximum acceptable undiluted radioactivity concentration of the radionuclides in the liquid effluent prior to discharge [$\mu\text{Ci/ml}$]) for each of the dilution water flow rates by:

$$C_u = \frac{F \cdot C_d}{f} \quad (2.1.3)$$

F = Dilution water flow rate (gpm).

= 160,000 gpm from one circulating water pump², Unit 2.

= 250,000 gpm from two circulating water pumps², Unit 2.

= 400,000 gpm from three circulating water pumps², Unit 2.

or

= 50,000 gpm from one circulating water pump⁴ Unit 1.

= 80,000 gpm from two circulating water pumps⁴, Unit 1.

- f = The maximum acceptable discharge flow rate prior to dilution (gpm).
- = 60 gpm for the Waste Disposal System Liquid Effluent Monitor.⁵
- = 80 gpm for the Steam Generator Blowdown Monitor during normal operation.⁵
- = 300 gpm for the Steam Generator Blowdown Monitor while draining a steam generator.⁵

2.1.1.4 Determine C_m (the maximum acceptable radioactivity concentration of the radionuclides (excluding tritium) in the liquid discharge prior to dilution [$\mu\text{Ci/ml}$]) for each of the dilution water flow rates by:

$$C_m = C_u - (C_u S_t) \quad (2.1-4)$$

S_t = The fraction of the total radioactivity in the liquid effluent comprised of tritium and other radionuclides that do not emit gamma or X-ray radiation.

2.1.1.5 Determine CR (the calculated monitor count rate above background, in corrected counts per minute [ccpm]), attributed to the radionuclides for each of the dilution water flow rates.

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

E_m = 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.

2.1.1.6 Determine HSP (the monitor high alarm setpoint including background [cpm]) for each of the dilution water flow rates.

$$HSP = (T_m CR + \text{Background [cpm]}) F \quad (2.1-5)$$

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.

= .50 for the Waste Disposal System Liquid Effluent Monitor (RMS-18).

= .50 for the Steam Generator Blowdown Monitor⁵ (RMS-19).

2.1.1.7 The monitor high alarm setpoint shall be set at or below the HSP value for the appropriate liquid effluent stream as calculated above.

2.1.2 Setpoint Based on an Analysis of Liquid Prior to Discharge

The following method applies to liquid releases when determining the setpoint for the maximum acceptable discharge flow rate prior to dilution and determining the associated high alarm setpoint based on this flow rate for the Waste Disposal System Liquid Effluent Monitor (RMS-18) and the Steam Generator Blowdown Monitor (RMS-19) when an analysis of the activity of the principal gamma emitters has been made prior to each batch release.

Note: To be developed at a later date.

TABLE 2.1-1 LIQUID SOURCE TERMS

<u>RADIONUCLIDE</u>	<u>MPC_i¹ (μCi/ml)</u>	WASTE DISPOSAL SYSTEM ³		
		<u>A_i (Ci/yr)*</u>	<u>S_i</u>	<u>S_i/MPC_i</u>
H-3	3 E-3	4.50 E2	9.83 E-1	3.28 E2
Mo-99	4 E-5	6.70 E-1	1.46 E-3	3.65 E1
Te-132	2 E-5	1.70 E-1	3.71 E-4	1.86 E1
I-131	3 E-7	2.00 E0	4.37 E-3	1.46 E4
I-132	8 E-6	1.20 E0	2.62 E-3	3.28 E2
I-133	1 E-6	2.40 E0	5.24 E-3	5.24 E3
I-135	4 E-6	9.60 E-1	2.10 E-3	5.25 E2
Cs-134	9 E-6	2.10 E-1	4.59 E-4	5.10 E1
Cs-137	2 E-5	1.50 E-1	3.28 E-4	1.64 E1
TOTAL		4.58 E2		2.11 E4

* Liquid source terms are also applicable for the Steam Generator Blow-down.

SECTION 2.1 REFERENCES

1. 10CFR20 Appendix B, Table II, Column 2.
2. Carolina Power & Light Company Drawing Number G-190825. Using the System Q-H Curve for Emergency Low Water Level.
3. Evaluation of H. B. Robinson Unit 2 to Demonstrate Conformance to the Design Objectives of 10CFR50, Appendix I, Table 2-4.
4. Carolina Power & Light Company, Darlington County S.E. Plant. 1960-182 MW Installation, Unit 1. SYSTEM HEAD CURVES Unit 1 Circulating Water System Draining Quosig.
5. H. B. Robinson Electric Plant Unit 2, Updated Final Safety Analysis Report.

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 sample 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 a given radionuclide mix 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:

$$\text{Conc}_i = \frac{C_{ic} V_c}{V_{dc}} \quad (2.2-1)$$

where:

Conc_i = Concentration of radionuclide "i" at the unrestricted area, $\mu\text{Ci/ml}$;

C_{ic} = Concentration of radionuclide "i" in the continuous release, $\mu\text{Ci/ml}$;

V_c = Volume of continuous effluent released, gal;

V_{dc} = Volume of dilution flow during release, gal.

2.2.2 Batch Releases

Batch releases will occur during normal operation. When this does occur at HBR, a continuous release will usually also be occurring at the same time. However, during certain shutdown conditions, only batch releases may occur at HBR. Therefore, both situations are treated here to provide the methodology to show compliance with 10CFR20.

2.2.2.1 Prerelease

The radioactivity content of each batch release will be determined prior to release in accordance with Table 4.10-1 of the technical specifications for HBR. HBR will show compliance with 10CFR20 in the following manner:

For the case where only a batch release is to occur, the concentration of the various radionuclides in the batch release, determined in accordance with Table 4.10-1 of the technical specifications for HBR, is multiplied by the ratio of the maximum release rate of the potential batch release to the dilution flow rate to obtain the concentration at the unrestricted area. This calculation is shown in the following equation:

$$\text{Conc}_i = \frac{C_{ib} R_b}{D_{fr}} \quad (2.2-2)$$

where:

Conc_i = Concentration of radionuclide "i" at the unrestricted area, $\mu\text{Ci/ml}$;

C_{ib} = Concentration of radionuclide "i" in the potential batch release, $\mu\text{Ci/ml}$;

R_b = Release rate of the potential batch release, gpm;

D_{fr} = The dilution flow rate based upon the number of circulating water pumps in service during the release, gpm.

The concentration in the unrestricted area is compared to the concentrations in Appendix B, Table II, Column 2, of 10CFR20. Before release may occur, the mixture of radionuclides released must be of such concentration that Equation 2.2-3 is met.

$$\sum_i (\text{Conc}_i / \text{MPC}_i) \leq 1 \quad (2.2-3)$$

where:

MPC_i = Maximum permissible concentration of radionuclide "i" from Appendix B, Table II, Column 2 of 10CFR20, $\mu\text{Ci/ml}$.

For those cases where batch releases may be occurring at the same time that continuous releases are occurring, the concentration in the unrestricted area will be calculated by the following equation:

$$\text{Conc}_i = \frac{C_{ib} R_b + C_{ic} R_c}{D_{fr}} \quad (2.2-4)$$

where:

R_c = Maximum continuous liquid effluent release rate, gpm.

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

For the HBR, the liquid radwaste system 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 3 circulating water pumps. Pump curves show that with 3 pumps operating, the circulating water flow is 400,000 gpm, with 2 pumps--

250,000 gpm, and with 1 pump--160,000 gpm. Unit 1 of the H. B. Robinson Steam Electric Plant has 2 circulating water pumps. The circulating water flow is 50,000 gpm with 1 pump and 80,000 gpm with 2 pumps. At least 1 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, and the steam generators. The maximum release rate (R_b) is 300 gpm for the steam generators and 60 gpm from the monitor and waste condensate tanks.

2.2.2.2 Postrelease

The Steam Generation Blowdown Monitor (RMS-19) and the Waste Disposal System Liquid Monitor (RMS-18) 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 and 10CFR20 limits may not actually be 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:

For the case where only batch releases are occurring, the total activity of radionuclide "i" released is divided by the actual dilution flow to obtain the concentration in the unrestricted area. This calculation is shown in the following equation:

$$\text{Conc}_{ik} = \frac{C_{ikb} V_{kb}}{V_{kd}} \quad (2.2-5)$$

where:

Conc_{ik} = The concentration of radionuclide "i" at the unrestricted area during release k, $\mu\text{Ci/ml}$;

C_{ikb} = Concentration of radionuclide "i" in the batch release k, $\mu\text{Ci/ml}$;

V_{kb} = Volume of batch release k, gal;

V_{kd} = Actual volume of dilution flow during release k, gal.

To show compliance with 10CFR20, the following relationship must hold:

$$\sum_i (\text{Conc}_{ik} / \text{MPC}_i) \leq 1 \quad (2.2-6)$$

The actual dilution volume during release k (V_{kd}) is calculated by the following equation:

$$V_{kd} = 60 \sum_k (D_{fr}) t_k \quad (2.2-7)$$

where:

60 = Conversion factor, min/hr;

t_k = Duration of release k, hr;

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:

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

where:

C_{ikc} = Concentration of radionuclide "i" in continuous releases during release period k, $\mu\text{Ci/ml}$;

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

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:

$$D_{\tau b} = \sum_k \sum_i A_{i\tau} t_{kb} C_{ikb} F_{kb} e^{-\lambda_i t_p} \quad (2.3-1)$$

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, $\mu\text{Ci/ml}$;

$A_{i\tau}$ = 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 ;

λ_i = Radiological decay constant of radionuclide "i", hr^{-1} ;

= $0.693/(t_{1/2})_i$

$(t_{1/2})_i$ = Radiological half-life of radionuclide "i", hr;

t_p = average transport time to reach the point of exposure, hr;

= 24 hours for the fish pathway from Equation A-3 of Regulatory Guide 1.101, Rev. 1.

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:

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

where:

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

21 = Adult fish consumption rate from Table A-2 of Regulatory Guide 1.101, Rev. 1, kg/yr;

BF_i = Bioaccumulation factor for radionuclide "i" in fish from Table A-1 of Regulatory Guide 1.109, Rev. 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, Rev. 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. Values of $\exp(-\lambda_i t_p)$ are presented in Table 2.3-2 as a function of radionuclide.

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:

$$D_{\tau c} = \sum_k \sum_i A_{i\tau} t_{kc} C_{ikc} F_{kc} e^{-\lambda_i t_p} \quad (2.3-3)$$

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, $\mu\text{Ci/ml}$;

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 the 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,

$$D_{\tau} \leq 1.5 \text{ mrem total body} \quad (2.3-4)$$

$$D_{\tau} \leq 5 \text{ mrem any organ} \quad (2.3-5)$$

For the calendar year,

$$D_{\tau} \leq 3 \text{ mrem total body} \quad (2.3-6)$$

$$D_{\tau} \leq 10 \text{ mrem any organ} \quad (2.3-7)$$

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 6.9.4.a must be filed with the NRC. This report complies with Section IV.A of Appendix I of 10CFR50.

2.3.2 Projection of Doses

Doses resulting from the release of liquid effluents will be projected once per month. The doses will be projected using Equations 2.3-1 and 2.3-3 with F_{kb} and F_{kc} now based on minimum dilution flow rate (D_{fr}) as given in Equation 2.2-2 rather than dilution volume (V_{kd}) and based upon the maximum release rates (R_b and R_c) as given in Equation 2.2-4 rather than actual release volume (V_b and V_c). C_{ikb} and C_{ikc} are based on the projected releases for the remainder of the calendar quarter.

TABLE 2.3-1
 A_{1T} VALUES FOR THE ADULT FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT
(MREM/HR PER MICRO-Ci/ML)

<u>Nuclide</u>	<u>Bone</u>	<u>Liver</u>	<u>T.Body</u>	<u>Thyroid</u>	<u>Kidney</u>	<u>Lung</u>	<u>GI-LLI</u>
H-3	0.00E-01	2.26E 01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01
C-14	3.13E-04	6.26E 03	6.26E-03	6.26E-03	6.26E-03	6.26E-03	6.26E-03
Na-24	4.07E-02	4.07E 02	4.07E-02	4.07E-02	4.07E-02	4.07E-02	4.07E-02
P-32	4.62E-07	2.87E 06	1.79E 06	0.00E-01	0.00E-01	0.00E-01	5.19E 06
Cr-51	0.00E-01	0.00E-01	1.27E 00	7.61E-01	2.81E-01	1.69E 00	3.20E 02
Mn-54	0.00E-01	4.38E 03	8.35E 02	0.00E-01	1.30E 03	0.00E-01	1.34E 04
Mn-56	0.00E-01	1.10E 02	1.95E 01	0.00E-01	1.40E 02	0.00E-01	3.51E 03
Fe-55	6.58E 02	4.55E 02	1.06E 02	0.00E-01	0.00E-01	2.54E 02	2.61E 02
Fe-59	1.04E 03	2.44E 03	9.36E 02	0.00E-01	0.00E-01	6.82E 02	8.14E 03
Co-58	0.00E-01	8.92E 01	2.00E 02	0.00E-01	0.00E-01	0.00E-01	1.81E 03
Co-60	0.00E-01	2.56E 02	5.65E 02	0.00E-01	0.00E-01	0.00E-01	4.81E 03
Ni-63	3.11E 04	2.16E 03	1.04E 03	0.00E-01	0.00E-01	0.00E-01	4.50E 02
Ni-65	1.26E 02	1.64E 01	7.49E 00	0.00E-01	0.00E-01	0.00E-01	4.17E 02
Cu-64	0.00E-01	9.97E 00	4.68E 00	0.00E-01	2.51E 01	0.00E-01	8.50E 02
Zn-65	2.32E 04	7.37E 04	3.33E 04	0.00E-01	4.93E 04	0.00E-01	4.64E 04
Zn-69	4.93E 01	9.43E 01	6.56E 00	0.00E-01	6.13E 01	0.00E-01	1.42E 01
Br-83	0.00E-01	0.00E-01	4.04E 01	0.00E-01	0.00E-01	0.00E-01	5.82E 01
Br-84	0.00E-01	0.00E-01	5.24E 01	0.00E-01	0.00E-01	0.00E-01	4.11E-04
Br-85	0.00E-01	0.00E-01	2.15E 00	0.00E-01	0.00E-01	0.00E-01	1.01E-15
Rb-86	0.00E-01	1.01E 05	4.71E 04	0.00E-01	0.00E-01	0.00E-01	1.99E 04
Rb-88	0.00E-01	2.90E 02	1.54E 02	0.00E-01	0.00E-01	0.00E-01	4.00E-09
Rb-89	0.00E-01	1.92E 02	1.35E 02	0.00E-01	0.00E-01	0.00E-01	1.12E-11
Sr-89	2.21E 04	0.00E-01	6.35E 02	0.00E-01	0.00E-01	0.00E-01	3.55E 03
Sr-90	5.44E 05	0.00E-01	1.34E 05	0.00E-01	0.00E-01	0.00E-01	1.57E 04
Sr-91	4.07E 02	0.00E-01	1.64E 01	0.00E-01	0.00E-01	0.00E-01	1.94E 03
Sr-92	1.54E 02	0.00E-01	6.68E 00	0.00E-01	0.00E-01	0.00E-01	3.06E 03
Y-90	5.76E-01	0.00E-01	1.54E-02	0.00E-01	0.00E-01	0.00E-01	6.10E 03
Y-91M	5.44E-03	0.00E-01	2.11E-04	0.00E-01	0.00E-01	0.00E-01	1.60E-02
Y-91	8.44E 00	0.00E-01	2.26E-01	0.00E-01	0.00E-01	0.00E-01	4.64E 03
Y-92	5.06E-02	0.00E-01	1.48E-03	0.00E-01	0.00E-01	0.00E-01	8.86E 02
Y-93	1.60E-01	0.00E-01	4.43E-03	0.00E-01	0.00E-01	0.00E-01	5.09E 03
Zr-95	2.40E-01	7.70E-02	5.21E-02	0.00E-01	1.21E-01	0.00E-01	2.44E 02
Zr-97	1.33E-02	2.68E-03	1.22E-03	0.00E-01	4.04E-03	0.00E-01	8.30E 02
Nb-95	4.47E 02	2.48E 02	1.34E 02	0.00E-01	2.46E 02	0.00E-01	1.51E 06
Mo-99	0.00E-01	1.03E 02	1.96E 01	0.00E-01	2.34E 02	0.00E-01	2.39E 02

TABLE 2.3-1 (continued)

<u>Nuclide</u>	<u>Bone</u>	<u>Liver</u>	<u>T.Body</u>	<u>Thyroid</u>	<u>Kidney</u>	<u>Lung</u>	<u>GI-LLI</u>
Tc-99M	8.87E-03	2.51E-02	3.19E-01	0.00E-01	3.81E-01	1.23E-02	1.48E-01
Tc-101	9.12E-03	1.31E-02	1.29E-01	0.00E-01	2.37E-01	6.72E-03	3.95E-14
Ru-103	4.43E-00	0.00E-01	1.91E-00	0.00E-01	1.69E-01	0.00E-01	5.17E-02
Ru-105	3.69E-01	0.00E-01	1.46E-01	0.00E-01	4.76E-00	0.00E-01	2.26E-02
Ru-106	6.58E-01	0.00E-01	3.33E-00	0.00E-01	1.27E-02	0.00E-01	4.26E-03
Ag-110M	8.81E-01	8.15E-01	4.84E-01	0.00E-01	1.60E 00	0.00E-01	3.33E 02
Te-125M	2.57E 03	9.30E 02	3.44E 02	7.72E 02	1.04E 04	0.00E-01	1.02E 04
Te-127M	6.48E 03	2.32E 03	7.90E 02	1.66E 03	2.63E 04	0.00E-01	2.17E 04
Te-127	1.05E 02	3.76E 01	2.28E 01	7.80E 01	4.29E 02	0.00E-01	8.31E 03
Te-129M	1.10E 04	4.11E 03	1.74E 03	3.78E 03	4.60E 04	0.00E-01	5.54E 04
Te-129	3.01E 01	1.13E 01	7.33E 00	2.31E 01	1.26E 02	0.00E-01	2.27E 01
Te-131M	1.66E 03	8.10E 02	6.75E 02	1.28E 03	8.21E 03	0.00E-01	8.04E 04
Te-131	1.89E 01	7.88E 00	5.96E 00	1.55E 01	8.26E 01	0.00E-01	2.67E 00
Te-132	2.41E 03	1.56E 03	1.47E 03	1.72E 03	1.50E 04	0.00E-01	7.38E 04
I-130	2.71E 01	8.01E 01	3.16E 01	6.79E 03	1.25E 02	0.00E-01	6.89E 01
I-131	1.49E 02	2.14E 02	1.22E 02	7.00E 04	3.66E 02	0.00E-01	5.64E 01
I-132	7.29E 00	1.95E 01	6.82E 00	6.82E 02	3.11E 01	0.00E-01	3.66E 00
I-133	5.10E 01	8.87E 01	2.70E 01	1.30E 04	1.55E 02	0.00E-01	7.97E 01
I-134	3.81E 00	1.03E 01	3.70E 00	1.79E 02	1.64E 01	0.00E-01	9.01E-03
I-135	1.59E 01	4.17E 01	1.54E 01	2.75E 03	6.68E 01	0.00E-01	4.70E 01
Cs-134	2.98E 05	7.09E 05	5.79E 05	0.00E-01	2.29E 05	7.61E 04	1.24E 04
Cs-136	3.12E 04	1.23E 05	8.86E 04	0.00E-01	6.85E 04	9.38E 03	1.40E 04
Cs-137	3.82E 05	5.22E 05	3.42E 05	0.00E-01	1.77E 05	5.89E 04	1.01E 04
Cs-138	2.64E 02	5.22E 02	2.59E 02	0.00E-01	3.84E 02	3.79E-01	2.23E-03
Ba-139	9.29E-01	6.62E-04	2.72E-02	0.00E-01	6.19E-04	3.75E-04	1.65E 00
Ba-140	1.94E 02	2.44E-01	1.27E 01	0.00E-01	8.30E-02	1.40E-01	4.00E 02
Ba-141	4.51E-01	3.41E-04	1.52E-02	0.00E-01	3.17E-04	1.93E-04	2.13E-10
Ba-142	2.04E-01	2.10E-04	1.28E-02	0.00E-01	1.77E-04	1.19E-04	2.87E-19
La-140	1.50E-01	7.54E-02	1.99E-02	0.00E-01	0.00E-01	0.00E-01	5.54E 03
La-142	7.66E-03	3.48E-03	8.68E-04	0.00E-01	0.00E-01	0.00E-01	2.54E 01
Ce-141	2.24E-02	1.52E-02	1.72E-03	0.00E-01	7.04E-03	0.00E-01	5.79E 01
Ce-143	3.95E-03	2.92E 00	3.23E-04	0.00E-01	1.29E-03	0.00E-01	1.09E 02
Ce-144	1.17E 00	4.88E-01	6.27E-02	0.00E-01	2.90E-01	0.00E-01	3.95E 02
Pr-143	5.51E-01	2.21E-01	2.73E-02	0.00E-01	1.27E-01	0.00E-01	2.41E 03
Pr-144	1.80E-03	7.48E-04	9.16E-05	0.00E-01	4.22E-04	0.00E-01	2.59E-10
Nd-147	3.76E-01	4.35E-01	2.60E-02	0.00E-01	2.54E-01	0.00E-01	2.09E 03
W-187	2.96E 02	2.47E 02	8.65E 01	0.00E-01	0.00E-01	0.00E-01	8.10E 04
Np-239	2.85E-02	2.80E-03	1.54E-03	0.00E-01	8.74E-03	0.00E-01	5.75E 02

TABLE 2.3-2

Values of $e^{-\lambda_i t_p}$ For Liquid Dose Calculations

Radionuclide	$\lambda_i(\text{hr}^{-1})$	$e^{-\lambda_i t_p^*}$	Radionuclide	$\lambda_i(\text{hr}^{-1})$	$e^{-\lambda_i t_p^*}$
H-3	6.43E-6	1.00	Zr-95	4.44E-4	9.89E-1
C-14	1.38E-8	1.00	Zr-97	4.08E-2	3.76E-1
F-18	3.75E-1	1.23E-4	Nb-95	8.25E-4	9.80E-1
Na-24	4.62E-2	3.30E-1	Mo-99	1.03E-2	7.81E-1
P-32	2.02E-3	9.53E-1	Tc-99m	1.16E-1	6.18E-2
Cr-51	1.04E-3	9.75E-1	Tc-101	2.97	0.00
Mn-54	9.53E-5	9.98E-1	Ru-103	7.29E-4	9.83E-1
Mn-56	2.69E-1	1.57E-3	Ru-105	1.56E-1	2.37E-2
Fe-55	3.04E-5	9.99E-1	Ru-106	7.87E-5	9.98E-1
Fe-59	6.42E-4	9.85E-1	Ag-110m	1.14E-4	9.97E-1
Co-58	4.05E-4	9.90E-1	Sb-124	4.81E-4	9.89E-1
Co-60	1.50E-5	1.00	Te-125m	4.98E-4	9.88E-1
Ni-63	8.60E-7	1.00	Te-127m	2.65E-4	9.94E-1
Ni-65	2.71E-1	1.50E-3	Te-127	7.37E-2	1.71E-1
Cu-64	5.42E-2	2.72E-1	Te-129m	8.49E-4	9.80E-1
Zn-65	1.18E-4	9.97E-1	Te-129	6.03E-1	5.19E-7
Zn-69	7.29E-1	2.52E-8	Te-131m	2.31E-2	5.74E-1
Br-83	2.89E-1	9.72E-4	Te-131	1.66	4.99E-18
Br-84	1.31	2.22E-14	Te-132	8.89E-3	8.08E-1
Br-85	1.39E-1	0.00	I-130	5.59E-2	2.61E-1
Rb-86	1.55E-3	9.63E-1	I-131	3.59E-3	9.17E-1
Rb-88	2.33	5.18E-25	I-132	3.01E-1	7.29E-4
Rb-89	2.70	0.00	I-133	3.30E-2	4.53E-1
Sr-89	5.55E-4	9.87E-1	I-134	8.00E-1	4.59E-9
Sr-90	2.80E-6	1.00	I-135	1.03E-1	8.44E-2
Sr-91	7.17E-2	1.79E-1	Cs-134	3.86E-5	9.99E-1
Sr-92	2.56E-1	2.15E-3	Cs-136	2.22E-3	9.48E-1
Y-90	1.08E-2	7.72E-1	Cs-137	2.63E-6	1.00
Y-91m	8.32E-1	2.13E-9	Cs-138	1.29	3.58E-14
Y-91	4.91E-4	9.88E-1	Ba-139	5.02E-1	5.86E-6
Y-92	1.96E-1	9.06E-3	Ba-140	2.26E-3	9.47E-1
Y-93	6.80E-2	1.96E-1	Ba-141	2.31	8.37E-25
Ba-142	3.78	0.00	Pr-143	2.12E-3	9.50E-1
La-140	1.72E-2	6.62E-1	Pr-144	2.41	0.00
La-142	4.52E-1	1.94E-5	Nd-147	2.60E-3	9.40E-1
Ce-141	8.75E-4	9.79E-1	W-187	2.90E-2	4.99E-1
Ce-143	2.09E-2	6.06E-1	Np-239	1.23E-2	7.44E-1
Ce-144	1.02E-4	9.98E-1			

* Note: All values less than 1E-25 are reported as 0.

3.0 GASEOUS EFFLUENTS

3.1 MONITOR ALARM SETPOINT DETERMINATION

This procedure 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 alternate 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 gaseous source terms that are representative of the "mix" of the gaseous effluent. Gaseous source terms are the noble gas activities in the effluent.

Gaseous source terms can be obtained from Table 3.1-1 or from analysis of the gaseous effluent.

- 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.

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

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 [$\mu\text{Ci/sec}$]) based upon the whole body exposure limit of 500 mrem by:

$$Q_m = \frac{500}{(\bar{X}/Q) \sum_i K_i S_i} \quad (3.1-2)$$

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

= $8.1 \text{ E-5 } \text{sec}/\text{m}^3$ (Continuous Ground Release) from Table A-1, Appendix A;

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

= $5.1 \text{ E-5 } \text{sec}/\text{m}^3$ (Batch Ground Release) from Table A-7, Appendix A;

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

K_i = The total whole body dose factor due to gamma emissions from noble gas radionuclide "i" ($\text{mrem}/\text{yr}/\mu\text{Ci}/\text{m}^3$) 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 [$\mu\text{Ci}/\text{sec}$]) based upon the skin exposure limit of 3000 mrem by:

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

$L_i + 1.1 M_i$ = The total skin dose factor due to emissions from noble gas radionuclide "i" ($\text{mrem}/\text{year}/\mu\text{Ci}/\text{m}^3$) 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 [$\mu\text{Ci/cc}$]).

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

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;

2.12 E-3 = Unit conversion constant to convert $\mu\text{Ci/sec/cfm}$ to $\mu\text{Ci/cc}$.

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

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

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:

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

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;
- = 0.80 percent for Plant Vent Gas Monitor (RMS-14);
- = 0.20 percent for the Condenser Vacuum Pump Vent Monitor (RMS-15).

3.1.2 Gaseous Effluents Analyzed Prior to Release


The following method applies to gaseous releases via the plant vent when determining the maximum acceptable effluent flow rate at the point of release and the associated high alarm setpoint based on this flow rate for the Plant Vent Gas Monitor (RMS-14) during the following operational conditions:

- ° Batch release of containment purge
- ° Batch release of containment pressure relief
- ° Batch release of Waste Gas Decay Tanks


NOTE: To develop at a later date.



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Table 3.1-1

Gaseous Source Terms*

Radionuclide	<u>Plant Vent Release</u>		<u>Condenser Vacuum Pump Vent</u>		<u>Containment Purge or Pressure Relief</u>		<u>Gas Decay Tanks</u>	
	<u>A_i (Ci/yr)</u>	<u>S_i</u>	<u>A_i (Ci/yr)</u>	<u>S_i</u>	<u>A_i (Ci/yr)</u>	<u>S_i</u>	<u>A_i (Ci/yr)</u>	<u>S_i</u>
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	1.8E1	7.83E-1	3.1E2	8.99E-1	3.1E1	1.55E-1
Xe-135	4.0E0	1.05E-1	2.0E0	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.

Table 3.1-2

Dose Factors and Constants*

<u>Radionuclide</u>	<u>Total Whole Body Dose Factor (K_i) (mrem/yr/μCi/m³)</u>	<u>Total Skin Dose Factor ($L_i + 1.1 M_i$) (mrem/yr/μCi/m³)</u>
Kr-83m	7.56E-2	2.12E1
Kr-85m	1.17E3	2.81E3
Kr-85	1.61E1	1.36E3
Kr-87	5.92E3	1.65E4
Kr-88	1.47E4	1.91E4
Kr-89	1.66E4	2.91E4
Kr-90	1.56E4	2.52E4
Xe-131m	9.15E1	6.48E2
Xe-133m	2.51E2	1.35E3
Xe-133	2.94E2	6.94E2
Xe-135m	3.12E3	4.41E3
Xe-135	1.81E3	3.97E3
Xe-137	1.42E3	1.39E4
Xe-138	8.83E3	1.43E4
Xe-139	0.00	0.00
Ar-41	8.84E3	1.29E4

*Regulatory Guide 1.109, October 1977, Table B-1 times (1.0 E6 pCi/ μ Ci).

3.2 COMPLIANCE WITH 10CFR20 (GASEOUS)

3.2.1 Noble Gases

The gaseous effluent monitors setpoints are utilized to show compliance with 10CFR20 for noble gases. However, because they are based upon a conservative mix of radionuclides, the possibility exists that the setpoints could be exceeded and yet 10CFR20 limits may actually be met. Therefore, the following methodology has been provided in the event that if the alarm trip setpoints are exceeded, a determination may be made as to whether the actual releases have exceeded 10CFR20.

The dose rate in unrestricted areas resulting from noble gas effluents is limited to 500 mrem/year to the total body and 3000 mrem/year to the skin. Based upon NUREG 0133, the following are used to show compliance with 10CFR20.

$$\sum_i K_i \left[(\overline{X/Q})_v \dot{Q}_{iv} + (\overline{X/Q})_e \dot{Q}_{ie} \right] \leq 500 \text{ mrem/yr} \quad (3.2-1)$$

$$\sum_i (L_i + 1.1M_i) \left[(\overline{X/Q})_v \dot{Q}_{iv} + (\overline{X/Q})_e \dot{Q}_{ie} \right] \leq 3000 \text{ mrem/yr} \quad (3.2-2)$$

where:

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

= From Table A-1 for ground level releases;

= From Table A-10 for mixed mode releases only with upper wind speed of ≥ 9 mph;

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

= From Table A-1 for ground level releases;

- K_i = The total body dose factor due to gamma emissions for noble gas radionuclide "i," mrem/year per $\mu\text{Ci}/\text{m}^3$;
- L_i = The skin dose factor due to beta emissions for noble gas radionuclide "i," mrem/year per $\mu\text{Ci}/\text{m}^3$;
- M_i = The air dose factor due to gamma emissions for noble gas radionuclide "i," mrad/year per $\mu\text{Ci}/\text{m}^3$;
- 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}_{i_e} = The release rate of noble gas radionuclide "i" in gaseous effluents from condenser vacuum pump vent $\mu\text{Ci}/\text{sec}$;
- \dot{Q}_{i_v} = The release rate of noble gas radionuclide "i" in gaseous effluents from the plant vent $\mu\text{Ci}/\text{sec}$.

The determination of limiting location for implementation of 10CFR20 for noble gases is a function of the radionuclide mix, isotopic release rate, and the meteorology.

The radionuclide mix was based upon source terms calculated using the NRC GALE Code. They were calculated based upon the present operating mode of HBR. They are presented in Table 3.2-1 as a function of release point.

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 derivation 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 $1.0 \text{ E}6$ 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 unrestricted areas resulting from the release of radioiodines and particulates with half-lives ≥ 8 days is limited to 1500 mrem/yr to any organ. Based upon NUREG 0133, the following is used to show compliance with 10CFR20.

$$\sum_i \left[P_{i_I} \left[(\overline{X/Q})_v \dot{Q}_{iv} + (\overline{X/Q})_e \dot{Q}_{ie} \right] + (P_{i_M} + P_{i_G}) \left[(\overline{D/Q})_v \dot{Q}_{iv} + (\overline{D/Q})_e \dot{Q}_{ie} \right] + (P_{T_I} + P_{T_M}) \left[(\overline{X/Q})_v \dot{Q}_{TV} + (\overline{X/Q})_e \dot{Q}_{Te} \right] \right] \leq 1500 \text{ mrem/yr} \quad (3.2-3)$$

where:

$(\overline{X/Q})_v$ = Annual average relative dilution for plant vent releases at the site boundary, 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 ≥ 9 mph;

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

= From Table A-1 for ground level releases;

$(\overline{D/Q})_v$ = Annual average deposition factor for plant vent releases at site boundary, m^{-2} ;

= From Table A-3 for ground level releases;

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

$(\overline{D/Q})_e$ = Annual average deposition factor for condenser vacuum pump vent releases at site boundary, m^{-2} ;

= From Table A-3 for ground level releases;

P_{iI} = Dose parameter for radionuclide "i" for the inhalation pathway, mrem/year per $\mu\text{Ci}/\text{m}^3$;

P_{iG} = Dose parameter for radionuclide "i" for the ground plane pathway, mrem/year per $\mu\text{Ci}/\text{sec}$ per m^{-2} ;

P_{iM} = Dose parameter for radionuclide "i" for either the cow milk or goat milk pathway, mrem/year per $\mu\text{Ci/sec per m}^{-2}$;

P_{TI} = Dose parameter for tritium for the inhalation pathway, mrem/year per $\mu\text{Ci/m}^3$;

P_{TM} = Dose parameter for tritium for milk pathway, mrem/year per $\mu\text{Ci/m}^3$;

\dot{Q}_{iv} = Release rate for radionuclide "i" from the plant vent, $\mu\text{Ci/sec}$;

\dot{Q}_{ie} = Release rate of radionuclide "i" from the man condenser vacuum pump vent, $\mu\text{Ci/sec}$;

\dot{Q}_{TV} = Release rate for tritium from the plant vent, $\mu\text{Ci/sec}$;

\dot{Q}_{Te} = Release rate of tritium from the condenser vacuum pump vent, $\mu\text{Ci/sec}$.

In the calculation to show compliance with 10CFR20, only the inhalation, ground plane, cow milk, and goat milk pathways are considered. Equation 3.2-3 is evaluated first at the limiting site boundary. If the 1500 mrem/yr limit is exceeded at the limiting site boundary when all pathways are considered present at this site boundary but the inhalation pathway contributes < 1500 mrem/yr, then Equation 3.2-3 is evaluated at the limiting site boundary is 0.26 miles SSE and the limiting real pathway location is the cow milk pathway 4.2 miles E.

The determination of limiting location for implementation of 10CFR20 for radioiodines and particulates is a function of the same parameters as for

noble gases plus a fourth, actual receptor pathway. The radionuclide mix was again based upon the source terms calculated using the GALE Code. The mix and the source terms are presented in Table 3.2-1 as a function of release point.

The determination of the controlling site boundary location was based upon the highest site boundary D/Q value. The determination of actual receptor limiting location was based upon the milk pathway D/Q value and the P_i value for the respective milk pathway. Values for P_i were calculated for an infant for various radionuclides for the inhalation, ground plane, cow milk, and goat milk pathways using the methodology of NUREG 0133. The P_i values are presented in Table 3.2-4. A description of the methodology used in calculating the P_i values is presented in Appendix B. The values of P_i reflect, for each radionuclide, the maximum P_i value for any organ for each individual pathway of exposure. The goat milk pathway is present near HBR, as is the cow milk pathway. However, the cow milk pathway P_i values were utilized in the determination of the controlling location because the product of the maximum cow milk pathway D/Q and P_i were greater than those for the goat. In addition, the goat milk is not used for human consumption. For the case of an infant being present at the site at the site boundary or at the real pathway location, the ground plane pathway is not considered as a reasonable exposure pathway (i.e., $P_{iG} = 0$). However, P_{iG} values are presented in Table 3.2-4 for completeness.

The annual average D/Q values at the special locations, which will be utilized in Equation 3.2-3, are obtained from the tables presented in Appendix A. The X/Q values which will be utilized in Equation 3.2-3 are also obtained from the tables presented in Appendix A. A description of the derivation of the X/Q and D/Q values is provided in Appendix A.

Table 3.2-1

Releases from H. B. Robinson Unit No. 2*
(Ci/yr)

<u>Isotope</u>	<u>Plant Vent (Q_v)</u>	<u>Condenser Vacuum Pump Vent (Q_e)</u>	<u>Total</u>
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 Conformance 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)

<u>Sector</u>	<u>Site Boundary</u>	<u>Milk Cow</u>	<u>Milk Goat</u>	<u>Meat Animal</u>	<u>Nearest Resident</u>	<u>Nearest Garden</u>
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 $\mu\text{Ci}/\text{m}^3$)	Skin Dose Factor L_i (mrem/yr per $\mu\text{Ci}/\text{m}^3$)	Gamma Air Dose Factor M_i (mrad/yr per $\mu\text{Ci}/\text{m}^3$)	Beta Air Dose Factor N_i (mrad/yr per $\mu\text{Ci}/\text{m}^3$)
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*

<u>Isotope</u>	<u>Inhalation</u>	<u>Ground Plane</u>	<u>Cow Milk</u>	<u>Goat Milk</u>
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	7.28E6
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 $\mu\text{Ci}/\text{m}^3$ for H-3 and the inhalation pathway and mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^{-2} for the food and ground plane pathways.

3.3 COMPLIANCE WITH 10CFR50 (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:

$$D_Y = 3.17 \times 10^{-8} \sum_i M_i \left[(\overline{X/Q})_v \overline{q}_{iv} + (\overline{X/q})_v q_{iv} + (\overline{X/Q})_e Q_{ie} \right] \quad (3.3-1)$$

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

where:

D_Y = 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 $\mu\text{Ci}/\text{m}^3$;

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

$(\overline{X/Q})_v$ = 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 ≥ 9 mph;
- $(\overline{X/Q})_v$ = The dilution for areas at or beyond the unrestricted area boundary for short-term vent releases (≤ 500 hours/year), sec/m^3 ;
- = From Table A-7 for ground level releases;
- = From Table A-16 for mixed mode releases;
- $(\overline{X/Q})_e$ = The annual average dilution for areas at or beyond the unrestricted area boundary for long-term, free-standing stack releases (> 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 (≤ 500 hours/year), μCi ;
- 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 ;
- 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 $(\text{sec/year})^{-1}$.

At HBR the limiting location is 0.26 miles SSE. Based upon the tables presented in Appendix A, substitution of the appropriate X/Q values into

Equation 3.3-1 would yield an equation with the short-term X/Q value being less than the long-term value. Therefore, for this document, only the long-term annual average $\overline{X/Q}$ values (i.e., the more conservative values) will be used.

The determination of the limiting location for implementation of 10CFR50 is a function of parameters such as radionuclide mix, isotopic release, and meteorology. The radionuclide mix was based upon source terms calculated using the NRC GALE Code and is presented in Table 3.2-1 as a function of release point. The only source of short-term releases from the plant vent are containment purges.

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:

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

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

For the calendar year:

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

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

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 Equations 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 month. The doses will be projected using Equations 3.3-1 and 3.3-2.

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 and particulates with half-lives > 8 days in gaseous effluents released to unrestricted areas can be determined by the following equation.

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

$$\begin{aligned}
D\tau = & 3.17 \times 10^{-8} \sum_i \left[R_{iI} \left[(\overline{X/Q})_v Q_{iv} + (\overline{X/Q})_v q_{iv} + (\overline{X/Q})_e Q_{ie} \right] + \right. \\
& (R_{iV} + R_{iG}) \left[(\overline{D/Q})_v Q_{iv} + (\overline{D/Q})_v q_{iv} + (\overline{D/Q})_e Q_{ie} \right] + \\
& \left. (R_{TI} + R_{TV}) \left[(\overline{X/Q})_v Q_{TV} + (\overline{X/Q})_v q_{TV} + (\overline{X/Q})_e Q_{Te} \right] \right] \quad (3.3-7)
\end{aligned}$$

where:

$D\tau$ = Dose to any organ τ from radioiodines and particulates, 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/m³;

= 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/m³;

= 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 (≤ 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_{iG} = Dose factor for an organ for radionuclide "i" for the ground plane exposure pathway, mrem/yr per $\mu Ci/sec$ per m^{-2} ;
- R_{iI} = Dose factor for an organ for radionuclide "i" for the inhalation pathway, mrem/yr per $\mu Ci/m^3$;

- R_{iV} = Dose factor for an organ for radionuclide "i" for the vegetable pathway, mrem/yr per $\mu\text{Ci}/\text{m}^{-2}$;
- R_{TV} = Dose factor for an organ for tritium for the vegetable pathway, mrem/yr per $\mu\text{Ci}/\text{m}^3$;
- R_{TI} = Dose factor for an organ for tritium for the inhalation pathway, mrem/yr per $\mu\text{Ci}/\text{m}^3$;
- Q_{TV} = Release of tritium in gaseous effluents for long-term vent releases (> 500 hrs/yr), μCi ;
- 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 3.3-7 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 3.3-7 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 radio-

iodines 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, inhala-

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:

$$D_T \leq 7.5 \text{ mrem} \quad (3.3-8)$$

For the calendar year:

$$D_T \leq 15 \text{ mrem} \quad (3.3-9)$$

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 3.3-8 or 3.3-9 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 particulates will be projected once per month using Equation 3.3-7.

TABLE 3.3-1
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Ground

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
Cr-51	4.66E 06	4.66E 06	4.66E 06	4.66E 06	4.66E 06	4.66E 06	4.66E 06	5.51E 06
Mn-54	1.34E 09	1.34E 09	1.34E 09	1.34E 09	1.34E 09	1.34E 09	1.34E 09	1.57E 09
Fe-59	2.75E 08	2.75E 08	2.75E 08	2.75E 08	2.75E 08	2.75E 08	2.75E 08	3.23E 08
Co-58	3.79E 08	3.79E 08	3.79E 08	3.79E 08	3.79E 08	3.79E 08	3.79E 08	4.44E 09
Co-60	2.15E 10	2.15E 10	2.15E 10	2.15E 10	2.15E 10	2.15E 10	2.15E 10	2.52E 10
Zn-65	7.49E 08	7.49E 08	7.49E 08	7.49E 08	7.49E 08	7.49E 08	7.49E 08	8.61E 08
Rb-86	8.99E 06	8.99E 06	8.99E 06	8.99E 06	8.99E 06	8.99E 06	8.99E 06	1.03E 07
Sr-89	2.23E 04	2.23E 04	2.23E 04	2.23E 04	2.23E 04	2.23E 04	2.23E 04	2.58E 04
Y-91	1.08E 06	1.08E 06	1.08E 06	1.08E 06	1.08E 06	1.08E 06	1.08E 06	1.22E 06
Zr-95	2.49E 08	2.49E 08	2.49E 08	2.49E 08	2.49E 08	2.49E 08	2.49E 08	2.89E 08
Nb-95	1.36E 08	1.36E 08	1.36E 08	1.36E 08	1.36E 08	1.36E 08	1.36E 08	1.60E 08
Ru-103	1.09E 08	1.09E 08	1.09E 08	1.09E 08	1.09E 08	1.09E 08	1.09E 08	1.27E 08
Ru-106	4.19E 08	4.19E 08	4.19E 08	4.19E 08	4.19E 08	4.19E 08	4.19E 08	5.03E 08
Ag-110M	3.48E 09	3.48E 09	3.48E 09	3.48E 09	3.48E 09	3.48E 09	3.48E 09	4.06E 09
Te-127M	9.15E 04	9.15E 04	9.15E 04	9.15E 04	9.15E 04	9.15E 04	9.15E 04	1.08E 05
Te-129M	2.00E 07	2.00E 07	2.00E 07	2.00E 07	2.00E 07	2.00E 07	2.00E 07	2.34E 07
I-131	1.72E 07	1.72E 07	1.72E 07	1.72E 07	1.72E 07	1.72E 07	1.72E 07	2.09E 07
I-132	1.24E 06	1.24E 06	1.24E 06	1.24E 06	1.24E 06	1.24E 06	1.24E 06	1.46E 06
I-133	2.47E 06	2.47E 06	2.47E 06	2.47E 06	2.47E 06	2.47E 06	2.47E 06	3.00E 06
I-135	2.56E 06	2.56E 06	2.56E 06	2.56E 06	2.56E 06	2.56E 06	2.56E 06	2.99E 06
Cs-134	6.82E 09	6.82E 09	6.82E 09	6.82E 09	6.82E 09	6.82E 09	6.82E 09	7.96E 09
Cs-136	1.49E 08	1.49E 08	1.49E 08	1.49E 08	1.49E 08	1.49E 08	1.49E 08	1.69E 08
Cs-137	1.03E 10	1.03E 10	1.03E 10	1.03E 10	1.03E 10	1.03E 10	1.03E 10	1.20E 10
Ba-140	2.05E 07	2.05E 07	2.05E 07	2.05E 07	2.05E 07	2.05E 07	2.05E 07	2.34E 07
Ce-141	1.36E 07	1.36E 07	1.36E 07	1.36E 07	1.36E 07	1.36E 07	1.36E 07	1.53E 07
Ce-144	6.95E 07	6.95E 07	6.95E 07	6.95E 07	6.95E 07	6.95E 07	6.95E 07	8.03E 07

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M-2 mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-2
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Veget
AGE GROUP = Adult

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	2.28E 03	2.28E 03	0.00E 01	2.28E 03	2.28E 03	2.28E 03	2.28E 03	2.28E 03
P-32	5.91E 07	1.72E 08	1.53E 09	9.51E 07	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Cr-51	4.60E 04	1.16E 07	0.00E 01	0.00E 01	1.01E 04	2.75E 04	6.10E 04	0.00E 01
Mn-54	5.83E 07	9.36E 08	0.00E 01	3.05E 08	9.09E 07	0.00E 01	0.00E 01	0.00E 01
Fe-59	1.12E 08	9.75E 08	1.24E 08	2.93E 08	0.00E 01	0.00E 01	8.17E 07	0.00E 01
Co-58	6.71E 07	6.07E 08	0.00E 01	2.99E 07	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Co-60	3.67E 08	3.12E 09	0.00E 01	1.66E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zn-65	5.77E 08	8.04E 08	4.01E 08	1.28E 09	8.54E 08	0.00E 01	0.00E 01	0.00E 01
Rb-86	1.03E 08	4.36E 07	0.00E 01	2.21E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-89	2.87E 08	1.60E 09	1.00E 10	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-90	1.64E 11	1.93E 10	6.70E 11	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Y-91	1.34E 05	2.76E 09	5.01E 06	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zr-95	2.51E 05	1.17E 09	1.16E 06	3.71E 05	5.82E 05	0.00E 01	0.00E 01	0.00E 01
Nb-95	4.19E 04	4.73E 08	1.40E 05	7.79E 04	7.70E 04	0.00E 01	0.00E 01	0.00E 01
Ru-103	2.04E 06	5.53E 08	4.74E 06	0.00E 01	1.81E 07	0.00E 01	0.00E 01	0.00E 01
Ru-106	2.46E 07	1.26E 10	1.94E 08	0.00E 01	3.75E 08	0.00E 01	0.00E 01	0.00E 01
Ag-110M	6.23E 06	4.28E 09	1.13E 07	1.05E 07	2.06E 07	0.00E 01	0.00E 01	0.00E 01
Te-127M	6.12E 07	1.68E 09	5.02E 08	1.80E 08	2.04E 09	1.28E 08	0.00E 01	0.00E 01
Te-129M	4.71E 07	1.50E 09	2.98E 08	1.11E 08	1.24E 09	1.02E 08	0.00E 01	0.00E 01
I-131	6.61E 07	3.04E 07	8.07E 07	1.15E 08	1.98E 08	3.78E 10	0.00E 01	0.00E 01
I-132	5.21E 01	2.80E 01	5.57E 01	1.49E 02	2.37E 02	5.21E 03	0.00E 01	0.00E 01
I-133	1.12E 06	3.30E 06	2.11E 06	3.67E 06	6.40E 06	5.39E 08	0.00E 01	0.00E 01
I-135	3.91E 04	1.20E 05	4.05E 04	1.06E 05	1.70E 05	7.00E 06	0.00E 01	0.00E 01
Cs-134	8.83E 09	1.89E 08	4.54E 09	1.08E 10	3.49E 09	0.00E 01	1.16E 09	0.00E 01
Cs-136	1.19E 08	1.88E 07	4.19E 07	1.66E 08	9.21E 07	0.00E 01	1.26E 07	0.00E 01
Cs-137	5.94E 09	1.76E 08	6.63E 09	9.07E 09	3.08E 09	0.00E 01	1.02E 09	0.00E 01
Ba-140	8.40E 06	2.64E 08	1.28E 08	1.61E 05	5.47E 04	0.00E 01	9.22E 04	0.00E 01
Ce-141	1.48E 04	4.99E 08	1.93E 05	1.31E 05	6.07E 04	0.00E 01	0.00E 01	0.00E 01
Ce-144	1.69E 06	1.06E 10	3.15E 07	1.32E 07	7.80E 06	0.00E 01	0.00E 01	0.00E 01

*R Values in units of mrem/yr per micro-Ci/m³ for inhalation and tritium, and in units of M-2 mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-3
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Veget
AGE GROUP = Teen

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	2.61E 03	2.61E 03	0.00E 01	2.61E 03	2.61E 03	2.61E 03	2.61E 03	2.61E 03
P-32	6.80E 07	1.47E 08	1.75E 09	1.09E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Cr-51	6.11E 04	1.03E 07	0.00E 01	0.00E 01	1.34E 04	3.39E 04	8.72E 04	0.00E 01
Mn-54	8.79E 07	9.09E 08	0.00E 01	4.43E 08	1.32E 08	0.00E 01	0.00E 01	0.00E 01
Fe-59	1.60E 08	9.78E 08	1.77E 08	4.14E 08	0.00E 01	0.00E 01	1.30E 08	0.00E 01
Co-58	9.79E 07	5.85E 08	0.00E 01	4.25E 07	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Co-60	5.57E 08	3.22E 09	0.00E 01	2.47E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zn-65	8.68E 08	7.88E 08	5.36E 08	1.86E 09	1.19E 09	0.00E 01	0.00E 01	0.00E 01
Rb-86	1.30E 08	4.09E 07	0.00E 01	2.76E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-89	4.36E 08	1.81E 09	1.52E 10	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-90	2.05E 11	2.33E 10	8.32E 11	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Y-91	2.06E 05	3.15E 09	7.68E 06	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zr-95	3.68E 05	1.23E 09	1.69E 06	5.35E 05	7.86E 05	0.00E 01	0.00E 01	0.00E 01
Nb-95	5.77E 04	4.48E 08	1.89E 05	1.05E 05	1.02E 05	0.00E 01	0.00E 01	0.00E 01
Ru-103	2.90E 06	5.66E 08	6.78E 06	0.00E 01	2.39E 07	0.00E 01	0.00E 01	0.00E 01
Ru-106	3.93E 07	1.50E 10	3.12E 08	0.00E 01	6.02E 08	0.00E 01	0.00E 01	0.00E 01
Ag-110M	9.39E 06	4.34E 09	1.63E 07	1.54E 07	2.95E 07	0.00E 01	0.00E 01	0.00E 01
Te-127M	9.44E 07	1.98E 09	7.93E 08	2.81E 08	3.22E 09	1.89E 08	0.00E 01	0.00E 01
Te-129M	6.79E 07	1.61E 09	4.29E 08	1.59E 08	1.79E 08	1.38E 08	0.00E 01	0.00E 01
I-131	5.77E 07	2.13E 07	7.68E 07	1.07E 08	1.85E 08	3.14E 10	0.00E 01	0.00E 01
I-132	4.72E 01	5.72E 01	5.02E 01	1.31E 02	2.07E 02	4.43E 03	0.00E 01	0.00E 01
I-133	1.01E 06	2.51E 06	1.96E 06	3.32E 06	5.83E 06	4.64E 08	0.00E 01	0.00E 01
I-135	3.49E 04	1.04E 05	3.66E 04	9.42E 04	1.49E 05	6.06E 06	0.00E 01	0.00E 01
Cs-134	7.54E 09	2.02E 08	6.90E 09	1.62E 10	5.16E 09	0.00E 01	1.97E 09	0.00E 01
Cs-136	1.13E 08	1.35E 07	4.28E 07	1.68E 08	9.16E 07	0.00E 01	1.44E 07	0.00E 01
Cs-137	4.90E 09	2.00E 08	1.06E 10	1.41E 10	4.78E 09	0.00E 01	1.86E 09	0.00E 01
Ba-140	8.88E 06	2.12E 08	1.38E 08	1.69E 05	5.72E 04	0.00E 01	1.14E 05	0.00E 01
Ce-141	2.12E 04	5.29E 08	2.77E 05	1.85E 05	8.70E 04	0.00E 01	0.00E 01	0.00E 01
Ce-144	2.71E 06	1.27E 10	5.04E 07	2.09E 07	1.25E 07	0.00E 01	0.00E 01	0.00E 01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M-2 mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-4
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Veget
AGE GROUP = Child

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	4.04E 03	4.04E 03	0.00E 01	4.04E 03	4.04E 03	4.04E 03	4.04E 03	4.04E 03
P-32	1.42E 08	1.01E 08	3.67E 09	1.72E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Cr-51	1.16E 05	6.15E 06	0.00E 01	0.00E 01	1.76E 04	6.44E 04	1.18E 05	0.00E 01
Mn-54	1.73E 08	5.44E 08	0.00E 01	6.49E 08	1.82E 08	0.00E 01	0.00E 01	0.00E 01
Fe-59	3.17E 08	6.62E 08	3.93E 08	6.36E 08	0.00E 01	0.00E 01	1.84E 08	0.00E 01
Co-58	1.92E 08	3.66E 08	0.00E 01	6.27E 07	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Co-60	1.11E 09	2.08E 09	0.00E 01	3.76E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zn-65	1.70E 09	4.81E 08	1.03E 09	2.74E 09	1.73E 09	0.00E 01	0.00E 01	0.00E 01
Rb-86	2.81E 08	2.94E 07	0.00E 01	4.56E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-89	1.03E 09	1.40E 09	3.62E 10	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-90	3.49E 11	1.86E 10	1.38E 12	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Y-91	4.89E 05	2.44E 09	1.83E 07	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zr-95	7.44E 05	8.71E 08	3.80E 06	8.35E 05	1.20E 06	0.00E 01	0.00E 01	0.00E 01
Nb-95	1.12E 05	2.91E 08	4.04E 05	1.57E 05	1.48E 05	0.00E 01	0.00E 01	0.00E 01
Ru-103	5.86E 06	3.94E 08	1.52E 07	0.00E 01	3.84E 07	0.00E 01	0.00E 01	0.00E 01
Ru-106	9.38E 07	1.17E 10	7.52E 08	0.00E 01	1.02E 09	0.00E 01	0.00E 01	0.00E 01
Ag-110M	1.87E 07	2.78E 09	3.46E 07	2.34E 07	4.35E 07	0.00E 01	0.00E 01	0.00E 01
Te-127M	2.26E 08	1.54E 09	1.90E 09	5.12E 08	5.42E 09	4.55E 08	0.00E 01	0.00E 01
Te-129M	1.55E 08	1.22E 09	9.98E 08	2.79E 08	2.93E 09	3.22E 08	0.00E 01	0.00E 01
I-131	8.16E 07	1.23E 07	1.43E 08	1.44E 08	2.36E 08	4.75E 10	0.00E 01	0.00E 01
I-132	7.53E 01	1.93E 02	8.91E 01	1.64E 02	2.51E 02	7.60E 03	0.00E 01	0.00E 01
I-133	1.67E 06	1.78E 06	3.57E 06	4.42E 06	7.36E 06	8.21E 08	0.00E 01	0.00E 01
I-135	5.54E 04	8.92E 04	6.50E 04	1.17E 05	1.79E 05	1.04E 07	0.00E 01	0.00E 01
Cs-134	5.40E 09	1.38E 08	1.56E 10	2.56E 10	7.93E 09	0.00E 01	2.84E 09	0.00E 01
Cs-136	1.43E 08	7.77E 06	8.04E 07	2.21E 08	1.18E 08	0.00E 01	1.76E 07	0.00E 01
Cs-137	3.52E 09	1.50E 08	2.49E 10	2.39E 10	7.78E 09	0.00E 01	2.80E 09	0.00E 01
Ba-140	1.61E 07	1.40E 08	2.76E 08	2.42E 05	7.87E 04	0.00E 01	1.44E 05	0.00E 01
Ce-141	4.75E 04	3.99E 08	6.42E 05	3.20E 05	1.40E 05	0.00E 01	0.00E 01	0.00E 01
Ce-144	6.49E 06	9.94E 09	1.22E 08	3.81E 07	2.11E 07	0.00E 01	0.00E 01	0.00E 01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M-2 mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-5
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Meat
AGE GROUP = Adult

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	3.27E 02	3.27E 02	0.00E 01	3.27E 02	3.27E 02	3.27E 02	3.27E 02	3.27E 02
P-32	1.18E 08	3.43E 08	3.05E 09	1.89E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Cr-51	4.27E 03	1.08E 06	0.00E 01	0.00E 01	9.42E 02	2.56E 03	5.67E 03	0.00E 01
Mn-54	1.06E 06	1.71E 07	0.00E 01	5.57E 06	1.66E 06	0.00E 01	0.00E 01	0.00E 01
Fe-59	1.43E 08	1.25E 09	1.59E 08	3.74E 08	0.00E 01	0.00E 01	1.04E 08	0.00E 01
Co-58	2.43E 07	2.20E 08	0.00E 01	1.08E 07	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Co-60	1.03E 08	8.76E 08	0.00E 01	4.66E 07	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zn-65	3.58E 08	4.98E 08	2.49E 08	7.91E 08	5.29E 08	0.00E 01	0.00E 01	0.00E 01
Rb-86	1.42E 08	6.00E 07	0.00E 01	3.04E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-89	5.23E 06	2.92E 07	1.82E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-90	2.02E 09	2.38E 08	8.22E 09	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Y-91	1.80E 04	3.71E 08	6.75E 05	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zr-95	2.43E 05	1.14E 09	1.12E 06	3.59E 05	5.64E 05	0.00E 01	0.00E 01	0.00E 01
Nb-95	4.12E 05	4.65E 09	1.38E 06	7.66E 05	7.58E 05	0.00E 01	0.00E 01	0.00E 01
Rr-103	2.72E 07	7.38E 09	6.32E 07	0.00E 01	2.41E 08	0.00E 01	0.00E 01	0.00E 01
Ru-106	2.19E 08	1.12E 11	1.73E 09	0.00E 01	3.35E 09	0.00E 01	0.00E 01	0.00E 01
Ag-110M	2.34E 06	1.61E 09	4.27E 06	3.95E 06	7.76E 06	0.00E 01	0.00E 01	0.00E 01
Te-127M	1.00E 08	2.76E 09	8.22E 08	2.94E 08	3.34E 09	2.10E 08	0.00E 01	0.00E 01
Te-129M	1.17E 08	3.73E 09	7.40E 08	2.76E 08	3.09E 09	2.54E 08	0.00E 01	0.00E 01
I-131	5.77E 06	2.66E 06	7.04E 06	1.01E 07	1.73E 07	3.30E 09	0.00E 01	0.00E 01
I-133	1.51E-01	4.46E-01	2.85E-01	4.96E-01	8.66E-01	7.29E 01	0.00E 01	0.00E 01
I-135	6.07E-17	1.86E-16	6.28E-17	1.64E-16	2.64E-16	1.08E-14	0.00E 01	0.00E 01
Cs-134	7.81E 08	1.67E 07	4.01E 08	9.55E 08	3.09E 08	0.00E 01	1.03E 08	0.00E 01
Cs-136	2.14E 07	3.33E 06	7.53E 06	2.97E 07	1.65E 07	0.00E 01	2.27E 06	0.00E 01
Cs-137	4.99E 08	1.47E 07	5.57E 08	7.61E 08	2.58E 08	0.00E 01	8.59E 07	0.00E 01
Ba-140	1.20E 06	3.77E 07	1.83E 07	2.30E 04	7.82E 03	0.00E 01	1.32E 04	0.00E 01
Ce-141	6.46E 02	2.18E 07	8.42E 03	5.69E 03	2.65E 03	0.00E 01	0.00E 01	0.00E 01
Ce-144	4.70E 04	2.96E 08	8.75E 05	3.66E 05	2.17E 05	0.00E 01	0.00E 01	0.00E 01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M-2 mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-6
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Meat

AGE GROUP = Teen

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	1.95E 02	1.95E 02	0.00E 01	1.95E 02	1.95E 02	1.95E 02	1.95E 02	1.95E 02
P-32	9.98E 07	2.16E 08	2.58E 09	1.60E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Cr-51	3.42E 03	5.75E 05	0.00E 01	0.00E 01	7.49E 02	1.90E 03	4.88E 03	0.00E 01
Mn-54	8.43E 05	8.72E 06	0.00E 01	4.25E 06	1.27E 06	0.00E 01	0.00E 01	0.00E 01
Fe-59	1.15E 08	7.02E 08	1.27E 08	2.97E 08	0.00E 01	0.00E 01	9.36E 07	0.00E 01
Co-58	1.93E 07	1.15E 08	0.00E 01	8.36E 06	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Co-60	8.15E 07	4.71E 08	0.00E 01	3.62E 07	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zn-65	2.83E 08	2.57E 08	1.75E 08	6.07E 08	3.89E 08	0.00E 01	0.00E 01	0.00E 01
Rb-86	1.19E 08	3.76E 07	0.00E 01	2.54E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-89	4.40E 06	1.83E 07	1.54E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-90	1.31E 09	1.49E 08	5.32E 09	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Y-91	1.52E 04	2.33E 08	5.68E 05	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zr-95	1.95E 05	6.53E 08	8.97E 05	2.83E 05	4.16E 05	0.00E 01	0.00E 01	0.00E 01
Nb-95	3.29E 05	2.55E 09	1.08E 06	5.97E 05	5.79E 05	0.00E 01	0.00E 01	0.00E 01
Ru-103	2.20E 07	4.30E 09	5.15E 07	0.00E 01	1.82E 08	0.00E 01	0.00E 01	0.00E 01
Ru-106	1.84E 08	7.00E 10	1.46E 09	0.00E 01	2.81E 09	0.00E 01	0.00E 01	0.00E 01
Ag-110M	1.86E 06	8.59E 08	3.23E 06	3.06E 06	5.83E 06	0.00E 01	0.00E 01	0.00E 01
Te-127M	8.25E 07	1.73E 09	6.94E 08	2.46E 08	2.81E 09	1.65E 08	0.00E 01	0.00E 01
Te-129M	9.81E 07	2.33E 09	6.20E 08	2.30E 08	2.59E 09	2.00E 08	0.00E 01	0.00E 01
I-131	4.40E 06	1.62E 06	5.85E 06	8.20E 06	1.41E 07	2.39E 09	0.00E 01	0.00E 01
I-133	1.23E-01	3.06E-01	2.39E-01	4.05E-01	7.10E-01	5.65E 01	0.00E 01	0.00E 01
I-135	4.88E-17	1.46E-16	5.11E-17	1.32E-16	2.08E-16	8.46E-15	0.00E 01	0.00E 01
Cs-134	3.48E 08	9.34E 06	3.19E 08	7.51E 08	2.39E 08	0.00E 01	9.11E 07	0.00E 01
Cs-136	1.55E 07	1.86E 06	5.87E 06	2.31E 07	1.26E 07	0.00E 01	1.98E 06	0.00E 01
Cs-137	2.14E 08	8.75E 06	4.62E 08	6.15E 08	2.09E 08	0.00E 01	8.13E 07	0.00E 01
Ba-140	9.76E 05	2.34E 07	1.51E 07	1.86E 04	6.29E 03	0.00E 01	1.25E 04	0.00E 01
Ce-141	5.42E 02	1.35E 07	7.07E 03	4.72E 03	2.22E 03	0.00E 01	0.00E 01	0.00E 01
Ce-144	3.96E 04	1.85E 08	7.37E 05	3.05E 05	1.82E 05	0.00E 01	0.00E 01	0.00E 01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M-2 mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-7
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Meat
AGE GROUP = Child

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	2.36E 02	2.36E 02	0.00E 01	2.36E 02	2.36E 02	2.36E 02	2.36E 02	2.36E 02
P-32	1.87E 08	1.34E 08	4.86E 09	2.27E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Cr-51	5.33E 03	2.83E 05	0.00E 01	0.00E 01	8.09E 02	2.96E 03	5.40E 03	0.00E 01
Mn-54	1.30E 06	4.08E 06	0.00E 01	4.86E 06	1.36E 06	0.00E 01	0.00E 01	0.00E 01
Fe-59	1.82E 08	3.80E 08	2.25E 08	3.65E 08	0.00E 01	0.00E 01	1.06E 08	0.00E 01
Co-53	2.99E 07	5.70E 07	0.00E 01	9.76E 06	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Co-60	1.27E 08	2.38E 08	0.00E 01	4.30E 07	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zn-65	4.35E 08	1.23E 08	2.62E 08	6.99E 08	4.40E 08	0.00E 01	0.00E 01	0.00E 01
Rb-86	2.21E 08	2.32E 07	0.00E 01	3.60E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-89	8.31E 06	1.13E 07	2.91E 08	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Sr-90	1.74E 09	9.26E 07	6.87E 09	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Y-91	2.87E 04	1.43E 08	1.07E 06	0.00E 01	0.00E 01	0.00E 01	0.00E 01	0.00E 01
Zr-95	3.12E 05	3.65E 08	1.59E 06	3.50E 05	5.01E 05	0.00E 01	0.00E 01	0.00E 01
Nb-95	5.17E 05	1.34E 09	1.86E 06	7.23E 05	6.80E 05	0.00E 01	0.00E 01	0.00E 01
Ru-103	3.58E 07	2.41E 09	9.31E 07	0.00E 01	2.34E 08	0.00E 01	0.00E 01	0.00E 01
Ru-106	3.43E 08	4.27E 10	2.75E 09	0.00E 01	3.71E 09	0.00E 01	0.00E 01	0.00E 01
Ag-110M	2.89E 06	4.30E 08	5.36E 06	3.62E 06	6.74E 06	0.00E 01	0.00E 01	0.00E 01
Te-127M	1.55E 08	1.06E 09	1.31E 09	3.52E 08	3.73E 09	3.13E 08	0.00E 01	0.00E 01
Te-129M	1.81E 08	1.42E 09	1.17E 09	3.26E 08	3.43E 09	3.77E 08	0.00E 01	0.00E 01
I-131	6.20E 06	9.72E 05	1.09E 07	1.09E 07	1.79E 07	3.61E 09	0.00E 01	0.00E 01
I-133	2.07E-01	2.21E-01	4.43E-01	5.48E-01	9.13E-01	1.02E 02	0.00E 01	0.00E 01
I-135	7.87E-17	1.27E-16	9.25E-17	1.66E-16	2.55E-16	1.47E-14	0.00E 01	0.00E 01
Cs-134	1.95E 08	4.93E 06	5.63E 08	9.23E 08	2.86E 08	0.00E 01	1.03E 08	0.00E 01
Cs-136	1.80E 07	9.78E 05	1.01E 07	2.78E 07	1.48E 07	0.00E 01	2.21E 06	0.00E 01
Cs-137	1.20E 08	5.10E 06	8.51E 08	8.15E 08	2.65E 08	0.00E 01	9.55E 07	0.00E 01
Ba-140	1.63E 06	1.42E 07	2.80E 07	2.45E 04	7.97E 03	0.00E 01	1.46E 04	0.00E 01
Ce-141	9.86E 02	8.28E 06	1.33E 04	6.64E 03	2.91E 03	0.00E 01	0.00E 01	0.00E 01
Ce-144	7.42E 04	1.14E 08	1.39E 06	4.36E 05	2.41E 05	0.00E 01	0.00E 01	0.00E 01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M-2 mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-8
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Cow Milk

AGE GROUP = Adult

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	7.69E 02	7.69E 02	0.00E-01	7.69E 02	7.69E 02	7.69E 02	7.69E 02	7.69E 02
P-32	4.32E 08	1.26E 09	1.12E 10	6.95E 08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	1.73E 04	4.36E 06	0.00E-01	0.00E-01	3.82E 03	1.04E 04	2.30E 04	0.00E-01
Mn-54	9.76E 05	1.57E 07	0.00E-01	5.11E 06	1.52E 06	0.00E-01	0.00E-01	0.00E-01
Fe-59	1.60E 07	1.39E 08	1.77E 07	4.17E 07	0.00E-01	0.00E-01	1.17E 07	0.00E-01
Co-58	6.28E 06	5.68E 07	0.00E-01	2.80E 06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co-60	2.24E 07	1.91E 08	0.00E-01	1.02E 07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn-65	1.38E 09	1.92E 09	9.59E 08	3.05E 09	2.04E 09	0.00E-01	0.00E-01	0.00E-01
Rb-86	7.54E 08	3.19E 08	0.00E-01	1.62E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	2.50E 07	1.40E 08	8.70E 08	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-90	7.59E 09	8.94E 08	3.09E 10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Y-91	1.37E 02	2.81E 06	5.11E 03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr-95	1.22E 02	5.71E 05	5.62E 02	1.80E 02	2.83E 02	0.00E-01	0.00E-01	0.00E-01
Nb-95	1.48E 04	1.67E 08	4.95E 04	2.75E 04	2.72E 04	0.00E-01	0.00E-01	0.00E-01
Ru-103	2.63E 02	7.14E 04	6.11E 02	0.00E-01	2.33E 03	0.00E-01	0.00E-01	0.00E-01
Ru-106	1.60E 03	8.17E 05	1.26E 04	0.00E-01	2.44E 04	0.00E-01	0.00E-01	0.00E-01
Ag-110M	2.04E 07	1.40E 10	3.71E 07	3.44E 07	6.76E 07	0.00E-01	0.00E-01	0.00E-01
Te-127M	4.11E 06	1.13E 08	3.37E 07	1.21E 07	1.37E 08	8.62E 06	0.00E-01	0.00E-01
Te-129M	6.19E 06	1.97E 08	3.91E 07	1.46E 07	1.63E 08	1.34E 07	0.00E-01	0.00E-01
I-131	1.59E 08	7.32E 07	1.94E 08	2.77E 08	4.76E 08	9.09E 10	0.00E-01	0.00E-01
I-132	1.03E-01	5.51E-02	1.10E-01	2.93E-01	4.67E-01	1.03E 01	0.00E-01	0.00E-01
I-133	1.40E 06	4.13E 06	2.64E 06	4.59E 06	8.01E 06	6.75E 08	0.00E-01	0.00E-01
I-135	9.03E 03	2.76E 04	9.34E 03	2.45E 04	3.92E 04	1.61E 06	0.00E-01	0.00E-01
Cs-134	6.71E 09	1.44E 08	3.45E 09	3.21E 09	2.66E 09	0.00E-01	8.82E 08	0.00E-01
Cs-136	4.73E 08	7.46E 07	1.66E 08	6.57E 08	3.65E 08	0.00E-01	5.01E 07	0.00E-01
Cs-137	4.22E 09	1.25E 08	4.71E 09	6.44E 09	2.19E 09	0.00E-01	7.27E 08	0.00E-01
Ba-140	1.12E 06	3.53E 07	1.71E 07	2.15E 04	7.32E 03	0.00E-01	1.23E 04	0.00E-01
Ce-141	2.23E 02	7.52E 06	2.91E 03	1.97E 03	9.14E 02	0.00E-01	0.00E-01	0.00E-01
Ce-144	1.15E 04	7.26E 07	2.15E 05	8.97E 04	5.32E 04	0.00E-01	0.00E-01	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of m⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-9
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Cow Milk

AGE GROUP = Teen

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	1.00E 03	1.00E 03	0.00E-01	1.00E 03	1.00E 03	1.00E 03	1.00E 03	1.00E 03
P-32	8.00E 08	1.73E 09	2.06E 10	1.28E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	3.02E 04	5.08E 06	0.00E-01	0.00E-01	6.63E 03	1.68E 04	4.32E 04	0.00E-01
Mn-54	1.69E 06	1.75E 07	0.00E-01	8.52E 06	2.54E 06	0.00E-01	0.00E-01	0.00E-01
Fe-59	2.79E 07	1.71E 08	3.10E 07	7.23E 07	0.00E-01	0.00E-01	2.28E 07	0.00E-01
Co-58	1.09E 07	6.50E 07	0.00E-01	4.72E 06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co-60	3.88E 07	2.25E 08	0.00E-01	1.72E 07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn-65	2.38E 09	2.16E 09	1.47E 09	5.11E 09	3.27E 09	0.00E-01	0.00E-01	0.00E-01
Rb-86	1.39E 09	4.37E 08	0.00E-01	2.95E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	4.59E 07	1.91E 08	1.60E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-90	1.08E 10	1.23E 09	4.37E 10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Y-91	2.52E 02	3.85E 06	9.40E 03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr-95	2.13E 02	7.16E 06	9.83E 02	3.10E 02	4.56E 02	0.00E-01	0.00E-01	0.00E-01
Nb-95	2.58E 04	2.00E 08	8.45E 04	4.68E 04	4.54E 04	0.00E-01	0.00E-01	0.00E-01
Ru-103	4.65E 02	9.08E 04	1.09E 03	0.00E-01	3.83E 03	0.00E-01	0.00E-01	0.00E-01
Ru-106	2.93E 03	1.11E 06	2.32E 04	0.00E-01	4.48E 04	0.00E-01	0.00E-01	0.00E-01
Ag-110M	3.53E 07	1.63E 10	6.14E 07	5.81E 07	1.11E 08	0.00E-01	0.00E-01	0.00E-01
Te-127M	7.39E 06	1.55E 08	6.22E 07	2.21E 07	2.52E 08	1.48E 07	0.00E-01	0.00E-01
Te-129M	1.13E 07	2.69E 08	7.15E 07	2.65E 07	2.99E 08	2.31E 07	0.00E-01	0.00E-01
I-131	2.65E 08	9.75E 07	3.52E 08	4.93E 08	8.48E 08	1.44E 11	0.00E-01	0.00E-01
I-132	1.83E-01	2.22E-01	1.94E-01	5.09E-01	8.02E-01	1.71E 01	0.00E-01	0.00E-01
I-133	2.49E 06	6.19E 06	4.82E 06	8.18E 06	1.43E 07	1.14E 09	0.00E-01	0.00E-01
I-135	1.58E 04	4.74E 04	1.66E 04	4.27E 04	6.75E 04	2.75E 06	0.00E-01	0.00E-01
Cs-134	6.54E 09	1.75E 08	5.99E 09	1.41E 10	4.48E 09	0.00E-01	1.71E 09	0.00E-01
Cs-136	7.48E 08	8.97E 07	2.83E 08	1.11E 09	6.07E 08	0.00E-01	9.56E 07	0.00E-01
Cs-137	3.96E 09	1.62E 08	8.54E 09	1.14E 10	3.87E 09	0.00E-01	1.50E 09	0.00E-01
Ba-140	1.99E 06	4.77E 07	3.09E 07	3.79E 04	1.28E 04	0.00E-01	2.55E 04	0.00E-01
Ce-141	4.09E 02	1.02E 07	6.33E 03	3.56E 03	1.68E 03	0.00E-01	0.00E-01	0.00E-01
Ce-144	2.12E 04	9.93E 07	3.95E 05	1.63E 05	9.76E 04	0.00E-01	0.00E-01	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-10
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Cow Milk

AGE GROUP = Child

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	1.58E 03	1.58E 03	0.00E-01	1.58E 03	1.58E 03	1.58E 03	1.58E 03	1.58E 03
P-32	1.96E 09	1.41E 09	5.09E 10	2.38E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	6.17E 04	3.27E 06	0.00E-01	0.00E-01	9.36E 03	3.42E 04	6.25E 04	0.00E-01
Mn-54	3.39E 06	1.07E 07	0.00E-01	1.27E 07	3.57E 06	0.00E-01	0.00E-01	0.00E-01
Fe-59	5.79E 07	1.21E 08	7.18E 07	1.16E 08	0.00E-01	0.00E-01	3.37E 07	0.00E-01
Co-58	2.21E 07	4.20E 07	0.00E-01	7.21E 06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co-60	7.90E 07	1.48E 08	0.00E-01	2.68E 07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn-65	4.79E 09	1.35E 09	2.89E 09	7.70E 09	4.85E 09	0.00E-01	0.00E-01	0.00E-01
Rb-86	3.36E 09	3.52E 08	0.00E-01	5.47E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	1.13E 08	1.54E 08	3.97E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-90	1.87E 10	9.95E 08	7.38E 10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Y-91	6.21E 02	3.09E 06	2.32E 04	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr-95	4.47E 02	5.23E 05	2.28E 03	5.02E 02	7.18E 02	0.00E-01	0.00E-01	0.00E-01
Nb-95	5.31E 04	1.37E 08	1.91E 05	7.42E 04	6.98E 04	0.00E-01	0.00E-01	0.00E-01
Ru-103	9.88E 02	6.65E 04	2.57E 03	0.00E-01	6.47E 03	0.00E-01	0.00E-01	0.00E-01
Ru-106	7.14E 03	8.90E 05	5.72E 04	0.00E-01	7.72E 04	0.00E-01	0.00E-01	0.00E-01
Ag-110M	7.19E 07	1.07E 10	1.33E 08	9.00E 07	1.68E 08	0.00E-01	0.00E-01	0.00E-01
Te-127M	1.82E 07	1.24E 08	1.53E 08	4.13E 07	4.37E 08	3.66E 07	0.00E-01	0.00E-01
Te-129M	2.74E 07	2.15E 08	1.76E 08	4.92E 07	5.18E 08	5.68E 07	0.00E-01	0.00E-01
I-131	4.88E 08	7.64E 07	8.54E 08	8.59E 08	1.41E 09	2.84E 11	0.00E-01	0.00E-01
I-132	3.89E-01	9.95E-01	4.60E-01	8.45E-01	1.29E 00	3.92E 01	0.00E-01	0.00E-01
I-133	5.48E 06	5.84E 06	1.17E 07	1.45E 07	2.41E 07	2.69E 09	0.00E-01	0.00E-01
I-135	3.35E 04	5.39E 04	3.93E 04	7.07E 04	1.08E 05	6.26E 06	0.00E-01	0.00E-01
Cs-134	4.78E 09	1.22E 08	1.38E 10	2.27E 10	7.03E 09	0.00E-01	2.52E 09	0.00E-01
Cs-136	1.14E 09	6.17E 07	6.39E 08	1.76E 09	9.36E 08	0.00E-01	1.40E 08	0.00E-01
Cs-137	2.91E 09	1.23E 08	2.06E 10	1.97E 10	6.42E 09	0.00E-01	2.31E 09	0.00E-01
Ba-140	4.36E 06	3.78E 07	7.47E 07	6.54E 04	2.13E 04	0.00E-01	3.90E 04	0.00E-01
Ce-141	9.73E 02	8.17E 06	1.31E 04	6.55E 03	2.87E 03	0.00E-01	0.00E-01	0.00E-01
Ce-144	5.20E 04	7.96E 07	9.74E 05	3.05E 05	1.69E 05	0.00E-01	0.00E-01	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m³ for inhalation and tritium, and in units of M⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-11
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Cow Milk

AGE GROUP = Infant

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	2.40E 03	2.40E 03	0.00E-01	2.40E 03	2.40E 03	2.40E 03	2.40E 03	2.40E 03
P-32	4.06E 09	1.42E 09	1.05E 11	6.17E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	9.77E 04	2.85E 06	0.00E-01	0.00E-01	1.39E 04	6.38E 04	1.24E 05	0.00E-01
Mn-54	5.37E 06	8.71E 06	0.00E-01	2.37E 07	5.25E 06	0.00E-01	0.00E-01	0.00E-01
Fe-59	9.23E 07	1.12E 08	1.34E 08	2.34E 08	0.00E-01	0.00E-01	6.92E 07	0.00E-01
Co-58	3.60E 07	3.59E 07	0.00E-01	1.44E 07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co-60	1.29E 08	1.30E 08	0.00E-01	5.47E 07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn-65	6.14E 09	1.12E 10	3.88E 09	1.33E 10	6.45E 09	0.00E-01	0.00E-01	0.00E-01
Rb-86	6.86E 09	3.55E 08	0.00E-01	1.39E 10	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	2.17E 08	1.55E 08	7.55E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-90	2.05E 10	1.00E 09	8.04E 10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Y-91	1.16E 08	3.12E 06	4.36E 04	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr-95	7.01E 02	4.92E 05	4.05E 03	9.88E 02	1.06E 03	0.00E-01	0.00E-01	0.00E-01
Nb-95	8.48E 04	1.24E 08	3.56E 05	1.47E 05	1.05E 05	0.00E-01	0.00E-01	0.00E-01
Ru-103	1.74E 03	6.33E 04	5.21E 03	0.00E-01	1.08E 04	0.00E-01	0.00E-01	0.00E-01
Ru-106	1.47E 04	8.95E 05	1.18E 05	0.00E-01	1.39E 05	0.00E-01	0.00E-01	0.00E-01
Ag-110M	1.19E 08	9.32E 09	2.46E 08	1.80E 08	2.57E 08	0.00E-01	0.00E-01	0.00E-01
Te-127M	3.75E 07	1.25E 08	3.10E 08	1.03E 08	7.64E 08	8.96E 07	0.00E-01	0.00E-01
Te-129M	5.57E 07	2.16E 08	3.62E 08	1.24E 08	9.05E 08	1.39E 08	0.00E-01	0.00E-01
I-131	9.23E 08	7.49E 07	1.78E 09	2.10E 09	2.45E 09	6.90E 11	0.00E-01	0.00E-01
I-132	6.90E-01	1.57E-00	9.55E-01	1.94E 00	2.16E 00	9.09E 01	0.00E-01	0.00E-01
I-133	1.05E 07	6.09E 06	2.47E 07	3.60E 07	4.23E 07	6.55E 09	0.00E-01	0.00E-01
I-135	5.93E 04	5.83E 04	8.17E 04	1.63E 05	1.81E 05	1.46E 07	0.00E-01	0.00E-01
Cs-134	4.19E 09	1.13E 08	2.23E 10	4.15E 10	1.07E 10	0.00E-01	4.38E 09	0.00E-01
Cs-136	1.37E 09	5.58E 07	1.25E 09	3.67E 09	1.46E 09	0.00E-01	2.99E 08	0.00E-01
Cs-137	2.72E 09	1.20E 08	3.28E 10	3.84E 10	1.03E 10	0.00E-01	4.18E 09	0.00E-01
Ba-140	7.91E 06	3.77E 07	1.54E 08	1.54E 05	3.65E 04	0.00E-01	9.43E 04	0.00E-01
Ce-141	1.87E 03	3.21E 06	2.60E 04	1.59E 04	4.90E 03	0.00E-01	0.00E-01	0.00E-01
Ce-144	7.82E 04	8.01E 07	1.40E 06	5.71E 05	2.31E 05	0.00E-01	0.00E-01	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of m⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-12
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Goat Milk

AGE GROUP = Adult

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	1.57E 03	1.57E 03	0.00E-01	1.57E 03	1.57E 03	1.57E 03	1.57E 03	1.57E 03
P-32	5.19E 08	1.51E 09	1.34E 10	8.34E 08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	2.08E 03	5.23E 05	0.00E-01	0.00E-01	4.58E 02	1.24E 03	2.76E 03	0.00E-01
Mn-54	1.17E 05	1.88E 06	0.00E-01	6.14E 05	1.83E 05	0.00E-01	0.00E-01	0.00E-01
Fe-59	2.08E 05	1.81E 06	2.31E 05	5.42E 05	0.00E-01	0.00E-01	1.51E 05	0.00E-01
Co-58	7.54E 05	6.82E 06	0.00E-01	3.36E 05	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co-60	2.69E 06	2.29E 07	0.00E-01	1.22E 06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn-65	1.65E 08	2.31E 08	1.15E 08	3.66E 08	2.45E 08	0.00E-01	0.00E-01	0.00E-01
Rb-86	9.05E 07	3.83E 07	0.00E-01	1.94E 08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	5.24E 07	2.93E 08	1.83E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-90	1.59E 10	1.88E 09	6.49E 10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Y-91	1.64E 01	3.37E 05	6.13E 02	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr-95	1.46E 01	6.85E 04	6.74E 01	2.16E 01	3.39E 01	0.00E-01	0.00E-01	0.00E-01
Nb-95	1.78E 03	2.01E 07	5.94E 03	3.31E 03	3.27E 03	0.00E-01	0.00E-01	0.00E-01
Ru-103	3.16E 01	8.56E 03	7.33E 01	0.00E-01	2.80E 02	0.00E-01	0.00E-01	0.00E-01
Ru-106	1.92E 02	9.81E 04	1.52E 03	0.00E-01	2.93E 03	0.00E-01	0.00E-01	0.00E-01
Ag-110M	2.45E 06	1.68E 09	4.46E 06	4.12E 06	8.11E 06	0.00E-01	0.00E-01	0.00E-01
Te-127M	4.93E 05	1.36E 07	4.05E 06	1.45E 06	1.64E 07	1.03E 06	0.00E-01	0.00E-01
Te-129M	7.43E 05	2.36E 07	4.69E 06	1.75E 06	1.96E 07	1.61E 06	0.00E-01	0.00E-01
I-131	1.91E 08	8.78E 07	2.33E 08	3.33E 08	5.71E 08	1.09E 11	0.00E-01	0.00E-01
I-132	1.23E-01	6.61E-02	1.32E-01	3.52E-01	5.61E-01	1.23E 01	0.00E-01	0.00E-01
I-133	1.68E 06	4.95E 06	3.17E 06	5.51E 06	9.61E 06	8.10E 08	0.00E-01	0.00E-01
I-135	1.08E 04	3.32E 04	1.12E 04	2.94E 04	4.71E 04	1.94E 06	0.00E-01	0.00E-01
Cs-134	2.01E 10	4.31E 08	1.03E 10	2.46E 10	7.97E 09	0.00E-01	2.65E 09	0.00E-01
Cs-136	1.42E 09	2.24E 08	4.99E 08	1.97E 09	1.10E 09	0.00E-01	1.50E 08	0.00E-01
Cs-137	1.27E 10	3.74E 08	1.41E 10	1.93E 10	6.56E 09	0.00E-01	2.18E 09	0.00E-01
Ba-140	1.35E 05	4.23E 06	2.06E 06	2.58E 03	8.78E 02	0.00E-01	1.48E 03	0.00E-01
Ce-141	2.68E 01	9.03E 05	3.49E 02	2.36E 02	1.10E 02	0.00E-01	0.00E-01	0.00E-01
Ce-144	1.38E 03	8.71E 06	2.58E 04	1.08E 04	6.39E 03	0.00E-01	0.00E-01	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-13
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Goat Milk

AGE GROUP = Teen

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	2.04E 03	2.04E 03	0.00E-01	2.04E 03	2.04E 03	2.04E 03	2.04E 03	2.04E 03
P-32	9.60E 08	2.08E 09	2.48E 10	1.53E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	3.63E 03	6.10E 05	0.00E-01	0.00E-01	7.95E 02	2.02E 03	5.18E 03	0.00E-01
Mn-54	2.03E 05	2.10E 06	0.00E-01	1.02E 06	3.05E 05	0.00E-01	0.00E-01	0.00E-01
Fe-59	3.63E 05	2.22E 06	4.03E 05	9.40E 05	0.00E-01	0.00E-01	2.96E 05	0.00E-01
Co-58	1.30E 06	7.80E 06	0.00E-01	5.66E 05	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co-60	4.66E 06	2.69E 07	0.00E-01	2.07E 06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn-65	2.86E 08	2.60E 08	1.77E 08	6.13E 08	3.93E 08	0.00E-01	0.00E-01	0.00E-01
Rb-86	1.66E 08	5.24E 07	0.00E-01	3.54E 08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	9.65E 07	4.01E 08	3.37E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-90	2.27E 10	2.58E 09	9.18E 10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Y-91	3.02E 01	4.62E 05	1.13E 03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr-95	2.56E 01	8.59E 04	1.18E 02	3.72E 01	5.47E 01	0.00E-01	0.00E-01	0.00E-01
Nb-95	3.09E 03	2.40E 07	1.01E 04	5.62E 03	5.45E 03	0.00E-01	0.00E-01	0.00E-01
Ru-103	5.58E 01	1.09E 04	1.30E 02	0.00E-01	4.60E 02	0.00E-01	0.00E-01	0.00E-01
Ru-106	3.51E 02	1.34E 05	2.79E 03	0.00E-01	5.38E 03	0.00E-01	0.00E-01	0.00E-01
Ag-110M	4.24E 06	1.96E 09	7.37E 06	6.97E 06	1.33E 07	0.00E-01	0.00E-01	0.00E-01
Te-127M	8.87E 05	1.86E 07	7.46E 06	2.65E 06	3.02E 07	1.77E 06	0.00E-01	0.00E-01
Te-129M	1.36E 06	3.22E 07	8.58E 06	3.19E 06	3.59E 07	2.77E 06	0.00E-01	0.00E-01
I-131	3.18E 08	1.17E 08	4.22E 08	5.91E 08	1.02E 09	1.73E 11	0.00E-01	0.00E-01
I-132	2.19E-01	2.66E-01	2.33E-01	6.11E-01	9.62E-01	2.06E 01	0.00E-01	0.00E-01
I-133	2.99E 06	7.43E 06	5.79E 06	9.81E 06	1.72E 07	1.37E 09	0.00E-01	0.00E-01
I-135	1.90E 04	5.63E 04	1.99E 04	5.13E 04	8.10E 04	3.30E 06	0.00E-01	0.00E-01
Cs-134	1.96E 10	5.26E 08	1.80E 10	4.23E 10	1.34E 10	0.00E-01	5.13E 09	0.00E-01
Cs-136	2.25E 09	2.69E 07	8.50E 08	3.34E 09	1.82E 09	0.00E-01	2.87E 08	0.00E-01
Cs-137	1.19E 10	4.85E 08	2.56E 10	3.41E 10	1.16E 10	0.00E-01	4.51E 09	0.00E-01
Ba-140	2.39E 05	5.72E 06	3.71E 06	4.55E 03	1.54E 03	0.00E-01	3.06E 03	0.00E-01
Ce-141	4.91E 01	1.22E 06	6.40E 02	4.27E 02	2.01E 02	0.00E-01	0.00E-01	0.00E-01
Ce-144	2.55E 03	1.19E 07	4.74E 04	1.96E 04	1.17E 04	0.00E-01	0.00E-01	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of m⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-14
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Goat Milk

AGE GROUP = Child

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	3.23E 03	3.23E 03	0.00E-01	3.23E 03	3.23E 03	3.23E 03	3.23E 03	3.23E 03
P-32	2.35E 09	1.69E 09	6.11E 10	2.86E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	7.40E 03	3.93E 05	0.00E-01	0.00E-01	1.12E 03	4.11E 03	7.50E 03	0.00E-01
Mn-54	4.07E 05	1.28E 06	0.00E-01	1.53E 06	4.29E 05	0.00E-01	0.00E-01	0.00E-01
Fe-59	7.52E 05	1.57E 06	9.34E 05	1.51E 06	0.00E-01	0.00E-01	4.38E 05	0.00E-01
Co-58	2.65E 06	5.05E 06	0.00E-01	8.65E 05	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co-60	9.48E 06	1.78E 07	0.00E-01	3.21E 06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn-65	5.74E 08	1.62E 08	3.47E 08	9.24E 08	5.82E 08	0.00E-01	0.00E-01	0.00E-01
Rb-86	4.04E 08	4.22E 07	0.00E-01	6.57E 08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	2.38E 08	3.23E 08	8.34E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-90	3.93E 10	2.09E 09	1.55E 11	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Y-91	7.45E 01	3.71E 05	2.79E 03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr-95	5.36E 01	6.28E 04	2.74E 02	6.02E 01	8.62E 01	0.00E-01	0.00E-01	0.00E-01
Nb-95	6.37E 03	1.65E 07	2.29E 04	8.91E 03	8.37E 03	0.00E-01	0.00E-01	0.00E-01
Ru-103	1.19E 02	7.98E 03	3.09E 02	0.00E-01	7.77E 02	0.00E-01	0.00E-01	0.00E-01
Ru-106	8.56E 02	1.07E 05	6.86E 03	0.00E-01	9.27E 03	0.00E-01	0.00E-01	0.00E-01
Ag-110M	8.63E 06	1.28E 09	1.60E 07	1.08E 07	2.01E 07	0.00E-01	0.00E-01	0.00E-01
Te-127M	2.18E 06	1.49E 07	1.84E 07	4.95E 06	5.24E 07	4.40E 06	0.00E-01	0.00E-01
Te-129M	3.28E 06	2.58E 07	2.12E 07	5.91E 06	6.21E 07	6.82E 06	0.00E-01	0.00E-01
I-131	5.85E 08	9.17E 07	1.02E 09	1.03E 09	1.69E 09	3.41E 11	0.00E-01	0.00E-01
I-132	4.67E-01	1.19E 00	5.52E-01	1.01E 00	1.55E 00	4.71E 01	0.00E-01	0.00E-01
I-133	6.58E 06	7.00E 06	1.41E 07	1.74E 07	2.90E 07	3.23E 09	0.00E-01	0.00E-01
I-135	4.01E 04	6.47E 04	4.72E 04	8.49E 04	1.30E 05	7.52E 06	0.00E-01	0.00E-01
Cs-134	1.43E 10	3.67E 08	4.14E 10	6.80E 10	2.11E 10	0.00E-01	7.56E 09	0.00E-01
Cs-136	3.41E 09	1.85E 08	1.92E 09	5.27E 09	2.81E 09	0.00E-01	4.19E 08	0.00E-01
Cs-137	8.72E 09	3.70E 08	6.17E 10	5.91E 10	1.93E 10	0.00E-01	6.93E 09	0.00E-01
Ba-140	5.23E 05	4.54E 05	8.96E 06	7.85E 03	2.56E 03	0.00E-01	4.68E 03	0.00E-01
Ce-141	1.17E 02	9.81E 05	1.53E 03	7.36E 02	3.45E 02	0.00E-01	0.00E-01	0.00E-01
Ce-144	6.24E 03	9.55E 06	1.17E 05	3.66E 04	2.03E 04	0.00E-01	0.00E-01	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-15
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Goat Milk
AGE GROUP = Infant

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	4.90E 03	4.90E 03	0.00E-01	4.90E 03	4.90E 03	4.90E 03	4.90E 03	4.90E 03
P-32	4.88E 09	1.70E 09	1.26E 11	7.40E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	1.17E 04	3.42E 05	0.00E-01	0.00E-01	1.67E 03	7.65E 03	1.49E 04	0.00E-01
Mn-54	6.45E 05	1.04E 06	0.00E-01	2.84E 06	6.30E 05	0.00E-01	0.00E-01	0.00E-01
Fe-59	1.20E 06	1.45E 06	1.74E 06	3.04E 06	0.00E-01	0.00E-01	9.00E 05	0.00E-01
Co-58	4.31E 06	4.31E 06	0.00E-01	1.73E 06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co-60	1.55E 07	1.56E 07	0.00E-01	6.56E 06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn-65	7.36E 08	1.35E 09	4.66E 08	1.60E 09	7.74E 08	0.00E-01	0.00E-01	0.00E-01
Rb-86	8.23E 08	4.26E 07	0.00E-01	1.67E 09	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	4.55E 08	3.26E 08	1.59E 10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-90	4.30E 10	2.11E 09	1.69E 11	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Y-91	1.39E 02	3.75E 05	5.23E 03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr-95	8.41E 01	5.90E 04	4.85E 02	1.19E 02	1.28E 02	0.00E-01	0.00E-01	0.00E-01
Nb-95	1.02E 04	1.48E 07	4.27E 04	1.76E 04	1.26E 04	0.00E-01	0.00E-01	0.00E-01
Ru-103	2.09E 02	7.60E 03	6.25E 02	0.00E-01	1.30E 03	0.00E-01	0.00E-01	0.00E-01
Ru-106	1.77E 03	1.07E 05	1.41E 04	0.00E-01	1.67E 04	0.00E-01	0.00E-01	0.00E-01
Ag-110M	1.43E 07	1.12E 09	2.95E 07	2.16E 07	3.08E 07	0.00E-01	0.00E-01	0.00E-01
Te-127M	4.51E 06	1.50E 07	3.72E 07	1.23E 07	9.16E 07	1.08E 07	0.00E-01	0.00E-01
Te-129M	6.69E 06	2.59E 07	4.34E 07	1.49E 07	1.09E 08	1.67E 07	0.00E-01	0.00E-01
I-131	1.11E 09	8.99E 07	2.14E 09	2.52E 09	2.94E 09	8.28E 11	0.00E-01	0.00E-01
I-132	8.28E-01	1.88E 00	1.15E 00	2.33E 00	2.59E 00	1.09E 02	0.00E-01	0.00E-01
I-133	1.27E 07	7.31E 06	2.97E 07	4.32E 07	5.08E 07	7.86E 09	0.00E-01	0.00E-01
I-135	7.11E 04	7.06E 04	9.81E 04	1.95E 05	2.17E 05	1.75E 07	0.00E-01	0.00E-01
Cs-134	1.26E 10	3.38E 08	6.68E 10	1.25E 11	3.21E 10	0.00E-01	1.31E 10	0.00E-01
Cs-136	4.11E 09	1.67E 08	3.75E 09	1.10E 10	4.39E 09	0.00E-01	8.98E 08	0.00E-01
Cs-137	8.17E 09	3.61E 08	9.85E 10	1.15E 11	3.10E 10	0.00E-01	1.25E 10	0.00E-01
Ba-140	9.50E 05	4.53E 06	1.84E 07	1.84E 04	4.38E 03	0.00E-01	1.13E 04	0.00E-01
Ce-141	2.24E 02	9.85E 05	3.13E 03	1.91E 03	5.88E 02	0.00E-01	0.00E-01	0.00E-01
Ce-144	9.39E 03	9.61E 06	1.67E 05	6.86E 04	2.77E 04	0.00E-01	0.00E-01	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of m⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-16
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Inhal
AGE GROUP = Adult

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	1.26E 03	1.26E 03	0.00E-01	1.26E 03	1.26E 03	1.26E 03	1.26E 03	1.26E 03
P-32	5.00E 04	8.63E 04	1.32E 06	7.70E 04	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	9.99E 01	3.32E 03	0.00E-01	0.00E-01	2.28E 01	5.94E 01	1.44E 04	0.00E-01
Mn-54	6.29E 03	7.72E 04	0.00E-01	3.95E 04	9.83E 03	0.00E-01	1.40E 06	0.00E-01
Fe-59	1.05E 04	1.88E 05	1.17E 04	2.77E 04	0.00E-01	0.00E-01	1.01E 06	0.00E-01
Co-58	2.07E 03	1.06E 05	0.00E-01	1.58E 03	0.00E-01	0.00E-01	9.27E 05	0.00E-01
Co-60	1.48E 04	2.84E 05	0.00E-01	1.15E 07	0.00E-01	0.00E-01	5.96E 06	0.00E-01
Zn-65	4.65E 04	5.34E 04	3.24E 04	1.03E 05	6.89E 04	0.00E-01	8.63E 05	0.00E-01
Rb-86	5.89E 04	1.66E 04	0.00E-01	1.35E 05	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	8.71E 03	3.49E 05	3.04E 05	0.00E-01	0.00E-01	0.00E-01	1.40E 06	0.00E-01
Sr-90	6.09E 06	7.21E 05	9.91E 07	0.00E-01	0.00E-01	0.00E-01	9.59E 06	0.00E-01
Y-91	1.24E 04	3.84E 05	4.62E 05	0.00E-01	0.00E-01	0.00E-01	1.70E 06	0.00E-01
Zr-95	2.32E 04	1.50E 05	1.07E 05	3.44E 04	5.41E 04	0.00E-01	1.77E 06	0.00E-01
Nb-95	4.20E 03	1.04E 05	1.41E 04	7.80E 03	7.72E 03	0.00E-01	5.04E 05	0.00E-01
Ru-103	6.57E 02	1.10E 05	1.53E 05	0.00E-01	5.82E 03	0.00E-01	5.04E 05	0.00E-01
Ru-106	8.71E 03	9.11E 05	6.90E 05	0.00E-01	1.33E 05	0.00E-01	9.35E 06	0.00E-01
Ag-110M	5.94E 03	3.02E 05	1.08E 04	9.99E 03	1.97E 04	0.00E-01	4.63E 06	0.00E-01
Te-127M	1.57E 03	1.49E 05	1.26E 04	5.76E 03	4.57E 04	3.28E 03	9.59E 05	0.00E-01
Te-129M	1.58E 03	3.83E 05	9.75E 03	4.67E 03	3.65E 04	3.44E 03	1.16E 06	0.00E-01
I-131	2.05E 04	6.27E 03	2.52E 04	3.57E 04	6.12E 04	1.19E 07	0.00E-01	0.00E-01
I-132	1.16E 03	4.06E 02	1.16E 03	3.25E 03	5.18E 03	1.14E 05	0.00E-01	0.00E-01
I-133	4.51E 03	8.87E 03	8.63E 03	1.48E 04	2.58E 04	2.15E 06	0.00E-01	0.00E-01
I-135	2.56E 03	5.24E 03	2.68E 03	6.97E 03	1.11E 04	4.47E 05	0.00E-01	0.00E-01
Cs-134	7.27E 05	1.04E 04	3.72E 05	8.47E 05	2.87E 05	0.00E-01	9.75E 04	0.00E-01
Cs-136	1.10E 05	1.17E 04	3.90E 04	1.46E 05	8.55E 04	0.00E-01	1.20E 04	0.00E-01
Cs-137	4.27E 05	8.39E 03	4.78E 05	6.20E 05	2.22E 05	0.00E-01	7.51E 04	0.00E-01
Ba-140	2.56E 03	2.18E 05	3.90E 04	4.90E 01	1.67E 01	0.00E-01	1.27E 06	0.00E-01
Ce-141	1.53E 03	1.20E 05	1.99E 04	1.35E 04	6.25E 03	0.00E-01	3.61E 05	0.00E-01
Ce-144	1.84E 05	8.15E 05	3.43E 06	1.43E 06	8.47E 05	0.00E-01	7.76E 06	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-17
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Inhal
AGE GROUP = Teen

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	1.27E 03	1.27E 03	0.00E-01	1.27E 03	1.27E 03	1.27E 03	1.27E 03	1.27E 03
P-32	7.15E 04	9.27E 04	1.89E 06	1.09E 05	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	1.35E 02	3.00E 03	0.00E-01	0.00E-01	3.07E 01	7.49E 01	2.09E 04	0.00E-01
Mn-54	8.39E 03	6.67E 04	0.00E-01	5.10E 04	1.27E 04	0.00E-01	1.98E 06	0.00E-01
Fe-59	1.43E 04	1.78E 05	1.59E 04	3.69E 04	0.00E-01	0.00E-01	1.53E 06	0.00E-01
Co-58	2.77E 03	9.51E 04	0.00E-01	2.07E 03	0.00E-01	0.00E-01	1.34E 06	0.00E-01
Co-60	1.98E 04	2.59E 05	0.00E-01	1.51E 04	0.00E-01	0.00E-01	8.71E 06	0.00E-01
Zn-65	6.23E 04	4.66E 04	3.85E 04	1.33E 05	8.63E 04	0.00E-01	1.24E 06	0.00E-01
Rb-86	8.39E 04	1.77E 04	0.00E-01	1.90E 05	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	1.25E 04	3.71E 05	4.34E 05	0.00E-01	0.00E-01	0.00E-01	2.41E 06	0.00E-01
Sr-90	6.67E 06	7.64E 05	1.08E 08	0.00E-01	0.00E-01	0.00E-01	1.65E 07	0.00E-01
Y-91	1.77E 04	4.08E 05	6.60E 05	0.00E-01	0.00E-01	0.00E-01	2.93E 06	0.00E-01
Zr-95	3.15E 04	1.49E 05	1.45E 05	4.58E 04	6.73E 04	0.00E-01	2.68E 06	0.00E-01
Nb-95	5.66E 03	9.67E 04	1.85E 04	1.03E 04	9.99E 03	0.00E-01	7.50E 05	0.00E-01
Ru-103	8.95E 02	1.09E 05	2.10E 03	0.00E-01	7.42E 03	0.00E-01	7.82E 05	0.00E-01
Ru-106	1.24E 04	9.59E 05	9.83E 04	0.00E-01	1.90E 05	0.00E-01	1.61E 07	0.00E-01
Ag-110M	7.98E 03	2.72E 05	1.38E 04	1.31E 04	2.50E 04	0.00E-01	6.74E 06	0.00E-01
Te-127M	2.18E 03	1.59E 05	1.80E 04	8.15E 03	6.53E 04	4.38E 03	1.65E 06	0.00E-01
Te-129M	2.24E 03	4.04E 06	1.39E 04	6.57E 03	5.18E 04	4.57E 03	1.97E 06	0.00E-01
I-131	2.64E 04	6.48E 03	3.54E 04	4.90E 04	8.39E 04	1.46E 07	0.00E-01	0.00E-01
I-132	1.57E 03	1.27E 03	1.59E 03	4.37E 03	6.91E 03	1.51E 05	0.00E-01	0.00E-01
I-133	6.21E 03	1.03E 04	1.21E 04	2.05E 04	3.59E 04	2.92E 06	0.00E-01	0.00E-01
I-135	3.48E 03	6.94E 03	3.69E 03	9.43E 03	1.49E 04	6.20E 05	0.00E-01	0.00E-01
Cs-134	5.48E 05	9.75E 03	5.02E 05	1.13E 06	3.75E 05	0.00E-01	1.46E 05	0.00E-01
Cs-136	1.37E 05	1.09E 04	5.14E 04	1.93E 05	1.10E 05	0.00E-01	1.77E 04	0.00E-01
Cs-137	3.11E 05	3.47E 03	6.69E 05	8.47E 05	3.04E 05	0.00E-01	1.21E 05	0.00E-01
Ba-140	3.51E 03	2.28E 05	5.46E 04	6.69E 01	2.28E 01	0.00E-01	2.03E 06	0.00E-01
Ce-141	2.16E 03	1.26E 05	2.84E 04	1.89E 04	8.87E 03	0.00E-01	6.13E 05	0.00E-01
Ce-144	2.62E 05	8.63E 05	4.88E 06	2.02E 06	1.21E 06	0.00E-01	1.33E 07	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-18
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Inhal
AGE GROUP = Child

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	1.12E 03	1.12E 03	0.00E-01	1.12E 03	1.12E 03	1.12E 03	1.12E 03	1.12E 03
P-32	9.86E 04	4.21E 04	2.60E 06	1.14E 05	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	1.54E 02	1.08E 03	0.00E-01	0.00E-01	2.43E 01	8.53E 01	1.70E 04	0.00E-01
Mn-54	9.50E 03	2.29E 04	0.00E-01	4.29E 04	1.00E 04	0.00E-01	1.57E 06	0.00E-01
Fe-59	1.67E 04	7.06E 04	2.07E 04	3.34E 04	0.00E-01	0.00E-01	1.27E 06	0.00E-01
Co-58	3.16E 03	3.43E 04	0.00E-01	1.77E 03	0.00E-01	0.00E-01	1.10E 06	0.00E-01
Co-60	2.26E 04	9.61E 04	0.00E-01	1.31E 04	0.00E-01	0.00E-01	7.06E 06	0.00E-01
Zn-65	7.02E 04	1.63E 04	4.25E 04	1.13E 05	7.13E 04	0.00E-01	9.94E 05	0.00E-01
Rb-86	1.14E 05	7.98E 03	0.00E-01	1.98E 05	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	1.72E 04	1.67E 05	5.99E 05	0.00E-01	0.00E-01	0.00E-01	2.15E 06	0.00E-01
Sr-90	6.43E 06	3.43E 05	1.01E 08	0.00E-01	0.00E-01	0.00E-01	1.47E 07	0.00E-01
Y-91	2.43E 04	1.84E 05	9.13E 05	0.00E-01	0.00E-01	0.00E-01	2.62E 06	0.00E-01
Zr-95	3.69E 04	6.10E 04	1.90E 05	4.17E 04	5.95E 04	0.00E-01	2.23E 06	0.00E-01
Nb-95	6.54E 03	3.69E 04	2.35E 04	9.16E 03	8.61E 03	0.00E-01	6.13E 05	0.00E-01
Ru-103	1.07E 03	4.47E 04	2.79E 03	0.00E-01	7.02E 03	0.00E-01	6.61E 05	0.00E-01
Ru-106	1.69E 04	4.29E 05	1.36E 05	0.00E-01	1.84E 05	0.00E-01	1.43E 07	0.00E-01
Ag-110M	9.13E 03	1.00E 05	1.68E 04	1.14E 04	2.12E 04	0.00E-01	5.47E 06	0.00E-01
Te-127M	3.01E 03	7.13E 04	2.48E 04	8.53E 03	6.35E 04	6.06E 03	1.48E 06	0.00E-01
Te-129M	3.04E 03	1.81E 05	1.92E 04	6.84E 03	5.02E 04	6.32E 03	1.76E 06	0.00E-01
I-131	2.72E 04	2.84E 03	4.80E 04	4.80E 04	7.87E 04	1.62E 07	0.00E-01	0.00E-01
I-132	1.87E 03	3.20E 03	2.11E 03	4.06E 03	6.24E 03	1.93E 05	0.00E-01	0.00E-01
I-133	7.68E 03	5.47E 03	1.66E 04	2.03E 04	3.37E 04	3.84E 06	0.00E-01	0.00E-01
I-135	4.14E 03	4.43E 03	4.91E 03	8.72E 03	1.34E 04	7.91E 05	0.00E-01	0.00E-01
Cs-134	2.24E 05	3.84E 03	6.50E 05	1.01E 06	3.30E 05	0.00E-01	1.21E 05	0.00E-01
Cs-136	1.16E 05	4.17E 03	6.50E 04	1.71E 05	9.53E 04	0.00E-01	1.45E 04	0.00E-01
Cs-137	1.28E 05	3.61E 03	9.05E 05	8.24E 05	2.82E 05	0.00E-01	1.04E 05	0.00E-01
Ba-140	4.32E 03	1.02E 05	7.39E 04	6.47E 01	2.11E 01	0.00E-01	1.74E 06	0.00E-01
Ce-141	2.89E 03	5.65E 04	3.92E 04	1.95E 04	8.53E 03	0.00E-01	5.43E 05	0.00E-01
Ce-144	3.61E 05	3.88E 05	6.76E 06	2.11E 06	1.17E 06	0.00E-01	1.19E 07	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of m⁻² mrem/yr per micro-Ci/sec for all others.

TABLE 3.3-19
R VALUES FOR THE H. B. ROBINSON STEAM ELECTRIC PLANT*

PATHWAY = Inhal

AGE GROUP = Infant

<u>Nuclide</u>	<u>T.Body</u>	<u>GI-Tract</u>	<u>Bone</u>	<u>Liver</u>	<u>Kidney</u>	<u>Thyroid</u>	<u>Lung</u>	<u>Skin</u>
H-3	6.46E 02	6.46E 02	0.00E-01	6.46E 02	6.46E 02	6.46E 02	6.46E 02	6.46E 02
P-32	7.73E 04	1.61E 04	2.03E 06	1.12E 05	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Cr-51	8.93E 01	3.56E 02	0.00E-01	0.00E-01	1.32E 01	5.75E 01	1.28E 04	0.00E-01
Mn-54	4.98E 03	7.05E 03	0.00E-01	2.53E 04	4.98E 03	0.00E-01	9.98E 05	0.00E-01
Fe-59	9.46E 03	2.47E 04	1.35E 04	2.35E 04	0.00E-01	0.00E-01	1.01E 06	0.00E-01
Co-58	1.82E 03	1.11E 04	0.00E-01	1.22E 03	0.00E-01	0.00E-01	7.76E 05	0.00E-01
Co-60	1.18E 04	3.19E 04	0.00E-01	8.01E 03	0.00E-01	0.00E-01	4.50E 06	0.00E-01
Zn-65	3.10E 04	5.13E 04	1.93E 04	6.25E 04	3.24E 04	0.00E-01	6.46E 05	0.00E-01
Rb-86	8.81E 04	3.03E 03	0.00E-01	1.90E 05	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr-89	1.14E 04	6.39E 04	3.97E 05	0.00E-01	0.00E-01	0.00E-01	2.03E 06	0.00E-01
Sr-90	2.59E 06	1.31E 05	4.08E 07	0.00E-01	0.00E-01	0.00E-01	1.12E 07	0.00E-01
Y-91	1.57E 04	7.02E 04	5.87E 05	0.00E-01	0.00E-01	0.00E-01	2.45E 06	0.00E-01
Zr-95	2.03E 04	2.17E 04	1.15E 05	2.78E 04	3.10E 04	0.00E-01	1.75E 06	0.00E-01
Nb-95	3.77E 03	1.27E 04	1.57E 04	6.42E 03	4.71E 03	0.00E-01	4.78E 05	0.00E-01
Ru-103	6.78E 02	1.61E 04	2.01E 03	0.00E-01	4.24E 03	0.00E-01	5.51E 05	0.00E-01
Ru-106	1.09E 04	1.64E 05	8.67E 04	0.00E-01	1.06E 05	0.00E-01	1.15E 07	0.00E-01
Ag-110M	4.99E 03	3.30E 04	9.97E 03	7.21E 03	1.09E 04	0.00E-01	3.66E 06	0.00E-01
Te-127M	2.07E 03	2.73E 04	1.66E 04	6.89E 03	3.75E 04	4.86E 03	1.31E 06	0.00E-01
Te-129M	2.22E 03	6.89E 04	1.41E 04	6.08E 03	3.17E 04	5.47E 03	1.68E 06	0.00E-01
I-131	1.96E 04	1.06E 03	3.79E 04	4.43E 04	5.17E 04	1.48E 07	0.00E-01	0.00E-01
I-132	1.26E 03	1.90E 03	1.69E 03	3.54E 03	3.94E 03	1.69E 05	0.00E-01	0.00E-01
I-133	5.59E 03	2.15E 03	1.32E 04	1.92E 04	2.24E 04	3.55E 06	0.00E-01	0.00E-01
I-135	2.77E 03	1.33E 03	3.86E 03	7.59E 03	8.46E 03	6.95E 05	0.00E-01	0.00E-01
Cs-134	7.44E 04	1.33E 03	3.96E 05	7.02E 05	1.90E 05	0.00E-01	7.95E 04	0.00E-01
Cs-136	5.28E 04	1.43E 03	4.82E 04	1.34E 05	5.63E 04	0.00E-01	1.17E 04	0.00E-01
Cs-137	4.54E 04	1.33E 03	5.48E 05	6.11E 05	1.72E 05	0.00E-01	7.12E 04	0.00E-01
Ba-140	2.89E 03	3.83E 04	5.59E 04	5.59E 01	1.34E 01	0.00E-01	1.59E 06	0.00E-01
Ce-141	1.99E 03	2.15E 04	2.77E 04	1.66E 04	5.24E 03	0.00E-01	5.16E 05	0.00E-01
Ce-144	1.76E 05	1.48E 05	3.19E 06	1.21E 06	5.37E 05	0.00E-01	9.83E 06	0.00E-01

*R Values in units of mrem/yr per micro-Ci/m⁻³ for inhalation and tritium, and in units of M⁻² mrem/yr per micro-Ci/sec for all others.

4.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

TABLE 4.0-1 contains the sample point description, sampling and collection frequency, analysis, and analysis frequency for various exposure pathways in the vicinity of the HBR for the Radiological Monitoring Program. Figures 4.0-1a and 4.0-1b show the location of the various sampling points.

At the time of initial preparation of this manual, the limiting cow milk location was 1.3 miles in the NE sector. As of the time of submittal of this manual, there is no longer a cow present at this location. The radiological environmental monitoring program has been altered to reflect this change. However, the X/Q, and D/Q values associated with this location have been retained for future reference.

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 ¹ Frequency	Analysis ¹
1. Airborne Particulates and Radioiodine	1.	Florence, S. C. (Control Station) ² 26 miles SE	Continuous operating sampler with sample collection at least weekly	Weekly	I-131 for Air Cartridges Gross Beta, ³ Gamma Scan ⁴ of com- posit (by location)
	2.	Visitors Center 0.2 miles SW		Weekly	
	3.	Microwave tower 0.7 miles N		Quarterly	
	4.	Spillway 0.4 miles E			
	5.	East Shore of lake across from plant intake Johnson's Landing 0.9 miles ENE			
	6.	Construction access road, 0.3 miles W			
	7.	CP&L Hartsville office, 5.3 miles ESE			
2. Direct Radiation	1.	Florence, S. C. (Control Station) ² 26 miles SE	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.	Visitors Center 0.2 miles SW	Continuous measurement with readout at least once per quarter (TLDs)	Quarterly	Gamma Dose ⁵
	3.	Microwave tower 0.7 miles N			
	4.	Spillway 0.4 miles E			
	5.	East shore of lake across from plant intake Johnson's landing 0.9 miles ENE			
	6.	Construction access road, 0.3 miles W			
	7.	CP&L Hartsville office, 5.3 miles ESE			
	8.	On transmission poles inter- secting with different transmission lines directly from HBR, approx- imately two pole sections down from railroad tracks 0.8 miles SSE.			
	9.	Second transmission pole from 151 Highway 1.0 miles S.			
	10.	Power pole at corner of The Church of God cemetery 1.0 miles WSW.			

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)	11.	Fourth power pole from the Old Camden Road 1.0 miles SW.	Continuous measurement with readout of at least once per quarter (TLDs)	Quarterly	Gamma Dose ⁵
	12.	Pine tree located at the second intersection of dirt road. Yellow mark on tree 1.2 miles SSW.			
	13.	Corner pine tree where dirt road splits 1.0 miles W.			
	14.	Power pole by Highway 151 on front of Pine Ridge Church 0.9 miles WNW.			
	15.	Pine tree down dirt road off of Highway 151 directly adjacent to ash pond on CP&L property 10 miles NW.			
	16.	South East fence at Darlington Country I.C. Turbine Plant 1.0 miles NNW.			
	17.	Small pine tree, right side of road, one 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 miles SE.			
	19.	Third power pole on Road #S-16-23 from intersection with 1.0 miles E.			
	20.	Power Pole #47 at right side of Road #S-16-39 going north 1.3 miles ENE.			

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)	21.	Power pole in the yard of A. Atkinson at Atkinson's boat landing.	Continuous measurement with readout of at least once per quarter (TLDs)	Quarterly	Gamma Dose ⁵
	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.			
	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 Trespas- sing" 4.6 miles NNW.			
	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.			

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)	29.	Transmission pole nearest Road #S-16-20 ~1/2-mile south of lookout tower.	Continuous measurement with readout at least once per quarter (TLDs)	Quarterly	Gamma Dose ⁵
	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.			
	35.	Power pole at corner of Road #S-31-51 off Road #S-16-12 4.4 miles SSW.			
	36.	Power pole ~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.			

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)	38.	Transmission pole right side of Road S-16-231 next to Union Church 4.9 miles W.	Continuous measurement with readout at least once per quarter (TLDs)	Quarterly	Gamma Dose ⁵	
	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 miles 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.	Grab sample	Monthly	Gamma Scan ⁴ H-3	
	b. Ground Water	40.	Artesian well 0.6 miles ESE.	Grab Sample	Monthly	Gamma Scan ⁴ H-3
		42.	Unit 1 well near site entrance.			
		43.	Well located on west side of Unit 2.			
		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
	4. Ingestion a. Milk	00	The closest milk station is 7.5 miles SW ,therefore, broad leaf vegetation shall be sampled in lieu of milk sampling.			

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
b. Fish	45.	Site varies within Lake Robinson.	Quarterly (collect same 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.	Quarterly (collect same species of all three locations)	Each sample	Gamma Scan ⁴ Edible portions
c. Food Products leafy vegetables	48.	One location within 3 miles of site in the sector with the highest de- position rate based on the latest information or historical data ⁸ (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 .			
d. Broad leaf vegetation	50.	0.25 miles 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 this 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. Agricultural irrigation from waters downstream of liquid release points do not exist.
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.

FIGURE 4-1
RADIOLOGICAL SAMPLE
LOCATIONS NEAR SITE

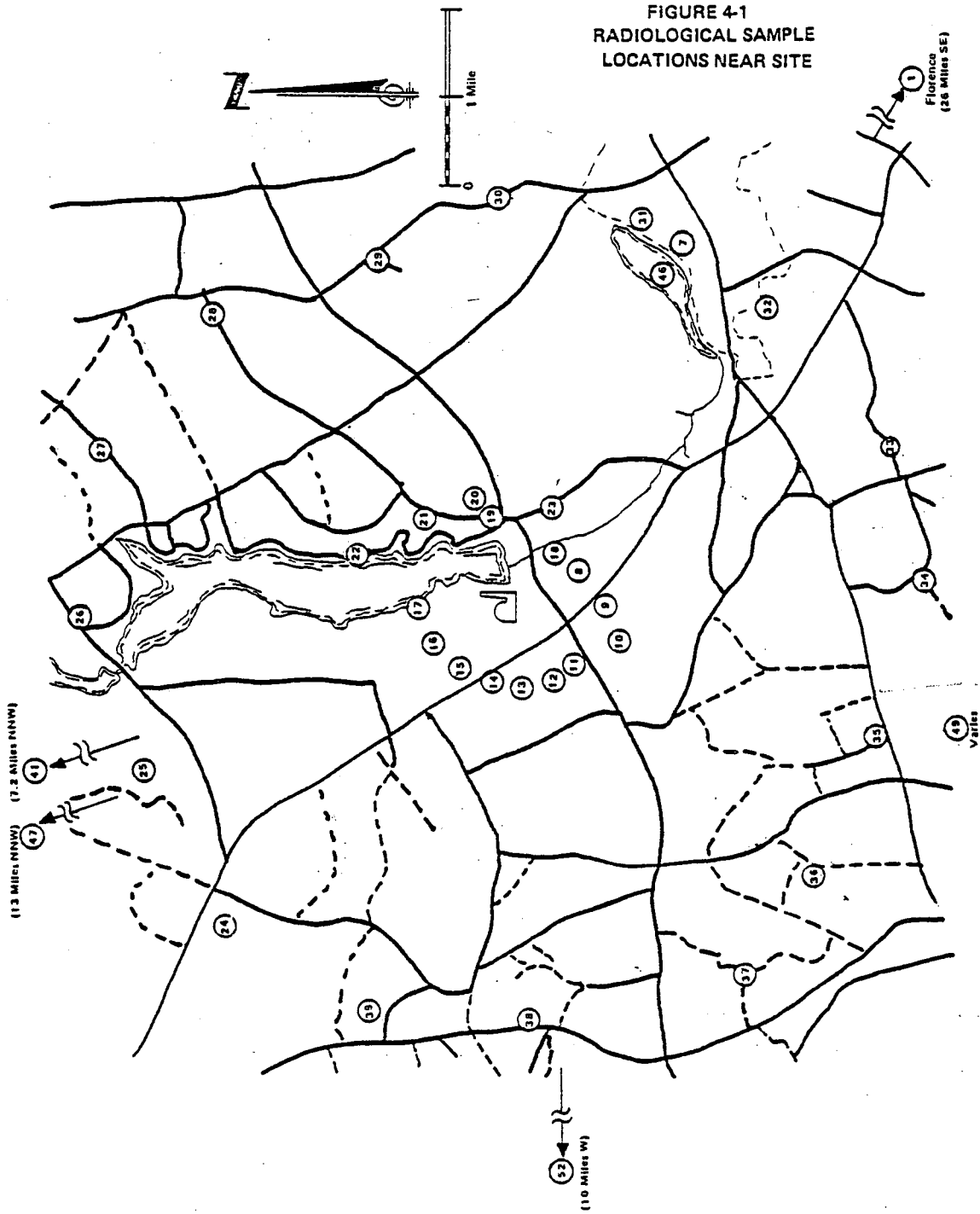
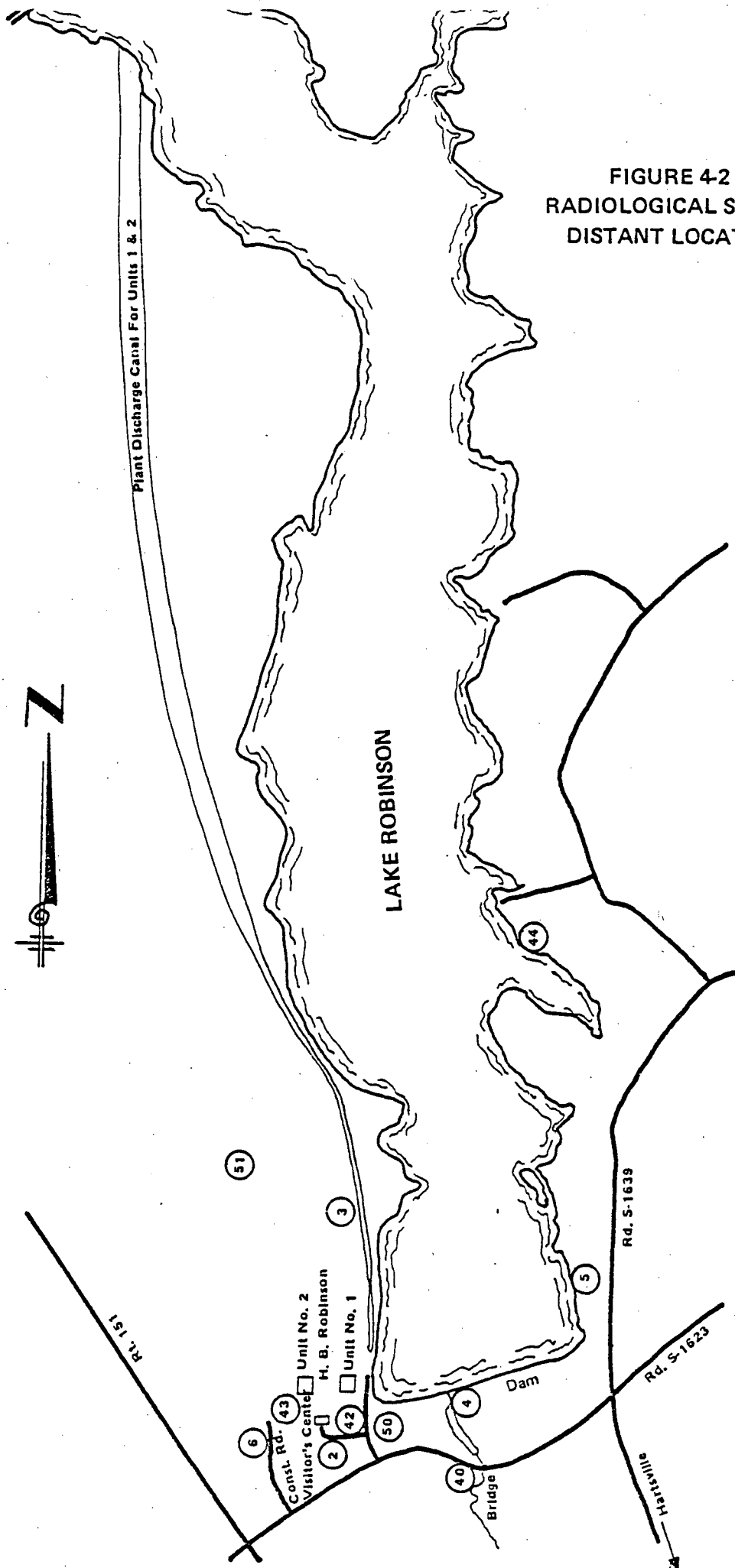


FIGURE 4-2
RADIOLOGICAL SAMPLE
DISTANT LOCATIONS



48 Varies

5.0 INTERLABORATORY COMPARISON STUDIES

5.1 OBJECTIVE

The objective of this program is to evaluate the total laboratory analysis process by comparing results with results obtained by a separate laboratory or laboratories for an equivalent sample.

5.2 PROGRAM

5.2.1 Environmental Sample Analyses Comparison Program

Environmental samples from the HBR environs are to be analyzed by the Harris Energy & Environmental Center or by a qualified contracting laboratory. These laboratories will participate at least annually in a nationally recognized interlaboratory comparison study. The results of the laboratories' performances in the study will be provided to HBR E&RC. The results will be provided to the NRC upon request.

5.2.2 Effluent Release Analyses Program

HBR E&RC will perform sample analyses for gamma-emitting radionuclides in effluent releases. The E&RC radiochemistry laboratory will participate annually in a corporate interlaboratory comparison study or an equivalent study. The results of these studies will be provided to the NRC upon request.

5.2.3 Abnormal Results

If the CP&L laboratory or vendor laboratory results lie at greater than three sigma from the "recognized value," an evaluation will be performed to identify any recommended remedial actions to reduce anomalous errors. Complete documentation on the evaluation will be available to HBR and will be provided to the NRC upon request.

6.0 TOTAL DOSE (40CFR190 CONFORMANCE)

6.1 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 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 are considered to be <1 mrem/yr. (Ref: NUREG 0543).
- (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:

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

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

$1.49\text{E}+6$ = 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 are to incorporate planned plant operations such as power reduction or outages for the projected period.

APPENDIX A

METEOROLOGICAL DISPERSION FACTOR COMPUTATIONS

Carolina Power & Light Company (CP&L) engaged the services of Dames & Moore to assess the transport and dispersion of the effluent in the atmosphere as outlined in Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants, NUREG 0133 (USNRC 1978). The methodology for this assessment was based on guidelines presented in Regulatory Guide (RG) 1.111, Revision 1 (USNRC 1977). The results of the assessment were to provide the relative deposition flux and relative concentrations (undepleted and depleted) based on numerical models acceptable for use in Appendix I evaluations.

Regulatory Guide 1.111 presented three acceptable diffusion models for use in estimating deposition flux and concentrations. These were (1) particle-in-cell model (a variable trajectory model based on the gradient-transport theory), (2) puff-advection model (a variable trajectory model based on the statistical approach to diffusion), and (3) the constant mean wind direction model referred to here as the straight-line trajectory Gaussian diffusion model (the most widely used model based on a statistical approach). It was resolved that for operational efficiency, the straight-line described in XOQDOQ Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations (Draft), NUREG 0324 (USNRC September 1977) would be used for generating the required analyses of Appendix I. To provide a more realistic accounting of the variability of wind around the plant site, terrain/recirculation correction factors (TCF) were to be determined from a combined puff-advection/straight-line scheme for a one-year meteorological data base.

Dames & Moore was provided a one-year record of meteorological data from the on-site meteorological program at the H. B. Robinson Steam Electric Plant. These data consisted of all collected parameters at both the 11.03-meter and 62.39-meter tower levels for the year 1977. Dames & Moore computed dispersions and depositions using the model described in the reference. The following tables from the reference provide the basis for the meteorological dilution factor development of the technical specifications for Appendix I and were the source of the X/Q and D/Q values used to show compliance with 10CFR20 and 10CFR50 for noble gases and radioiodines and particulates.

Tables A-1 through A-6

Relative undepleted concentration, relative depleted concentration, and relative deposition flux estimates for ground level releases for both standard distances and special locations for long-term releases.

Tables A-7 through A-9

Relative undepleted concentration, relative depleted concentration, and relative deposition flux estimates for ground level releases for special locations for short-term releases.

The X/Q and D/Q values which are used in Appendix B for showing compliance with 10CFR20 and 10CFR50 when the HBR Plant vent has been modified such that it qualifies as a mixed mode release were based upon the following tables:

Tables A-10 through A-15

Relative undepleted concentration, relative depleted concentration, and relative deposition flux estimates for elevated release for both standard distances and special locations for long-term releases.

Tables A-16 through A-18

Relative undepleted concentration, relative depleted concentration, and relative deposition flux estimates for mixed mode releases for special locations for short-term releases.

It should be noted that the short-term releases were based upon 100 hours per year of containment purges.

Future Operation Computations

The NRC "XOQDOQ" Program (Revision 1) was obtained and installed on the CP&L computer system. In general, Dames & Moore concluded that the straight-line model is as reasonable a projection of concentrations as the puff-advection

model. By inclusion of the terrain correction factors developed by a combination of the puff-advection/straight-line scheme with the results of the XOQDOQ Program, ready evaluation of on-site meteorological data may be made.

For routine meteorological dispersion evaluations, the "XOQDOQ" Program will be run with the appropriate physical plant data, appropriate meteorological information for the standard distances, and special locations of interest without a terrain/recirculation factor. The resulting computations will have applied the TCFs to produce a final atmospheric diffusion estimate for the site. The input to "XOQDOQ" for ground level releases at HBR are presented in Table A-19 and for mixed mode releases at HBR in Table A-20.

Reference

Chandler, Martin W. and George Hoopes, Revised Radiological Effluent Technical Specifications. Gaseous Effluent Dilution Factors, Prepared for Carolina Power & Light Company, Robinson Facility, Dames & Moore, January 18, 1979.

TABLE A-1

X/Q Values for Long-Term Ground Level Releases at Special Locations (sec/cm³)*

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Ground Level

Variable: Relative 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	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/cm³)*

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-3

D/Q Values for Long-Term Ground Level Releases at Special Locations (m^{-2})*

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Ground Level

Variable: Relative Deposition Rate (Meter^{-2})

Calculation Points: Special

Model: Straight Line (ANNX0Q9)

Application of Terrain Correction Factors: Yes

Number of Observations: 8703

Affected Sector	Site Boundary	Meat	Dairy	Resident	Garden
NNE	9.80E-09	5.63E-09	0.00	9.09E-09	7.74E-09
NE	5.59E-09	4.65E-09	3.70E-09	4.42E-09	3.70E-09
ENE	8.06E-09	6.96E-10	0.00	7.59E-09	1.05E-09
E	1.24E-08	4.13E-10	1.80E-10	6.43E-09	5.11E-10
ESE	1.71E-08	1.46E-09	0.00	1.20E-08	1.20E-08
SE	4.23E-08	0.00	0.00	4.14E-08	4.14E-08
SSE	8.08E-08	0.00	0.00	6.21E-08	6.21E-08
S	4.39E-08	4.77E-10	0.00	3.82E-08	2.33E-08
SSW	5.92E-08	1.38E-09	0.00	6.12E-08	2.33E-08
SW	2.80E-08	6.49E-10	5.17E-10**	2.15E-08	1.65E-08
WSW	1.91E-08	4.37E-10	0.00	1.54E-08	8.84E-09
W	8.84E-09	1.09E-10	0.00	5.75E-09	5.75E-09
WNW	8.10E-09	1.88E-10	0.00	5.08E-09	2.97E-09
NW	2.44E-09	1.45E-09	0.00	2.16E-09	2.16E-09
NNW	2.44E-09	7.45E-10	0.00	6.83E-10	5.73E-10
N	1.76E-09	6.44E-10	0.00	6.67E-10	6.67E-10

* 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/cm³)

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Ground Level

Variable: Relative Concentration (Sec./Cubic Meter)

Calculation Points: Standard

Model: Straight Line (ANNX0Q9)

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/cm³)

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	.75	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75
		.40	1.21	2.01	2.82	3.62	4.42	5.23	6.03	6.84	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	7.5E-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-6

D/Q Values for Long-Term Ground Level Releases at Standard Distances (m^{-2})

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Ground Level

Variable: Relative Concentration ($Meter^{-2}$)

Calculation Points: Standard

Model: Straight Line (ANNX009)

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.	1.3E-07	2.4E-08	9.3E-09	4.8E-09	3.0E-09	2.0E-09	1.2E-09	8.2E-10	5.4E-10	3.4E-10
NE	0.	7.1E-08	8.9E-09	3.4E-09	1.8E-09	1.0E-09	6.5E-10	4.6E-10	3.4E-10	2.6E-10	2.0E-10
ENE	0.	5.5E-08	9.6E-09	3.1E-09	1.5E-09	7.9E-10	5.1E-10	3.3E-10	2.6E-10	1.9E-10	1.6E-10
E	0.	5.1E-08	8.7E-09	2.7E-09	1.4E-09	9.4E-10	4.7E-10	3.6E-10	2.4E-10	1.5E-10	1.1E-10
ESE	0.	5.0E-08	8.2E-09	3.2E-09	1.6E-09	1.1E-09	6.9E-10	5.1E-10	3.6E-10	2.5E-10	1.8E-10
SE	0.	4.8E-08	7.0E-09	3.1E-09	1.5E-09	8.6E-10	4.5E-10	3.1E-10	1.8E-10	1.5E-10	1.2E-10
SSE	0.	8.2E-08	1.3E-08	5.2E-09	2.6E-09	1.4E-09	7.7E-10	4.9E-10	3.9E-10	3.0E-10	2.5E-10
S	0.	4.8E-08	6.3E-09	2.2E-09	1.2E-09	4.8E-10	3.5E-10	2.6E-10	1.9E-10	1.6E-10	1.2E-10
SSW	0.	7.2E-08	1.4E-08	5.1E-09	2.0E-09	1.1E-09	6.8E-10	4.5E-10	3.2E-10	2.3E-10	1.8E-10
SW	0.	4.2E-08	6.5E-09	2.3E-09	1.0E-09	5.7E-10	3.7E-10	2.7E-10	1.8E-10	1.4E-10	1.1E-10
WSW	0.	3.0E-08	4.9E-09	1.7E-09	8.5E-10	6.3E-10	3.8E-10	2.5E-10	1.9E-10	1.6E-10	1.2E-10
W	0.	2.7E-08	3.4E-09	1.2E-09	6.1E-10	4.4E-10	2.7E-10	2.0E-10	1.3E-10	8.5E-11	6.7E-11
WNW	0.	3.0E-08	3.9E-09	1.4E-09	7.4E-10	5.4E-10	3.7E-10	2.6E-10	2.0E-10	1.4E-10	1.0E-10
NW	0.	3.4E-08	5.2E-09	2.2E-09	1.2E-09	6.3E-10	3.2E-10	1.8E-10	1.5E-10	1.1E-10	9.0E-11
NNW	0.	4.1E-08	7.4E-09	3.6E-09	2.5E-09	1.6E-09	8.0E-10	3.9E-10	2.4E-10	1.5E-10	1.2E-10
N	0.	6.7E-08	1.1E-08	4.1E-09	2.0E-09	1.1E-09	7.2E-10	4.7E-10	3.3E-10	2.5E-10	2.0E-10

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

TABLE A-7

X/Q Values for Short-Term Ground Level Releases at Special Locations (sec/m³)*

Carolina Power & Light Company - Robinson

Release Type: Purge

Release Mode: Ground Level

Variable: Relative Concentration (Sec./Cubic Meter)

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	7.20E-06	5.00E-06	0.00	6.80E-06	6.20E-06
NE	5.30E-06	4.60E-06	4.00E-06	4.40E-06	4.00E-06
ENE	6.90E-06	1.50E-06	0.00	6.70E-06	1.90E-06
E	1.00E-05	1.10E-06	6.40E-07	6.20E-06	1.20E-06
ESE	1.50E-05	2.60E-06	0.00	1.10E-05	1.10E-05
SE	3.40E-05	0.00	0.00	3.30E-05	3.30E-05
SSE	5.10E-05	0.00	0.00	4.10E-05	4.10E-05
S	3.00E-05	1.20E-06	0.00	2.60E-05	1.80E-05
SSW	2.10E-05	1.30E-06	0.00	2.00E-05	9.80E-06
SW	1.10E-05	7.80E-07	6.70E-07**	9.10E-06	7.20E-06
WSW	8.10E-06	5.50E-07	0.00	6.90E-06	4.20E-06
W	5.50E-06	3.00E-07	0.00	4.20E-06	4.20E-06
WNW	5.30E-06	3.90E-07	0.00	3.70E-06	2.50E-06
NW	2.30E-06	1.70E-06	0.00	2.20E-06	2.20E-06
NNW	2.40E-06	1.20E-06	0.00	1.20E-06	1.10E-06
N	2.70E-06	1.50E-06	0.00	1.50E-06	1.50E-06

* Zeroes indicate that this point was not calculated

** A milk goat is located here

TABLE A-8

Depleted X/Q Values for Short-Term Ground Level Releases at Special Locations (sec/m³)*

Carolina Power & Light Company - Robinson

Release Type: Purge

Release Mode: Ground Level

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

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	6.30E-06	4.09E-06	0.00	5.71E-06	5.31E-06
NE	4.71E-06	3.97E-06	3.37E-06	3.77E-06	3.37E-06
ENE	6.19E-06	1.21E-06	0.00	5.96E-06	1.53E-06
E	9.06E-06	8.80E-07	4.80E-07	5.51E-06	9.34E-07
ESE	1.36E-05	2.14E-06	0.00	9.90E-06	9.90E-06
SE	3.19E-05	0.00	0.00	3.08E-05	3.08E-05
SSE	4.71E-05	0.00	0.00	3.83E-05	3.83E-05
S	2.83E-05	9.74E-07	0.00	2.44E-05	1.67E-05
SSW	1.91E-05	1.05E-06	0.00	1.92E-05	8.93E-06
SW	1.02E-05	6.38E-07	7.64E-07**	8.49E-06	6.52E-06
WSW	7.50E-06	4.23E-07	0.00	6.30E-06	3.85E-06
W	5.16E-06	2.28E-07	0.00	3.85E-06	3.85E-06
WNW	4.82E-06	2.98E-07	0.00	3.33E-06	2.23E-06
NW	1.95E-06	1.41E-06	0.00	1.88E-06	1.88E-06
NNW	1.99E-06	9.53E-07	0.00	9.46E-07	8.59E-07
N	2.31E-06	1.19E-06	0.00	1.18E-06	1.18E-06

* Zeros indicate that this point was not calculated

** A milk goat is located here

TABLE A-9
D/Q Values for Short-Term Ground Level Releases at Special Locations (m⁻²)*

Carolina Power & Light Company - Robinson

Release Type: Purge

Release Mode: Ground Level

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	1.06E-08	6.80E-09	0.00	9.86E-09	8.62E-09
NE	9.80E-09	8.37E-09	6.96E-09	7.96E-09	6.96E-09
ENE	1.26E-08	2.12E-09	0.00	1.21E-08	2.72E-09
E	1.94E-08	1.51E-09	8.00E-10	1.13E-08	1.67E-09
ESE	2.29E-08	3.22E-09	0.00	1.68E-08	1.68E-08
SE	4.25E-08	0.00	0.00	4.19E-08	4.19E-08
SSE	5.10E-08	0.00	0.00	4.22E-08	4.22E-08
S	3.99E-08	1.36E-09	0.00	3.59E-08	2.54E-08
SSW	5.92E-08	3.18E-09	0.00	6.00E-08	2.83E-08
SW	3.46E-08	1.93E-09	1.61E-09**	2.83E-08	2.20E-08
WSW	3.90E-08	2.07E-09	0.00	3.30E-08	2.03E-08
W	2.30E-08	8.40E-10	0.00	1.75E-08	1.75E-08
WNW	2.65E-08	1.38E-09	0.00	1.82E-08	1.22E-08
NW	7.08E-09	4.86E-09	0.00	6.42E-09	6.42E-09
NNW	4.46E-09	1.87E-09	0.00	1.86E-09	1.65E-09
N	3.27E-09	1.50E-09	0.00	1.50E-09	1.50E-09

* Zeroes indicate that this point was not calculated

** A milk goat is located here

TABLE A-10

X/Q Values for Long-Term Mixed Mode Releases at Special Locations (sec/m³)*

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Mixed Mode

Variable: Relative Concentration (Sec./Cubic Meter)

Calculation Points: Special

Model: Straight Line (ANNX0Q9)

Application of Terrain Correction Factors: Yes

Number of Observations: 8703

Affected Sector	Site Boundary	Meat	Dairy	Resident	Garden
NNE	3.33E-07	2.82E-07	0.00	3.23E-07	3.18E-07
NE	1.34E-07	1.40E-07	1.23E-07	1.39E-07	1.23E-07
ENE	2.74E-07	1.23E-07	0.00	2.79E-07	8.51E-08
E	2.40E-07	1.11E-07	5.39E-08	2.53E-07	1.33E-07
ESE	2.75E-07	1.25E-07	0.00	2.17E-07	2.17E-07
SE	5.13E-07	0.00	0.00	5.23E-07	5.23E-07
SSE	9.94E-07	0.00	0.00	7.61E-07	7.61E-07
S	4.57E-07	3.61E-08	0.00	4.00E-07	2.50E-07
SSW	5.54E-07	1.27E-07	0.00	5.71E-07	2.69E-07
SW	2.31E-07	5.38E-08	4.72E-08**	1.84E-07	1.51E-07
WSW	2.06E-07	4.64E-08	0.00	1.68E-07	1.02E-07
W	9.36E-08	1.87E-08	0.00	7.13E-08	7.13E-08
WNW	1.02E-07	4.28E-08	0.00	9.55E-08	9.80E-08
NW	1.52E-07	1.30E-07	0.00	1.54E-07	1.54E-07
NNW	1.71E-07	8.86E-08	0.00	8.30E-08	7.28E-08
N	9.32E-08	5.66E-08	0.00	5.80E-08	5.80E-08

* Zeroes indicate that this point was not calculated

** A milk goat is located here

TABLE A-11

Depleted X/Q Values for Long-Term Mixed Mode Releases at Special Locations (sec/m³)*

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Mixed Mode

Variable: Relative 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	3.33E-07	2.82E-07	0.00	3.23E-07	2.98E-07
NE	1.23E-07	1.28E-07	1.23E-07	1.28E-07	1.23E-07
ENE	2.59E-07	1.23E-07	0.00	2.63E-07	8.12E-08
E	2.40E-07	1.11E-07	4.39E-08	2.53E-07	1.23E-07
ESE	2.54E-07	1.18E-07	0.00	1.96E-07	1.96E-07
SE	4.93E-07	0.00	0.00	5.02E-07	5.02E-07
SSE	9.32E-07	0.00	0.00	7.21E-07	7.21E-07
S	4.39E-07	3.42E-08	0.00	3.82E-07	2.33E-07
SSW	5.35E-07	1.27E-07	0.00	5.51E-07	2.51E-07
SW	2.31E-07	5.14E-08	5.31E-08**	1.84E-07	1.45E-07
WSW	2.06E-07	4.46E-08	0.00	1.68E-07	9.91E-08
W	9.10E-08	1.82E-08	0.00	6.90E-08	6.90E-08
WNW	9.88E-08	4.07E-08	0.00	9.26E-08	9.54E-08
NW	1.51E-07	1.27E-07	0.00	1.54E-07	1.54E-07
NNW	1.64E-07	8.44E-08	0.00	8.04E-08	6.92E-08
N	8.91E-08	5.42E-08	0.00	5.56E-08	5.56E-08

* Zeroes indicate that this point was not calculated

** A milk goat is located here

TABLE A-12
D/Q Values for Long-Term Mixed Mode Releases at Special Locations (m⁻²)*

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Mixed Mode

Variable: Relative Deposition Rate (Meter⁻²)

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	2.29E-09	1.39E-09	0.00	2.22E-09	1.89E-09
NE	1.79E-09	1.51E-09	1.23E-09	1.39E-09	1.23E-09
ENE	3.19E-09	3.41E-10	0.00	3.10E-09	4.78E-10
E	4.99E-09	2.31E-10	1.15E-10	2.92E-09	2.76E-10
ESE	4.86E-09	5.90E-10	0.00	3.75E-09	3.75E-09
SE	6.98E-09	0.00	0.00	7.20E-09	7.20E-09
SSE	6.22E-09	0.00	0.00	5.21E-09	5.21E-09
S	7.31E-09	1.77E-10	0.00	6.60E-09	5.17E-09
SSW	1.01E-08	7.41E-10	0.00	1.06E-08	6.81E-09
SW	4.62E-09	3.32E-10	2.66E-10**	4.14E-09	3.87E-09
WSW	4.85E-09	2.59E-10	0.00	4.34E-09	3.35E-09
W	2.64E-09	6.74E-11	0.00	1.95E-09	1.95E-09
WNW	2.59E-09	1.25E-10	0.00	1.94E-09	1.29E-09
NW	1.20E-09	7.66E-10	0.00	1.12E-09	1.12E-09
NNW	7.77E-10	2.53E-10	0.00	2.41E-10	2.03E-10
N	3.62E-10	1.41E-10	0.00	1.51E-10	1.51E-10

* Zeroes indicate that this point was not calculated

** A milk goat is located here

TABLE A-13

X/Q Values for Long-Term Mixed Mode Releases at Standard Distances (sec/m³)

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Mixed Mode

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.	1.5E-06	3.9E-07	3.1E-07	2.7E-07	2.3E-07	2.0E-07	1.6E-07	1.4E-07	9.8E-08	6.5E-08
NE	0.	1.0E-06	1.5E-07	1.1E-07	9.0E-08	6.7E-08	5.2E-08	7.8E-08	3.8E-08	5.4E-08	3.4E-08
ENE	0.	8.6E-07	2.6E-07	1.9E-07	1.7E-07	1.2E-07	1.1E-07	7.4E-08	6.2E-08	4.8E-08	4.2E-08
E	0.	7.2E-07	2.6E-07	2.2E-07	2.0E-07	2.1E-07	1.2E-07	9.4E-08	7.0E-08	4.7E-08	3.6E-08
ESE	0.	7.8E-07	1.9E-07	1.7E-07	1.3E-07	1.0E-07	7.6E-08	6.6E-08	4.9E-08	3.8E-08	2.9E-08
SE	0.	5.9E-07	1.0E-07	7.5E-08	5.1E-08	3.8E-08	2.4E-08	1.9E-08	1.2E-08	1.2E-08	1.1E-08
SSE	0.	1.0E-06	1.8E-07	1.2E-07	8.0E-08	5.4E-08	3.6E-08	2.6E-08	2.3E-08	1.9E-08	1.8E-08
S	0.	5.0E-07	9.4E-08	7.0E-08	5.9E-08	3.5E-08	3.2E-08	2.9E-08	2.5E-08	2.2E-08	1.9E-08
SSW	0.	6.3E-07	2.7E-07	2.4E-07	1.5E-07	1.2E-07	8.4E-08	6.3E-08	4.7E-08	3.6E-08	3.1E-08
SW	0.	3.5E-07	9.9E-08	8.8E-08	6.1E-08	4.6E-08	3.7E-08	3.2E-08	2.3E-08	2.0E-08	1.7E-08
WSW	0.	3.0E-07	6.5E-08	6.2E-08	5.4E-08	5.4E-08	4.1E-08	3.0E-08	2.7E-08	2.4E-08	1.9E-08
W	0.	2.4E-07	6.2E-08	6.0E-08	4.9E-08	4.9E-08	3.5E-08	3.0E-08	2.0E-08	1.5E-08	1.2E-08
WNW	0.	2.8E-07	8.4E-08	8.6E-08	6.8E-08	6.3E-08	5.2E-08	4.2E-08	3.6E-08	3.6E-08	3.4E-08
NW	0.	3.8E-07	1.2E-07	1.5E-07	1.2E-07	9.2E-08	6.5E-08	4.7E-08	4.1E-08	3.5E-08	2.9E-08
NNW	0.	4.2E-07	1.8E-07	1.4E-07	1.6E-07	1.4E-07	9.2E-08	5.4E-08	3.7E-08	2.5E-08	2.1E-08
N	0.	7.8E-07	1.7E-07	1.3E-07	9.3E-08	7.2E-08	5.9E-08	4.5E-08	3.8E-08	3.3E-08	2.9E-08

Number of Valid Observations = 8703

Number of Invalid Observations = 57

Number of Calms Lower Level = 60

Number of Calms Upper Limit = 5

TABLE A-14

Depleted X/Q Values for Long-Term Mixed Mode Releases at Standard Distances (sec/m³)

Carolina Power & Light Company - Robinson

Release Type: Annual

Release Mode: Mixed Mode

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

Calculation Points: Standard

Model: Straight Line. (ANNX009)

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.	1.5E-06	3.7E-07	3.1E-07	2.5E-07	2.2E-07	1.8E-07	1.5E-07	1.3E-07	8.9E-08	6.1E-08
NE	0.	9.8E-07	1.4E-07	1.1E-07	8.5E-08	6.4E-08	4.9E-08	7.8E-08	3.6E-08	5.2E-08	3.1E-08
ENE	0.	8.3E-07	2.5E-07	1.8E-07	1.6E-07	1.2E-07	1.0E-07	6.9E-08	5.7E-08	4.5E-08	4.0E-08
E	0.	7.0E-07	2.4E-07	2.0E-07	1.9E-07	2.1E-07	1.1E-07	9.4E-08	6.6E-08	4.5E-08	3.4E-08
ESE	0.	7.3E-07	1.8E-07	1.6E-07	1.2E-07	9.6E-08	7.2E-08	6.1E-08	4.6E-08	3.6E-08	2.7E-08
SE	0.	5.7E-07	9.6E-08	6.9E-08	4.7E-08	3.6E-08	2.3E-08	1.8E-08	1.2E-08	1.0E-08	9.9E-09
SSE	0.	9.6E-07	1.7E-07	1.1E-07	7.4E-08	4.9E-08	3.3E-08	2.4E-08	2.1E-08	1.7E-08	1.6E-08
S	0.	4.8E-07	8.9E-08	6.7E-08	5.8E-08	3.8E-08	3.1E-08	2.7E-08	2.4E-08	2.1E-08	1.8E-08
SSW	0.	6.1E-07	2.5E-07	2.4E-07	1.5E-07	1.1E-07	8.0E-08	6.0E-08	4.5E-08	3.4E-08	2.9E-08
SW	0.	3.4E-07	9.5E-08	8.5E-08	5.8E-08	4.4E-08	3.6E-08	3.1E-08	2.2E-08	1.9E-08	1.6E-08
WSW	0.	2.9E-07	6.3E-08	6.1E-08	5.2E-08	5.2E-08	4.0E-08	2.9E-08	2.6E-08	2.2E-08	1.8E-08
W	0.	2.4E-07	6.0E-08	5.9E-08	4.8E-08	4.7E-08	3.4E-08	2.9E-08	1.9E-08	1.4E-08	1.2E-08
WNW	0.	2.6E-07	8.3E-08	8.4E-08	6.6E-08	6.2E-08	5.0E-08	4.0E-08	3.4E-08	3.4E-08	3.2E-08
NW	0.	3.8E-07	1.1E-07	1.5E-07	1.1E-07	9.0E-08	6.3E-08	4.5E-08	3.9E-08	3.0E-08	2.4E-08
NNW	0.	4.1E-07	1.2E-07	1.4E-07	1.6E-07	1.4E-07	8.8E-08	5.2E-08	3.5E-08	2.4E-08	2.0E-08
N	0.	7.5E-07	1.5E-07	1.2E-07	8.8E-08	6.9E-08	5.7E-08	4.3E-08	3.6E-08	3.1E-08	2.7E-08

Number of Valid Observations = 8703
 Number of Invalid Observations = 57
 Number of Calms Lower Level = 60
 Number of Calms Upper Limit = 5

TABLE A-15
D/Q Values for Long-Term Mixed Mode Releases at Standard Distances (m^{-2})

Carolina Power & Light Company - Robinson
Release Type: Annual
Release Mode: Mixed Mode
Variable: Relative Deposition Rate ($Meter^{-2}$)
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.	1.6E-08	5.0E-09	2.1E-09	1.2E-09	7.5E-10	5.2E-10	3.4E-10	2.7E-10	2.0E-10	1.4E-10
NE	0.	1.1E-08	2.6E-09	1.2E-09	6.2E-10	3.5E-10	2.3E-10	1.8E-10	1.2E-10	1.2E-10	1.0E-10
ENE	0.	1.1E-08	3.8E-09	1.4E-09	7.6E-10	3.7E-10	2.7E-10	1.8E-10	1.4E-10	1.2E-10	1.1E-10
E	0.	1.1E-08	3.7E-09	1.4E-09	7.2E-10	5.0E-10	2.6E-10	2.1E-10	1.4E-10	1.0E-10	7.8E-11
ESE	0.	8.6E-09	2.7E-09	1.2E-09	6.7E-10	4.3E-10	2.8E-10	2.1E-10	1.5E-10	1.0E-10	7.3E-11
SE	0.	7.0E-09	1.9E-09	9.5E-10	4.7E-10	2.8E-10	1.5E-10	1.1E-10	5.9E-11	5.0E-11	4.2E-11
SSE	0.	6.2E-09	1.8E-09	8.6E-10	4.6E-10	2.6E-10	1.5E-10	9.5E-11	7.7E-11	5.9E-11	5.0E-11
S	0.	7.1E-09	1.8E-09	7.6E-10	4.2E-10	1.8E-10	1.3E-10	9.9E-11	7.3E-11	6.1E-11	4.8E-11
SSW	0.	1.0E-08	5.0E-09	2.6E-09	1.1E-09	6.1E-10	3.9E-10	2.6E-10	1.8E-10	1.3E-10	1.0E-10
SW	0.	5.0E-09	2.0E-09	9.8E-10	4.7E-10	2.9E-10	1.9E-10	1.5E-10	9.8E-11	7.6E-11	6.4E-11
WSW	0.	4.9E-09	1.9E-09	8.4E-10	4.8E-10	3.7E-10	2.3E-10	1.5E-10	1.2E-10	1.0E-10	7.1E-11
W	0.	4.0E-09	1.4E-09	6.3E-10	3.4E-10	2.6E-10	1.6E-10	1.3E-10	7.9E-11	5.4E-11	4.1E-11
WNW	0.	4.6E-09	1.5E-09	7.1E-10	4.2E-10	3.2E-10	2.2E-10	1.6E-10	1.2E-10	9.9E-11	7.4E-11
NW	0.	5.6E-09	2.2E-09	1.1E-09	6.4E-10	3.6E-10	1.9E-10	1.2E-10	1.0E-10	1.1E-10	9.6E-11
NNW	0.	4.5E-09	1.9E-09	1.1E-09	8.1E-10	5.2E-10	2.7E-10	1.4E-10	8.8E-11	5.7E-11	4.5E-11
N	0.	5.9E-09	1.8E-09	8.2E-10	4.0E-10	2.4E-10	1.6E-10	1.0E-10	7.4E-11	5.8E-11	4.7E-11

Number of Valid Observations = 8703
Number of Invalid Observations = 57
Number of Calms Lower Level = 60
Number of Calms Upper Limit = 5

TABLE A-16

X/Q Values for Short-Term Mixed Mode Releases at Special Locations (sec/m³)*

Carolina Power & Light Company - Robinson

Release Type: Purge

Release Mode: Mixed Mode

Variable: Relative Concentration (Sec./Cubic Meter)

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	8.40E-07	7.00E-07	0.00	8.30E-07	7.90E-07
NE	5.40E-07	5.30E-07	4.70E-07	5.20E-07	4.70E-07
ENE	8.90E-07	4.20E-07	0.00	8.80E-07	3.10E-07
E	1.00E-06	4.00E-07	2.50E-07	9.20E-07	4.50E-07
ESE	1.24E-06	4.70E-07	0.00	1.00E-06	1.00E-06
SE	2.20E-06	0.00	0.00	2.10E-06	2.10E-06
SSE	2.90E-06	0.00	0.00	2.40E-06	2.40E-06
S	1.90E-06	2.00E-07	0.00	1.70E-06	1.20E-06
SSW	2.00E-06	4.00E-07	0.00	2.00E-06	1.10E-06
SW	1.10E-06	2.40E-07	2.10E-07**	9.50E-07	7.70E-07
WSW	1.20E-06	2.20E-07	0.00	9.90E-07	6.30E-07
W	7.40E-07	1.30E-07	0.00	5.90E-07	5.90E-07
WNW	7.90E-07	2.20E-07	0.00	6.80E-07	6.20E-07
NW	6.30E-07	5.10E-07	0.00	6.20E-07	6.20E-07
NNW	5.10E-07	3.20E-07	0.00	3.10E-07	2.90E-07
N	3.50E-07	2.30E-07	0.00	2.40E-07	2.40E-07

* Zeroes indicate that this point was not calculated

** A milk goat is located here

TABLE A-17

Depleted X/Q Values for Short-Term Mixed Mode Releases at Special Locations (sec/m³)*

Carolina Power & Light Company - Robinson

Release Type: Purge

Release Mode: Mixed Mode

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

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	8.40E-07	7.00E-07	0.00	8.30E-07	7.41E-07
NE	4.95E-07	4.86E-07	4.70E-07	4.77E-07	4.70E-07
ENE	8.40E-07	4.20E-07	0.00	8.31E-07	2.96E-07
E	1.00E-06	4.00E-07	2.03E-07	9.20E-07	4.15E-07
ESE	1.11E-06	4.44E-07	0.00	9.00E-07	9.00E-07
SE	2.11E-06	0.00	0.00	2.01E-06	2.01E-06
SSE	2.72E-07	0.00	0.00	2.27E-06	2.27E-06
S	1.82E-06	1.90E-07	0.00	1.63E-06	1.12E-06
SSW	1.93E-06	4.00E-07	0.00	1.93E-06	1.03E-06
SW	1.10E-06	2.29E-07	2.35E-07**	9.50E-07	7.36E-07
WSW	1.20E-06	2.12E-07	0.00	9.90E-07	6.11E-07
W	7.19E-07	1.26E-07	0.00	5.71E-07	5.71E-07
WNW	7.65E-07	2.09E-07	0.00	6.59E-07	6.04E-07
NW	6.24E-07	4.99E-07	0.00	6.20E-07	6.20E-07
NNW	4.90E-07	3.05E-07	0.00	3.00E-07	2.76E-07
N	3.35E-07	2.20E-07	0.00	2.30E-07	2.30E-07

* Zeroes indicate that this point was not calculated

** A milk goat is located here

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

TABLE A-19

Robinson Plant Site Information To Be Used
for Ground Level Calculations with NRC "XOQDOQ" Program

<u>Card Type</u>	<u>Columns</u>	<u>Description</u>	<u>Value To Be Used in XOQDOQ</u>
1	1	Print input data	1
	38	Calculate annual X/Qs for points of interest	1
	39	Calculate annual X/Q averages for site radial segments	1
	41	Print out set distance X/Qs and D/Qs	1
	55	Calculate annual D/Q averages for the set radial segments	1
	56	Allow depleted X/Qs (if Decays (1), (2), or (3) are negative)	1
	58	Calculate annual D/Qs for points of interest	1
2	1-80	Title card	N/A
3	1-5	Number of wind velocity categories	7
	6-10	Number of stability categories	7
	11-15	Number of distances within terrain data for each sector	5
	16-20	Total number of hours in joint wind frequency distribution	(1)
	21-25	Increment in % for which plotted results are to be printed	5
	26-30	Number of titles of receptor types	5
	31-35	Number of release exit locations	3
4	1-5	Height of the measured wind (meters)	11
	6-20	Half-life (days) used in the X/Q calculations	101.00
			226
			-8.00
5	N/A	N/A	—
6	1-80	Joint wind frequency distribution	(1)

TABLE A-19 (continued)

<u>Card Type</u>	<u>Columns</u>	<u>Description</u>	<u>Value To Be Used in XOQDOQ</u>
7	1-5	Wind velocity units correction	200.00
	6-75	Maximum wind speed in each wind class (m/sec)	0.75
			3.50
			7.50
			12.50
			18.50
			25.00
			26.00
8	1-80	Distance in meters at which terrain heights are given	(2)
9	1-80	Terrain heights (in meters, above plant grade) correspond to distances in Card Type 8	(2)
10	1-25	Number of receptor locations for a particular receptor type	Site boundary = 16 Dairy = 1 Meat = 14 Residence = 16 Garden = 16
11	1-16	Title of receptor type for receptor locations	Site Boundary Dairy Meat Residence Garden
12	1-80	Receptor direction and distance	(See Table 1)
13	1-80	Title for release point whose characteristics are described on Card Type 14	(1)

TABLE A-19 (continued)

<u>Card Type</u>	<u>Columns</u>	<u>Description</u>	<u>Value To Be Used in XOQDOQ</u>
14	1-5	Vent average velocity (m/sec)	20.1
	6-10	Vent inside diameter (m)	1.0
	11-15	Height of vent release point (m)	0.000
	16-20	Height of the vent's building (m)	59.0
	21-25	Minimum cross-sectional area for the vent's building (m ²)	1370.0
	26-30	Wind height used for vent elevated release	11.0
	31-35	Vent heat emission rate (cal/sec)	0.0
15	1	Identification for release point	A
	2-5	Intermittent releases	1
	6-10	Number of intermittent releases per year for this release point	100
	11-15	Average number of hours per intermittent release	1

(1) Appropriate data to be supplied

(2) Obtained from cross-sectional topographic maps

TABLE A-20

Robinson Plant Site Information To Be Used
for Mixed Mode Release Calculations with NRC "XOQDOQ" Program

<u>Card Type</u>	<u>Columns</u>	<u>Description</u>	<u>Value To Be Used in XOQDOQ</u>
1	1	Print input data	1
	38	Calculate annual X/Qs for points of interest	1
	39	Calculate annual X/Q averages for site radial segments	1
	41	Print out set distance X/Qs and D/Qs	1
	55	Calculate annual D/Q averages for the set radial segments	1
	56	Allow depleted X/Qs (if Decays (1), (2), or (3) are negative)	1
	58	Calculate annual D/Qs for points of interest	1
2	1-80	Title card	N/A
3	1-5	Number of wind velocity categories	7
	6-10	Number of stability categories	7
	11-15	Number of distances within terrain data for each sector	5
	16-20	Total number of hours in joint wind frequency distribution	(1)
	21-25	Increment in % for which plotted results are to be printed	5
	26-30	Number of titles of receptor types	5
	31-35	Number of release exit locations	3
4	1-5	Height of the measured wind (meters)	11
	6-20	Half-life (days) used in the X/Q calculations	101.00 226 -8.00
5	N/A	N/A	—
6	1-80	Joint wind frequency distribution	(1)

TABLE A-20 (continued)

<u>Card Type</u>	<u>Columns</u>	<u>Description</u>	<u>Value To Be Used in XOQDOQ</u>
7	1-5	Wind velocity units correction	200.00
	6-75	Maximum wind speed in each wind class (m/sec)	0.75
			3.50
			7.50
			12.50
			18.50
			25.00
			26.00
8	1-80	Distance in meters at which terrain heights are given	(2)
9	1-80	Terrain heights (in meters, above plant grade) corresponding to distances in Card Type 8	(2)
10	1-25	Number of receptor locations for a particular receptor type	Site boundary = 16 Dairy = 1 Meat = 14 Residence = 16 Garden = 16
11	1-16	Title of receptor type for receptor locations	Site Boundary Dairy Meat Residence Garden
12	1-80	Receptor direction and distance	(See Table 1)
13	1-80	Title for release point whose characteristics are described on Card Type 14	(1)

TABLE A-20 (continued)

<u>Card Type</u>	<u>Columns</u>	<u>Description</u>	<u>Value To Be Used in XOQDOQ</u>
14	1-5	Vent average velocity (m/sec)	20.1
	6-10	Vent inside diameter (m)	1.0
	11-15	Height of vent release point (m)	60.7
	16-20	Height of the vent's building (m)	59.0
	21-25	Minimum cross-sectional area for the vent's building (m ²)	1370.0
	26-30	Wind height used for vent elevated release	11.
	31-35	Vent heat emission rate (cal/sec)	0.
15	1	Identification for release point	A
	2-5	Intermittent releases	1
	6-10	Number of intermittent releases per year for this release point	100
	11-15	Average number of hours per intermittent release	1

(1) Appropriate data to be supplied

(2) Obtained from cross-sectional topographic maps

APPENDIX B

DOSE PARAMETERS FOR RADIOIODINES, PARTICULATES, AND TRITIUM

This appendix contains the methodology which was used to calculate the dose parameters for radioiodines, particulates, and tritium to show compliance with 10CFR20 and Appendix I of 10CFR50 for gaseous effluents. These dose parameters, P_i and R_i , were calculated using the methodology outlined in NUREG 0133 along with Regulatory Guide 1.109, Revision 1. The following sections provide the specific methodology which was utilized in calculating the P_i and R_i values for the various exposure pathways.

B.1 Calculation of P_i

The dose parameter, P_i , contained in the radioiodine and particulates portion of Section 3.2 includes pathway transport parameters of the "i" radionuclide, the receptor's usage of the pathway media, and the dosimetry of the exposure. Pathway usage rates and the internal dosimetry are functions of the receptor's age; however, the youngest age group, the infant, will always receive the maximum dose under the exposure conditions for Technical Specification 3.9.3.1.b. For the infant exposure, separate values of P_i may be calculated for the inhalation pathway which is combined with a W parameter based on (X/Q) and the food (milk) and ground pathway which is combined with a W parameter normally based on (D/Q) except for tritium. The following sections provide in detail the methodology which was used in calculating the P_i values for inclusion into this ODCM.

B.1.1 Inhalation Pathway

The evaluation of this pathway consists of estimating the maximum dose to the most critical organ received by an infant through inhalation by:

$$P_{iI} = K'(BR) DFA_i \quad (B.1-1)$$

where:

P_{iI} = Dose parameter for radionuclide "i" for the inhalation pathway, mrem/yr per $\mu\text{Ci}/\text{m}^3$;

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

BR = The breathing rate of the infant age group, m^3/yr ;

DFA_i = The maximum organ inhalation dose factor for the infant age group for radionuclide "i," mrem/pCi.

The age group considered is the infant group. The infant's breathing rate is taken as $1400 \text{ m}^3/\text{yr}$ from Table E-5 of Regulatory Guide 1.109, Revision 1. The inhalation dose factors for the infant, DFA_i , are presented in Table E-10 of Regulatory Guide 1.109 in units of mrem/pCi. The total body is considered as an organ in the selection of DFA_i .

The incorporation of breathing rate of an infant and the unit conversion factor results in the following equation:

$$P_{iI} = 1.4 \times 10^9 \text{ DFA}_i \quad (\text{B.1-2})$$

B.1.2 Ground Plane Pathway

The dose factor from ground plane pathway is calculated by:

$$P_{iG} = K' K'' \text{DFG}_i (1 - e^{-\lambda_i t}) / \lambda_i \quad (\text{B.1-3})$$

where:

P_{iG} = Dose parameter for radionuclide "i" for the ground plane pathway, mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^{-2} ;

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

- K'' = A constant of unit conversion;
 = 8760 hr/yr;
- λ_i = The radiological decay constant for radionuclide "i," sec^{-1} ;
- t = The exposure period;
 = 3.15×10^7 sec (1 year);
- DFG_i = The ground plane dose conversion factor for radionuclide "i,"
 mrem/hr per pCi/m^2 .

The deposition rate onto the ground plane results in a ground plane concentration that is assumed to persist over a year with radiological decay--the only operating removal mechanism for each radionuclide. The ground plane dose conversion factors for radionuclide "i," DFG_i , are presented in Table E-6 of Regulatory Guide 1.109, Revision 1.

Resolution of the units yields:

$$P_{iG} = 8.76 \times 10^9 DFG_i (1 - e^{-\lambda_i t}) / \lambda_i \quad (\text{B.1-4})$$

B.1.3 Milk

The dose factor from the cow/goat-milk-man pathway is calculated by:

$$P_{iM} = \frac{K' r Q_F (U_{ap}) F_m}{Y_p (\lambda_i + \lambda_w)} DFL_i e^{-\lambda_i t_f} \quad (\text{B.1-5})$$

where:

- P_{iM} = Dose parameter for radionuclide "i" for the cow milk or goat milk pathway, mrem/yr per $\mu\text{Ci}/\text{sec}$ per m^{-2} ;
- K' = A constant of unit conversion;
 = 10^6 $\text{pCi}/\mu\text{Ci}$;
- Q_F = The cow's or goat's consumption rate of feed, kg/day (wet weight);

- U_{ap} = The infant's milk consumption rate, liters/yr;
- Y_p = The agricultural productivity by unit area, kg/m²;
- F_m = The stable element transfer coefficient, pCi/liter per pCi/day;
- r = Fraction of deposited activity retained on cow's or goat's feed grass;
- DFL_i = The maximum organ ingestion dose factor for radionuclide "i," mrem/pCi;
- λ_i = The radiological decay constant for radionuclide "i," sec⁻¹;
- λ_w = The decay constant for removal of activity on leaf and plant surfaces by weathering, sec⁻¹;
- = 5.73×10^{-7} sec⁻¹ (corresponding to a 14-day half-life);
- t_f = The transport time from pasture cow or goat to milk to infant, sec.

A fraction of the airborne deposition is captured by the ground plane vegetation cover. The captured material is removed from the vegetation (grass) by both radiological decay and weathering processes.

Various parameters which were utilized to determine the P_i values for the cow and goat milk pathways are provided in Table B-1. Table E-1 of Regulatory Guide 1.109, Revision 1, provides the stable element transfer coefficients, F_m ; and Table E-14 of the same regulatory guide provides the ingestion dose factors, DFL_i , for the infant's organs. The organ with the maximum value of DFL_i was used in the determination of P_i for this pathway. The incorporation of the various constants of Table B-1 into Equation B.1-5 results in the following:

For radioiodines and particulates from cow's milk:

$$P_{iM} = 2.4 \times 10^{10} \frac{rF_m}{\lambda_i + \lambda_w} DFL_i e^{-\lambda_i t_f} \quad (B.1-6)$$

For radioiodines and particulates from goat's milk pathway:

$$P_{iM} = 2.8 \times 10^9 \frac{rF_m}{\lambda_i + \lambda_w} DFL_i e^{-\lambda_i t_f} \quad (B.1-7)$$

The concentration of tritium in milk is based on its airborne concentration rather than the deposition rate and is calculated by:

$$P_{TM} = K'K'F_m Q_{F_{ap}} DFL_T 0.75(0.5/H) \quad (B.1-8)$$

where:

P_{TM} = Dose parameter for tritium for the cow milk and goat milk pathways, mrem/yr per $\mu\text{Ci}/\text{m}^3$;

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;

DFL_T = Maximum organ ingestion dose factor for tritium, mrem/pCi.

B.2 Calculation of R_i

The radioiodine and particulate Technical Specification 3.9.5.1 is applicable to the location in the unrestricted area where the combination of existing pathways and receptor age groups indicates that the maximum potential exposure occurs. The inhalation and ground plane exposure pathways shall be considered to exist at all locations. The grass-goat-milk, the grass-cow-milk, grass-cow-meat, and vegetation pathways are considered based on their existence at the various locations. R_i values have been calculated for the adult, teen, child, and infant age groups for the ground plane, cow milk, goat milk, vegetable, and beef ingestion pathways. The methodology which was utilized to calculate these values is presented below.

B.2.1 Inhalation Pathway

The dose factor from the inhalation pathway is calculated by:

$$R_{iI} = K' (BR)_a (DFA_i)_a \quad (B.2.-1)$$

where:

R_{iI} = Dose factor for each identified radionuclide "i" of the organ of interest, mrem/yr per $\mu\text{Ci}/\text{m}^3$;

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

$(BR)_a$ = Breathing rate of the receptor of age group a, m^3/yr ;

$(DFA_i)_a$ = Organ inhalation dose factor for radionuclide "i" for the receptor of age group a, mrem/pCi.

The breathing rates $(BR)_a$ for the various age groups are tabulated below, as given in Table E-5 of Regulatory Guide 1.109, Revision 1.

<u>Age Group (a)</u>	<u>Breathing Rate (m^3/yr)</u>
Infant	1400
Child	3700
Teen	8000
Adult	8000

Inhalation dose factors $(DFA_i)_a$ for the various age groups are given in Tables E-7 through E-10 of Regulatory Guide 1.109, Revision 1.

B.2.2 Ground Plane Pathway

The ground plane pathway dose factor is calculated by:

$$R_{iG} = I_i K' K'' (SF) DFG_i (1 - e^{-\lambda_i t}) / \lambda_i \quad (B.2-2)$$

where:

R_{iG} = Dose factor for the ground plane pathway for each identified radionuclide "i" for the organ of interest, mrem/yr per $\mu Ci/sec$ per m^{-2} ;

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

K'' = A constant of unit conversion;
= 8760 hr/year;

λ_i = The radiological decay constant for radionuclide "i," sec^{-1} ;

t = The exposure time, sec;
= 4.73×10^8 sec (15 years);

DFG_i = The ground plane dose conversion factor for radionuclide "i;"
mrem/hr per pCi/m²;

A tabulation of DFG_i values is presented in Table E-6 of Regulatory Guide 1.109, Revision 1.

SF = The shielding factor (dimensionless);

A shielding factor of 0.7 is suggested in Table E-15 of Regulatory Guide 1.109, Revision 1.

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

For radionuclides other than iodine, the factor 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 Table 3.3-2.

B.2.3 Grass Cow or Goat Milk Pathway

The dose factor for the cow milk or goat milk pathway for each radionuclide for each organ is calculated by:

$$R_{iM} = I_i K' Q_F U_{ap} F_m (DFL_i)_a e^{-\lambda_i t_f} \left[f_p f_s \left[\frac{r(1-e^{-\lambda_i t_e})}{Y_p \lambda_{E_i}} + \frac{B_{iv} (1-e^{-\lambda_i t_b})}{P \lambda_i} \right] + \right. \\ \left. (1-f_p f_s) \left[\frac{r(1-e^{-\lambda_i t_e})}{Y_s \lambda_{E_i}} + \frac{B_{iv} (1-e^{-\lambda_i t_b})}{P \lambda_i} \right] e^{-\lambda_i t_h} \right] \quad (B.2-3)$$

where:

R_{iM} = Dose factor for the cow milk or goat milk pathway, for each identified radionuclide "i" for the organ of interest, mrem/yr per μ Ci/sec per m⁻²;

- K' = A constant of unit conversion;
 = 10^6 pCi/ μ Ci;
- Q_F = The cow's or goat's feed consumption rate, kg/day (wet weight);
- U_{ap} = The receptor's milk consumption rate for age group a, liters/yr;
- Y_p = The agricultural productivity by unit area of pasture feed grass, kg/m²;
- Y_s = The agricultural productivity by unit area of stored feed, kg/m²;
- F_m = The stable element transfer coefficients, pCi/liter per pCi/day;
- r = Fraction of deposited activity retained on cow's feed grass;
- $(DFL_i)_a$ = The organ ingestion dose for radionuclide "i" for the receptor in age group a, mrem/pCi;
- λ_{E_i} = $\lambda_i + \lambda_w$;
- λ_i = The radiological decay constant for radionuclide "i," sec⁻¹;
- λ_w = The decay constant for removal of activity on leaf and plant surfaces by weathering, sec⁻¹;
 = 5.73×10^{-7} sec⁻¹ (corresponding to a 14 day half-life);
- t_f = The transport time from feed to cow, or goat to milk, to receptor, sec;

- t_h = The transport time for harvest, to cow or goat, to consumption, sec;
- t_b = Period of time that sediment is exposed to gaseous effluents, sec;
- B_{iv} = Concentration factor for uptake of radionuclide "i" from the soil by the edible parts of crops, pCi/Kg (wet weight) per pCi/Kg (dry soil);
- P = Effective surface density for soil, Kg (dry soil)/m²;
- f_p = Fraction of the year that the cow or goat is on pasture;
- f_s = Fraction of the cow feed that is pasture grass while the cow is on pasture;
- 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, the factor 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 3.3-9 through 3.3-16.

Milk cattle and goats are considered to be fed from two potential sources, pasture grass and stored feeds. Following the development in Regulatory Guide 1.109, Revision 1, the value of f_s was considered unity in lieu of site-specific information. The value of f_p was 0.667 based upon an 8-month grazing period.

Table B-1 contains the appropriate parameter values and their source in Regulatory Guide 1.109, Revision 1.

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 :

$$R_{T_M} = K'K''F_m Q_{F_{ap}} (DFL_i)_a 0.75(0.5/H) \quad (B.2-4)$$

where:

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

K'' = A constant of unit conversion;
 $= 10^3 \text{ gm/kg}$;

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 $H = 8 \text{ grams/meter}^3$, 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:

$$R_{i_M} = I_i K' Q_{F_{ap}} F_m (DFL_i)_a e^{-\lambda_i t_s} \left[f_p f_s \left[\frac{r(1-e^{-\lambda_{E_i} t_e})}{Y_p \lambda_{E_i}} + \frac{B_{iv} (1-e^{-\lambda_i t_b})}{P \lambda_i} \right] + \right. \\ \left. (1-f_p f_s) \left[\frac{r(1-e^{-\lambda_{E_i} t_e})}{Y_s \lambda_{E_i}} + \frac{B_{iv} (1-e^{-\lambda_i t_b})}{P \lambda_i} \right] e^{-\lambda_i t_h} \right] \quad (B.2-5)$$

where:

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

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 .

$$R_{TB} = K'K''F_m Q U_{ap} (DFL_i)_a 0.75(0.5/H) \quad (\text{B.2-6})$$

where:

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

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:

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

where:

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

K' = A constant of unit conversion;
= $10^6 \text{pCi}/\mu\text{Ci}$;

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;

- t_h = The average time between harvest of stored vegetation and its consumption, sec;
- Y_v = The vegetation areal density, kg/m²;
- t_e = Period of leafy vegetable exposure during growing season, sec;
- I_i = Factor to account for fractional deposition of radionuclide "i."

All other factors as defined before.

For radionuclides other than iodine, the factor I_i is equal to one. For radioiodines, the value of I_i may vary. However, a value of 1.0 was used in Tables 3.3-3 through 3.3-5.

Table B-3 presents the appropriate parameter values and their source in Regulatory Guide 1.109, Revision 1.

In lieu of site-specific data default values for f_L and f_g , 1.0 and 0.76, respectively, were used in the calculations on R_i . These values were obtained from Table E-15 of Regulatory Guide 1.109, Revision 1.

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

$$R_{T_V} = K'K'' \left[U_a^L f_L + U_a^S f_g \right] (DF_{L_i})_a \quad 0.75(0.5/H) \quad (B.2-8)$$

where:

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

All other terms remain the same as those in Equations B.2-4 and B.2-7.

TABLE B-1

Parameters For Cow and Goat Milk Pathways

<u>Parameter</u>	<u>Value</u>	<u>Reference</u> <u>(Reg. Guide 1.109, Rev. 1)</u>
Q_F (kg/day)	50 (cow) 6 (goat)	Table E-3 Table E-3
Y_p (kg/m ²)	0.7	Table E-15
T_f (seconds)	1.73×10^5 (2 days)	Table E-15
r	1.0 (radioiodines) 0.2 (particulates)	Table E-15 Table E-15
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	Tables E-11 to E-14
F_m (pCi/day per pCi/liter)	Each stable element	Table E-1 (cow) Table E-2 (goat)
T_b (seconds)	4.73×10^8 (15 yr)	Table E-15
Y_s (kg/m ²)	2.0	Table E-15
Y_p (kg/m ²)	0.7	Table E-15
t_h (seconds)	7.78×10^6 (90 days)	Table E-15
U_{ap} (liters/yr)	330 infant 330 child 400 teen 310 adult	Table E-5 Table E-5 Table E-5 Table E-5
t_e (seconds)	2.59×10^6 (pasture) 5.18×10^6 (stored feed)	Table E-15
B_{iv} (pCi/kg [wet weight] per pCi/kg [dry soil])	Each stable element	Table E-1
P kg (dry soil/m ²)	240	Table E-15

TABLE B-2
Parameters For The Meat Pathway

<u>Parameter</u>	<u>Value</u>	<u>Reference</u> <u>(Reg. Guide 1.109, Rev. 1)</u>
r	1.0 (radioiodines)	Table E-15
	0.2 (particulates)	Table E-15
F_f (pCi/kg per pCi/day)	Each stable element	Table E-1
U_{ap} (kg/yr)	0 infant	Table E-5
	41 child	Table E-5
	65 teen	Table E-5
	110 adult	Table E-5
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	Tables E-11 to E-14
Y_p (kg/m ²)	0.7	Table E-15
Y_s (kg/m ²)	2.0	Table E-15
T_b (seconds)	4.73×10^8 (15 yr)	Table E-15
T_s (seconds)	1.73×10^6 (20 days)	Table E-15
t_h (seconds)	7.78×10^6 (90 days)	Table E-15
t_e (seconds)	2.59×10^6 (pasture)	Table E-15
	5.18×10^6 (stored feed)	
Q_F (kg/day)	50	Table E-3
B_{iv} (pCi/kg [wet weight] per pCi/kg [dry soil])	Each stable element	Table E-1
P (kg [dry soil/m ²])	240	Table E-15

TABLE B-3

Parameters for The Vegetable Pathway

<u>Parameter</u>	<u>Value</u>	<u>Reference</u> <u>(Reg. Guide 1.109, Rev. 1)</u>
r (dimensionless)	1.0 (radioiodines) 0.2 (particulates)	Table E-1 Table E-1
$(DFL_i)_a$ (mrem/Ci)	Each radionuclide	Tables E-11 to E-14
Q_F (kg/day)	50 (cow) 6 (goat)	Table E-3 Table E-3
U_a^L (kg/yr) - Infant	0	Table E-5
- Child	26	Table E-5
- Teen	42	Table E-5
- Adult	64	Table E-5
U_a^S (kg/yr) - Infant	0	Table E-5
- Child	520	Table E-5
- Teen	630	Table E-5
- Adult	520	Table E-5
T_L (seconds)	8.6×10^4 (1 day)	Table E-15
t_h (seconds)	5.18×10^6 (60 days)	Table E-15
Y_v (kg/m ²)	2.0	Table E-15
t_e (seconds)	5.18×10^6 (60 days)	Table E-15
T_b (seconds)	4.73×10^8 (15 yr)	Table E-15
P (kg [dry soil/m ²])	240	Table E-15
B_{iv} (pCi/kg [wet weight] per pCi/kg [dry soil])	Each stable element	Table E-1

APPENDIX C LOWER LIMIT OF DETECTABILITY

The LLD^{1,2} is defined, for purposes of these specifications, as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

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

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

where:

LLD = "A priori" lower limit of detection as defined above, as picocuries per unit mass or volume;

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

E = Counting efficiency, as counts per disintegration;

V = Sample size in units of mass or volume;

2.22 = Number of disintegrations per minute per picocurie;

Y = Fractional radiochemical yield, when applicable;

λ = Radioactive decay constant for the particular radionuclide; and

Δt = The elapsed time between sample collection or end of the sample collection period and time of counting;

Typical values of efficiency, volume/mass, chemical yield, and radionuclide decay corrections are to be used in the calculation.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement. Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report pursuant to Specification 6.9.1.E.³

References

1. HASL-300 (Suppl. 4), HASL Procedures Manual, (1972).
2. NBS SP456 "The Minimum Detectable Activity Concept," J. C. Lockamy (1976).
3. Technical Specifications for H. B. Robinson Unit 2.

TABLE D-1
Liquid Process Monitors

<u>Name</u>	<u>RMS #</u>	<u>ID #</u>	<u>Drawing #</u>
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
Steam Generator Blowdown	19	R-19	997261

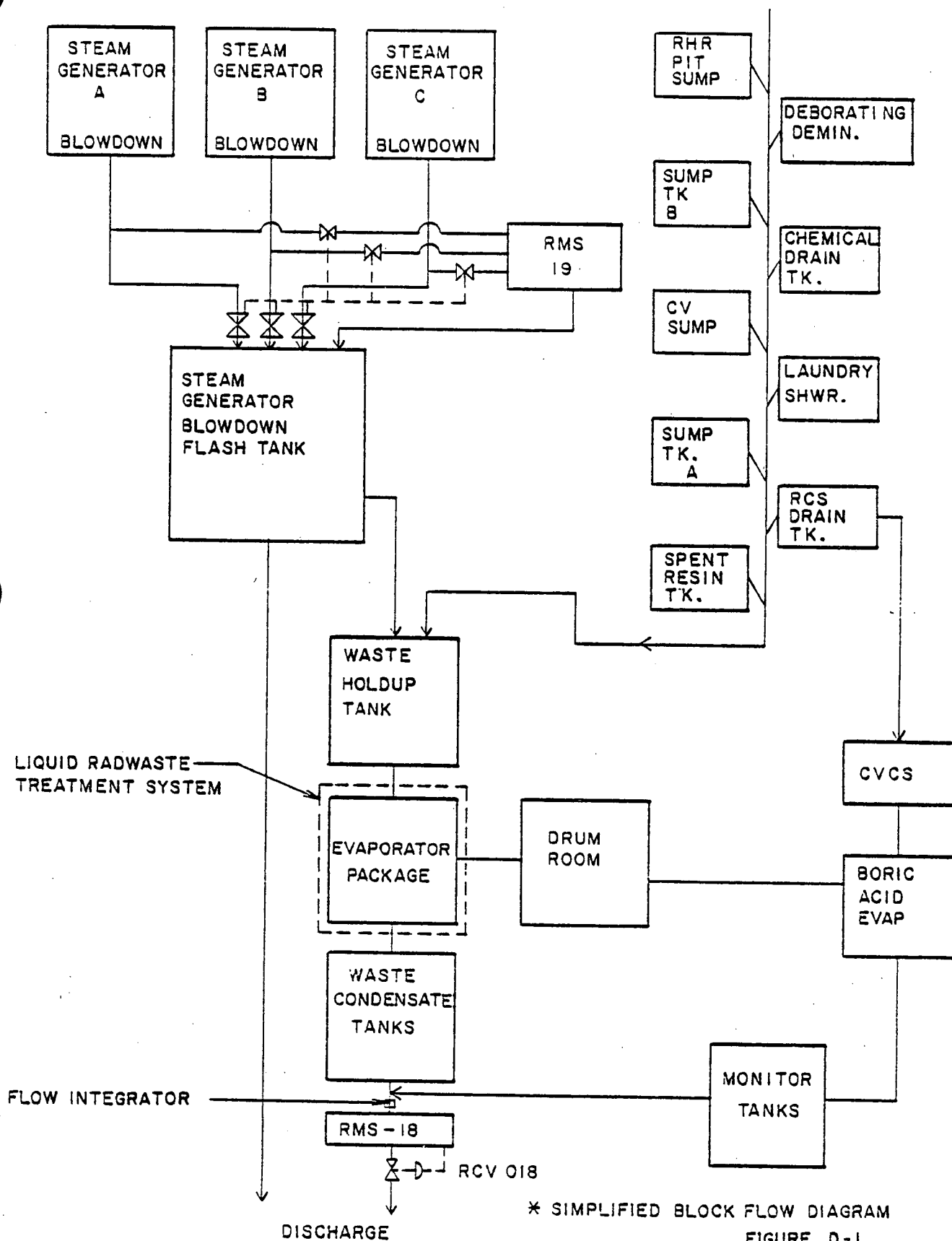
Liquid Radwaste Flow Measurement Devices

Liquid Radwaste Flow (ITT Barton Flow Integrator)	N/A	FT 1064
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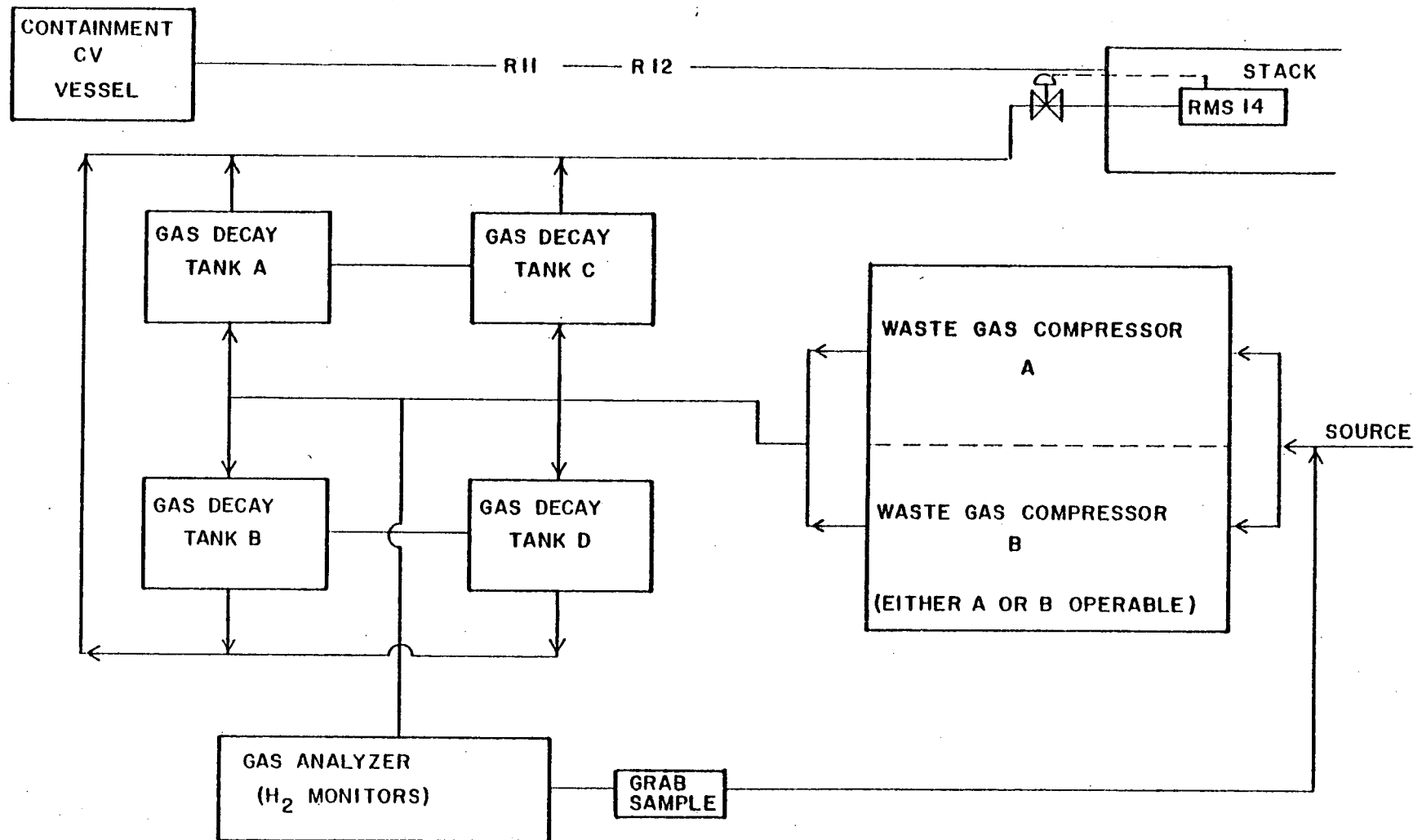
TABLE D-2
Gaseous Process Monitors

<u>Name</u>	<u>RMS #</u>	<u>ID #</u>	<u>Drawing #</u>	<u>Sample Flow Rate Measurement Device</u>	<u>System Flow Rate Measurement Device</u>
Containment Vessel Particulate	11	11	D997556	F&P Co. Flow Tube FP-3/4-27-G 10/80	UGC Microflow 3000 (if sampling stack)
Containment Vessel Gaseous	12	12	D997556	F&P Co. Flow Tube FP-3/4-27-G 10/80	UGC Microflow 3000 (if sampling stack)
Plant Vent Low Range	14	R-14	D997704	UGC Microflow 3000	UGC Microflow 3000
Condenser Vacuum Pump Vent	15	R-15	D997299	Condenser Vacuum Pump Flowmeter (on pump)	Condenser Vacuum Flowmeter (on pump)
Fuel Handling Building Basement Exhaust	20	R-20	C998233	Fisher Porter Flowmeter Mod. 10A35755Z Serial 6908A0837A1	None (Use fan ratings)
Fuel Handling Building Upper Level Exhaust	21	R-21	C998233	Fisher Porter Flowmeter Mod. 1043565 Mod. 6908A0837A1	None (Use fan ratings)
PING 2A Effluent Monitoring System	34	R-34	Eberline Pins 2-A Manual	Dwyer Flowmeter VRFA27	UGC Microflow 3000
Plant Vent High Range	36	R-36	Harshaw Manual NR-75	None	UGC Microflow 3000

H.B. ROBINSON LIQUID RADWASTE PROCESS/EFFLUENT
SYSTEM *



H.B. ROBINSON GASEOUS RADWASTE EFFLUENT SYSTEM *



* SIMPLIFIED BLOCK FLOW DIAGRAM

THE GASEOUS RADWASTE SYSTEM MAY BE
COMPRISED OF ONE WASTE GAS COMPRESSOR
AND ONE WASTE GAS DECAY TANK

FIGURE D-2