NRC RA18-026

2017 Annual Radioactive Effluent Release Report

Part 5

Table 1 - 3
Miscellaneous Dose Assessment Factors: Environmental Parameters

Parameter	Value	Comment	Equation	Basis[a]
f_g	0.76		4-11, 4-12	A
f_L	1.0	Fraction of annual intake of fresh, leafy vegetation grown locally	4-11, 4-12	A
f_p	1.0	Fraction of year animals on pasture	4-13, 4-15	A
f_s	1.0	Fraction of feed from pasture when on pasture	4-13, 4-15	A
t_b	262,800 hrs or 9.46E8 sec	30 years. Period of buildup of activity in soil	4-9	C
t_f	48 hrs or 1.73E5 sec	Cow Milk Pathway	4-13	A
	480 hrs or 1.73E6	Cow Meat Pathway	4-15	A
t_h	1440 hrs or 5.18E6 sec	Delay time for ingestion of vegetation by man 60 days for produce	4-11	A
	2160 hrs or 7.78E6 sec	Delay time for ingestion of stored feed by animals	4-13, 4-15	A
t_L	24 hrs or 8.64E4 sec	Delay time for ingestion of leafy vegetable by man	4-11	A
Q_F	50 Kg/day	Cow Feed Consumption Rate	4-13, 4-14, 4-15, 4-16	B
r	1.0	For Iodines Fraction of deposited particulates retained on vegetation	4-11, 4-13, 4-15	A
	0.2	For Particulates	4-11, 4-13, 4-15	A
Y_p	0.7 Kg/m^2	Grass Yield	4-13, 4-15	A
Y_s	2.0 Kg/m^2	Stored Feed Yield	4-13, 4-15	A
Y_v	2.0 Kg/m^2	Vegetarian Area Density	4-11	A
λ_w	0.0021 hr^{-1} or 5.73 E-7 sec^{-1}	Weathering decay constant	4-11, 4-13, 4-15	A
H	8 gm/m^3	Absolute Atmospheric Humidity	4-12, 4-14, 4-16	D
D_W	1.0	Dilution Factor at point of withdrawal of drinking water	3-3	

Table 1 – 3
Miscellaneous Dose Assessment Factors: Environmental Parameters

Parameter	Value	Comment	Equation	Basis[a]
BR		Breathing Rate (m^3 / yr)		E
	1400 m^3/yr	Infant		
	3700 m^3/yr	Child		
	8000 m^3/yr	Teen		
	8000 m^3/yr	Adult		E
U^L		Leafy Vegetation Consumption Rate (kg/yr)		
	0 kg/yr	Infant		
	26 Kg/yr	Child		
	42 kg/yr	Teen		
	64 kg/yr	Adult		
U^V		Stored Vegetation Consumption (kg/yr)		E
	0 kg/yr	Infant		
	520 kg/yr	Child		
	630 kg/yr	Teen		
	520 kg/yr	Adult		
U^C		Cow Milk Consumption Rate (L/yr)		E
	330 L/yr	Infant		
	330 L/yr	Child		
	400 L/yr	Teen		
	310 L/yr	Adult		
U^M		Meat Consumption Rate (kg/yr)		E
	0 kg/yr	Infant		
	41 kg/yr	Child		
	65 kg/yr	Teen		
	110 kg/yr	Adult		
U^F		Fish Consumption Rate (kg/yr)		E
	0 kg/yr	Infant		
	6.9 kg/yr	Child		
	16 kg/yr	Teen		
	21 kg/yr	Adult		
U^D		Drinking Water Consumption Rate (L/yr)		E
	330 L/yr	Infant		
	510 L/yr	Child		
	510 L/yr	Teen		
	730 L/yr	Adult		

[a]Basis key:

- A: Reference 6, Table E-15.
- B: Reference 6, Table E-3.
- C: The parameter t_b is taken as the midpoint of plant operating life (based upon an assumed 60 year plant operating lifetime).
- D: Reference 14, Section 5.3.1.3.
- E: Reference 6, Table E-5

Table 1 - 4
Stable Element Transfer Data

Element	F_f Meat (d/kg)	F_M(Cow) Milk (d/L)	Reference
H	1.2E-02	1.0E-02	6
Be	1.5E-03	3.2E-03	Footnote 1
C	3.1E-02	1.2E-02	6
F	2.9E-03	1.4E-02	Footnote 2
Na	3.0E-02	4.0E-02	6
Mg	1.5E-03	3.2E-03	Footnote 1
Al	1.5E-02	1.3E-03	Footnote 3
P	4.6E-02	2.5E-02	6
Cl	2.9E-03	1.4E-02	Footnote 2
Ar	NA	NA	NA
K	1.8E-02	7.2E-03	16
Ca	1.6E-03	1.1E-02	16
Sc	2.4E-03	7.5E-06	Footnote 4
Ti	3.4E-02	5.0E-06	Footnote 5
V	2.8E-01	1.3E-03	Footnote 6
Cr	2.4E-03	2.2E-03	6
Mn	8.0E-04	2.5E-04	6
Fe	4.0E-02	1.2E-03	6
Co	1.3E-02	1.0E-03	6
Ni	5.3E-02	6.7E-03	6
Cu	8.0E-03	1.4E-02	6
Zn	3.0E-02	3.9E-02	6
Ga	1.5E-02	1.3E-03	Footnote 3
Ge	9.1E-04	9.9E-05	Footnote 7
As	1.7E-02	5.0E-04	Footnote 8
Se	7.7E-02	1.0E-03	Footnote 9
Br	2.9E-03	2.2E-02	F_f Footnote 2;F_M from Ref. 16
Kr	NA	NA	NA
Rb	3.1E-02	3.0E-02	6
Sr	6.0E-04	8.0E-04	6
Y	4.6E-03	1.0E-05	6
Zr	3.4E-02	5.0E-06	6
Nb	2.8E-01	2.5E-03	6
Mo	8.0E-03	7.5E-03	6
Tc	4.0E-01	2.5E-02	6
Ru	4.0E-01	1.0E-06	6
Rh	1.5E-03	1.0E-02	6
Pd	5.3E-02	6.7E-03	Footnote 10
Cd	3.0E-02	2.0E-02	Footnote 11
In	1.5E-02	1.3E-03	Footnote 3
Sn	9.1E-04	9.9E-05	Footnote 7
Sb	5.0E-03	2.0E-05	98
Ag	1.7E-02	5.0E-02	6
Te	7.7E-02	1.0E-03	6
I	2.9E-03	6.0E-03	6
Xe	NA	NA	NA
Cs	4.0E-03	1.2E-02	6
Ba	3.2E-03	4.0E-04	6
La	2.0E-04	5.0E-06	6
Ce	1.2E-03	1.0E-04	6
Pr	4.7E-03	5.0E-06	6
Nd	3.3E-03	5.0E-06	6

Table 1 - 4 (Cont'd)
Stable Element Transfer Data

Element	F_f Meat (d/kg)	F_M (Cow) Milk (d/L)	Reference
Pm	2.9E-04	2.0E-05	16
Sm	2.9E-04	2.0E-05	16
Eu	2.9E-04	2.0E-05	16
Gd	2.9E-04	2.0E-05	16
Dy	2.9E-04	2.0E-05	16
Er	2.9E-04	2.0E-05	16
Tm	2.9E-04	2.0E-05	16
Yb	2.9E-04	2.0E-05	16
Lu	2.9E-04	2.0E-05	16
Hf	3.4E-02	5.0E-06	Footnote 5
Ta	2.8E-01	1.3E-03	F_M - Ref.16; F_f -Footnote 6
W	1.3E-03	5.0E-04	6
Re	1.0E-01	1.3E-03	F_M - Ref.16; F_f -Footnote 12
Os	2.2E-01	6.0E-04	Footnote 13
Ir	7.3E-03	5.5E-03	Footnote 14
Pt	5.3E-02	6.7E-03	Footnote 10
Au	1.3E-02	3.2E-02	Footnote 15
Hg	3.0E-02	9.7E-06	F_M - Ref.16; F_f -Footnote 11
Tl	1.5E-02	1.3E-03	F_M - Ref.16; F_f -Footnote 3
Pb	9.1E-04	9.9E-05	98
Bi	1.7E-02	5.0E-04	98
Ra	5.5E-04	5.9E-04	98
Th	1.6E-06	5.0E-06	98
U	1.6E-06	1.2E-04	98
Np	2.0E-04	5.0E-06	6
Am	1.6E-06	2.0E-05	98

Notes:
1. NA = It is assumed that noble gases are not deposited on the ground.
2. Elements listed are those considered for 10CFR20 assessment and compliance.

Footnotes:

There are numerous F_f and F_M values that were not found in published literature. In these cases, the periodic table was used in conjunction with published values. The periodic table was used based on a general assumption that elements have similar characteristics when in the same column of the periodic table. The values of elements in the same column of the periodic table, excluding atomic numbers 58-71 and 90-103, were averaged then assigned to elements missing values located in the same column of the periodic table. This method was used for all columns where there were missing values except column 3A, where there was no data, hence, the average of column 2B and 4A were used.

1. Values obtained by averaging Reference 6 values of Ca, Sr, Ba and Ra.
2. F_f value obtained by assigning the Reference 6 value for I. F_M value obtained by averaging I (Ref. 6) and Br (Ref.16).
3. F_f values obtained by averaging Zn (Ref.6) and Pb (Ref. 98); there were no values for elements in the same column; an average is taken between values of columns 2B and 4A on the periodic table. F_M values obtained by using the value for Tl from Reference 16.
4. Values obtained by averaging Reference 6 values of Y and La.
5. Values obtained by assigning the Reference 6 value for Zr.
6. F_f values obtained from Ref. 6 value for Nb. F_M values obtained by averaging values for Nb (Ref.6) and Ta (Ref. 16).
7. Values obtained from the Reference 6 values for Pb.
8. Values obtained from the Reference 6 values for Bi.
9. Values obtained from the Reference 6 values for Te.
10. Values obtained from the Reference 6 values for Ni.
11. F_f values obtained from Ref. 6 values for Zn. F_M values obtained by averaging the Reference 6 values for Zn and Hg.
12. Values obtained by averaging Reference 6 values for Mn, Tc, Nd and Reference 98 value for U.
13. Values obtained by averaging Reference 6 values from Fe and Ru.
14. Values obtained by averaging Reference 6 values from Co and Rh.
15. Values obtained by averaging Reference 6 values from Cu and Ag.

Figure 1 – 2
Unrestricted Area Boundary

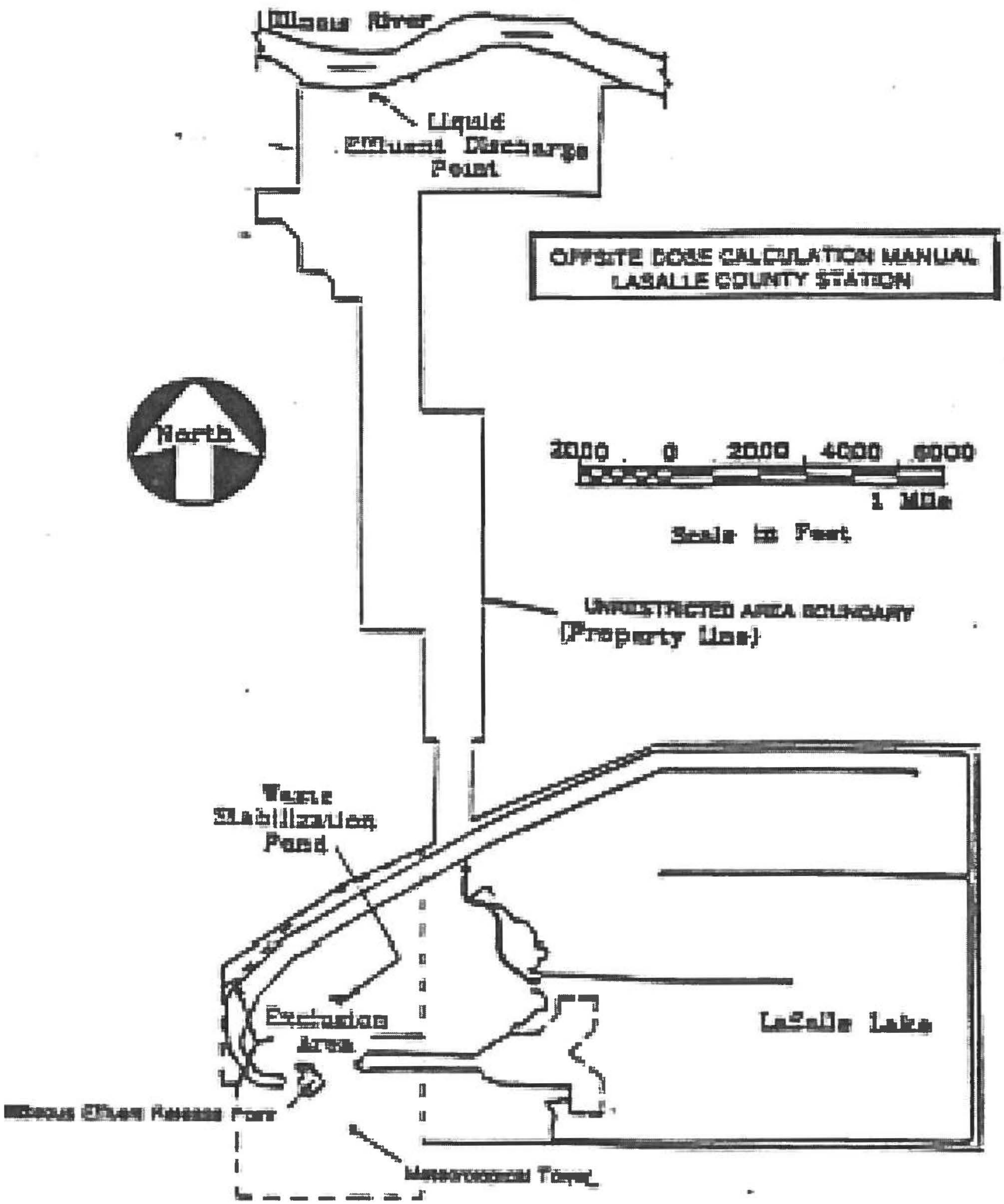
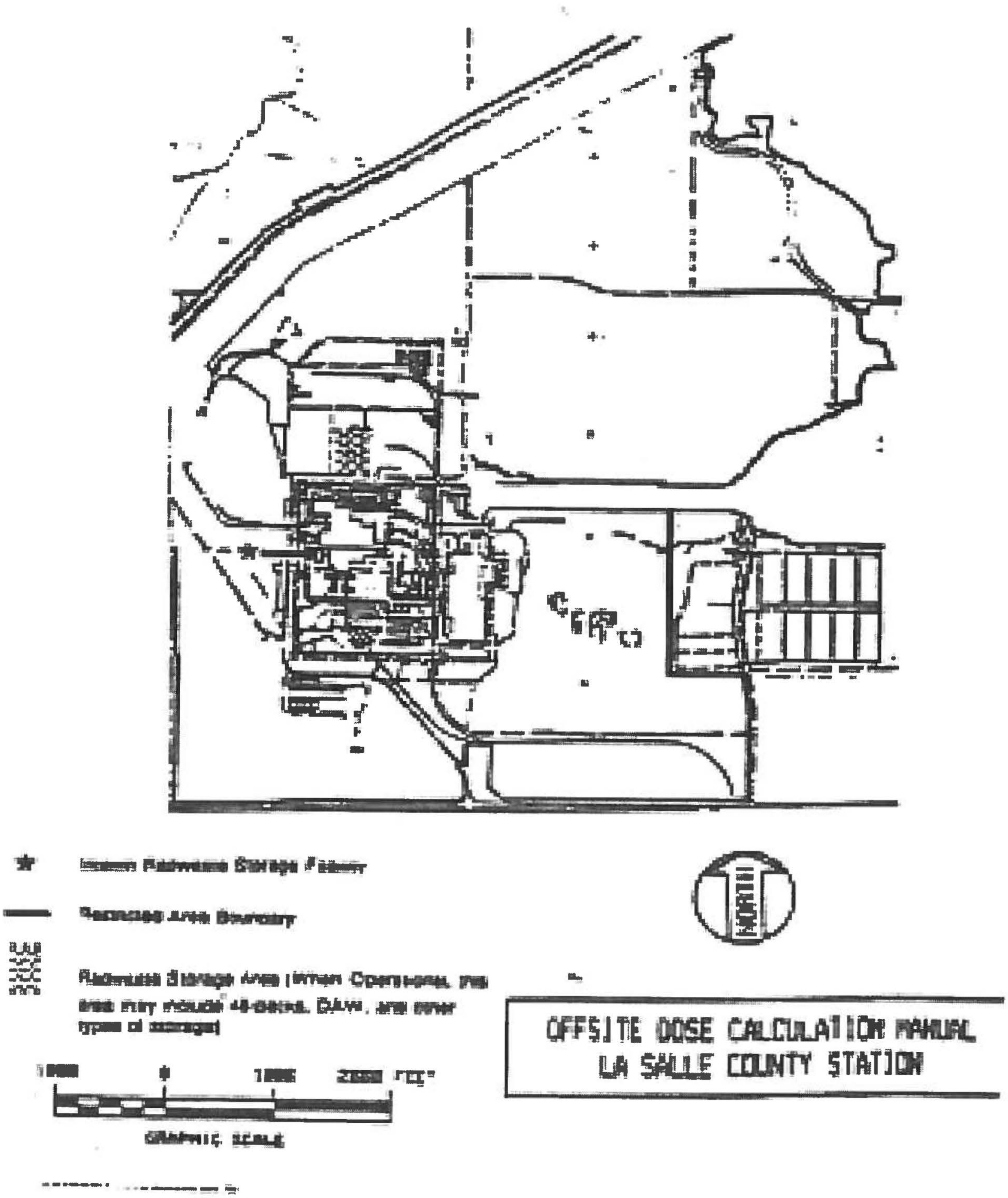


Figure 1 – 3
Restricted Area Boundary



2.0 INSTRUMENTATION AND SYSTEMS

2.1 Liquid Releases

A simplified liquid radwaste and liquid effluent flow diagram are provided in Figures 2-2 and 2-3.

The liquid radwaste treatment system is designed and installed to reduce radioactive liquid effluents by collecting the liquids, providing for retention or holdup, and providing for treatment by filter or demineralizer for the purpose of reducing the total radioactivity prior to release to the environment. The system is described in Section 11.2.2 of the LaSalle UFSAR.

The Station has identified a potential pathway for low levels of tritium to enter the LaSalle Cooling lake via the Waste Water Treatment Facility (WWTF) through efforts associated with the Station's on-going tritium monitoring program utilizing environmental LLDs. During periods of low inputs into the station fire sumps via the turbine lube oil conditioners, tritium tends to concentrate to measureable levels when analyzed to environmental LLDs. This has resulted in the periodic presence of low levels of H3 at the WWTF, also measured to environmental levels. However, measured values at the plants permitted outfall, the cooling pond Blowdown to the Illinois River, has remained undetectable as counted to effluent LLDs. This potential pathway has been assessed and determined not to be a significant contributor to the total dose of a member of the public in accordance with the regulatory position provided in RG 1.109.

2.1.1 Radwaste Discharge Tanks

There are two discharge tanks (1(2)WF05T, 25,000 gallons each) which receive water for discharge to the Illinois River via the cooling lake blowdown.

2.1.2 Cooling Pond Blowdown

Cooling Pond Blowdown is the liquid discharge line to the Illinois River. The Cooling Pond Blowdown has a compositor to meet the sampling requirements of Part I RECS Table R12.3.1-2. Blowdown flow is determined by Blowdown Flow Control Valve position, in accordance with site implementing procedures.

2.2 Radiation Monitors

2.2.1 Liquid Radwaste Effluent Monitor

Monitor 0D18-K907 monitors all releases from the release tanks. On hi-hi alarm the monitor automatically initiates closure of valve 0WL067 and trips the radwaste discharge pump to terminate the release.

Pertinent information on the monitor and associated control devices is provided in LaSalle UFSAR Section 11.5.2.3.3.

2.2.2 Service Water Effluent Monitors

Monitors 1(2)D18-K912 continuously monitor the service water effluent. On high alarm service water discharge may be terminated manually. No control device is initiated by these monitors.

Pertinent information on these monitors is provided in LaSalle UFSAR

2.2.3 RHR Heat Exchanger Cooling Water Effluent Monitors

Instrument channels 1(2)D18-N906/8 continuously monitor the RHR heat exchanger cooling water effluent. On high alarm the operating loop may be terminated manually and the redundant loop brought on line. No control device is initiated by these monitors.

Pertinent information on these monitors is provided in LaSalle UFSAR Section 11.5.2.3.4.

2.3 Liquid Radiation Effluent Monitors Alarm and Trip Setpoints

Alarm and trip setpoints of liquid effluent monitors at the principal release points are established to ensure that the limits of RECS are not exceeded in the unrestricted area.

2.3.1 Liquid Radwaste Effluent Monitor

The monitor setpoint is found by solving equation (2-1) for the total isotopic activity.

$$P \leq K \times [\Sigma C_i^T / \Sigma (C_i^T / 10 \times DWC_i)] \times [(F^d + F^r max)/F^r max] \qquad (2\text{-}1)$$

P	Release Setpoint	[cpm]

K	$[\Sigma (K_i \times C_i \times W_i) / \Sigma C_i^T]$	[cpm/µCi/ml]
K_i	Counting efficiency for radionuclide I	[cpm/µCi/ml]
W_i	Weighting Factor	
C_i^T	Concentration of radionuclide i in the release tank.	[µCi/ml]
F^r_{max}	Maximum Release Tank Discharge Flow Rate The maximum flow rate is 45 gpm.	[gpm]
DWC	Derived Water Concentration of radionuclide i The concentration of radionuclide i given in Appendix B, Table 2, Column 2 to 10CFR20.1001-2402.	[µCi/ml]
10	Multiplier associated with the limits specified in Part I RECS 12.3.1.	
F^d	Dilution Flow	[gpm]

2.3.2 Service Water Effluent Monitors

The monitor setpoint is established at two times the background count rate (not to exceed 10000 cpm).

2.3.3 RHR Heat Exchanger Cooling Water Effluent Monitors

The monitor setpoint is established at two times the background count rate (not to exceed 10000 cpm).

2.3.4 Discharge Flow Rates

2.3.4.1 Release Tank Discharge Flow Rate

Prior to each batch release, a grab sample is obtained.

The results of the analysis of the sample determine the discharge rate of each batch as follows:

$$F^r max = 0.1 \times [F^d / \Sigma (C_i / 10xDWC_i)] \quad (2\text{-}2)$$

The summation is over radionuclides i.

0.1 Reduction factor for conservatism.

$F^r{}_{max}$ Maximum Permitted Discharge Flow Rate [gpm]

The maxiumum permited flow rate from the radwaste discharge tank.

F^d Dilution Flow [gpm]

C_i Concentration of Radionuclide i in the Release Tank [µCi/mL]

The concentration of radioactivity in the radwaste discharge tank based on measurements of a sample drawn from the tank.

DWC_i Maximum Permissible Concentration of Radionuclide i[µCi/ml]

The concentration of radionuclide i given in Appendix B, Table 2, Column 2 to 10CFR20.1001-2402.

10 Multiplier associated with the limits specified in Part I RECS 12.3.1.

MF Multiplication Factor

$F^r_{max} < 0.5$; MF = 3

$0.5 < F^r_{max} < 5$; < MF = 5

$5 < F^r_{max}$; MF = 7.5

Recommended Release Tank Flow Rate.

$$F_{r\,rec} = F_r\,max \times MF \qquad (2\text{-}3)$$

F_{rrec} recommended discharge flow rate (gpm)

$F_{r\,max}$ maximum permitted discharge flow rate (gpm)

MF multiplication factor.

2.3.4.2 Release Limits

Release limits are determined from RECS. Calculated maximum permissible discharge rates are divided by 10 for conservatism and to ensure that release concentrations are well below applicable derived water concentrations (DWC).

2.3.4.3 Release Mixture

For the liquid radwaste effluent monitor the release mixture used for the setpoint determination is the radionuclide mix identified in the grab sample isotopic analysis plus four additional radionuclides. The additional radionuclides are H-3, Fe-59, Sr-89, and Sr-90. The quantities to be added are obtained from the most current analysis for these four radionuclides.

For all other liquid effluent monitors no release mixture is used because the setpoint is established at "two times background."

2.3.4.4 Liquid Dilution Flow Rates

A conservative maximum blowdown flowrate of 20,000 gpm is used for all radwaste discharge calculations unless actual blowdown flow is determined to be less.

2.3.4.5 Conversion Factors

The readout for the liquid radwaste effluent monitor is in CPM. The calibration constant is based on the detector sensitivity to Cs-137/Ba-137 and an energy response curve.

2.3.5 Allocation of Effluents from Common Release Points

Based on common release point, liquid releases from the Station will be allocated to Unit 1. Other potential pathways (i.e., RHR) are allocated to their respective unit.

2.3.6 Projected Doses for Releases

Doses are not calculated prior to release. Dose contributions from liquid effluents are determined in accordance with the RECS and station procedures.

2.3.7 Solidification of Waste/Process Control Program

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

Figure 2-4 is a simplified diagram of solid radwaste processing.

2.4 Airborne Release

A simplified gaseous radwaste and gaseous effluent flow diagram are provided in Figure 2-1.

The airborne release point for radioactive effluents is the ventilation stack, which is classified as a stack in accordance with the definitions in Section 4.1.4.

In addition, the standby gas treatment system effluent is released through a separate stack inside the ventilation stack. This release point has the same location and classification as the ventilation stack.

Exfiltration to the environment from the Turbine Building has been identified at times of positive pressure in the Turbine Building. Within 20 hours of the turbine building being at positive pressure continuous air sampling shall be in place in the south Turbine Building trackway to monitor releases through this pathway. The releases through the trackway door and other potential release paths contain insignificant levels of contamination when compared to the Station Vent Stack which has a 1,000,000 cfm typical stack flow compared to the Trackway flow rate of 40,000 scfm and conservatively estimated as a total of 80,000 scfm to account for pathways other than the trackway. In addition, typical releases from LaSalle Station have not exceeded 0.02% of the 10CFR50 Appendix I dose limits. Any identified release via this pathway is a ground level release and should be considered in dose calculations. See Figure 2-1 for further information.

Exfiltration to the environment from the North Service Building may occur due to changes in the ventilation system. Within 20 hrs of the turbine building being at positive pressure, air sampling shall be performed at times when the ventilation systems are aligned to support unit 2 egress. This air sampling is designed to ensure evaluation of releases emanating from the Turbine Building in accordance with Section 2.5.5.

The station vent stack is equipped with three access hatches at elevations 853', 888' and 1055'. Nominal leakage from these access hatches is expected at an approximated value of up to 1000 SCFM. Resultant doses due to this nominal leakage are negligible when compared to the SVS flow of 1.00 E6 SCFM and have been calculated as such. Doses due to this nominal leakage are therefore accounted for in the gaseous effluent stream and do not require further calculation.

During maintenance activities in which the hatch(es) would be opened, however, the lower elevation hatches (elevations 853' and 888') are classified as vent or "mixed mode" release pathways. These release pathways should be monitored during the maintenance activity period, with resultant releases calculated as mixed mode. Monitoring may be accomplished by determining flow at the point of release and conservatively utilizing the normal effluent release activity levels (at the SVS WRGM sample location). Flow via this pathway should be determined by measurement or engineering calculation. Release activities can be determined from the normal effluent sample point, assuming isokinetic flow at the release pathway. Alternately, grab sampling may be used to ensure representative sampling at the point of release.

The higher elevation hatch at 1050' remains as a stack (elevated) release pathway and can be monitored via the SVS instrumentation and methodology.

Airborne releases to the environment may result if a fire occurs in a contaminated material warehouse. In the event of a fire in a contaminated material warehouse this pathway would be considered a ground level release and should be quantified and considered in dose calculations.

Tritium contributions to gaseous effluents resulting from drum evaporation activities have been assessed at LaSalle Station. A bounding calculation using conservative source term assumptions demonstrated that expected drum evaporation activities would amount to <1% of station releases. In situ sampling of drum evaporation activities yielded analysis results well below the conservative estimates. Drum evaporation activities do not pose a significant contribution to effluent releases at LaSalle Station.

2.4.1 Condenser Offgas Treatment System

The condenser offgas treatment system is designed and installed to reduce radioactive gaseous effluents by collecting non-condensable off-gases from the condenser and providing for holdup to reduce the total radioactivity by radiodecay prior to release to the environment. The daughter products are retained by charcoal and HEPA filters. The system is described in Section 11.3.2.1 of the LaSalle UFSAR.

2.4.2 Ventilation Exhaust Treatment System

Ventilation exhaust treatment systems are designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in selected effluent streams by passing ventilation or vent exhaust gases through charcoal adsorbers and/or HEPA filters prior to release to the environment. Such a system is not considered to have any effect on noble gas effluents. The ventilation exhaust treatment systems are shown in Figure 2-1.

Engineered safety features atmospheric cleanup systems are not considered to be ventilation exhaust treatment system components.

2.5 Gaseous Effluent Radiation Monitors

2.5.1 Station Vent Stack Effluent Monitor

Monitor 0PLD5J (Wide Range Noble Gas Monitor) continuously monitors the final effluent from the station vent stack.

The monitor system has isokinetic sampling, gaseous grab sampling, iodine and particulate sampling, tritium sampling, and post-accident sampling capability.

In normal operation the low-range noble gas channel is on line and active. The midrange channel replaces the low-range channel at a concentration of 0.01 μCi/cc png* and the high-range channel replaces the mid-range channel at a concentration of 10 uCi/cc png.

The low-range and mid/high-range iodine and particulate samplers operate in a similar manner. In normal operation the low-range samplers are on line. At a concentration of 0.001 μCi/cc png the mid/high-range samplers are brought on line, and at a concentration of 0.1 μCi/cc png the low-range sample pump is turned off.

* To facilitate use of the wide range gas monitors on the Station Vent Stack and Standby Gas Treatment System Stack in post-accident dose assessment, the output of each is expressed in units of pseudo noble gas (png) activity. Pseudo noble gas is a fictitious radionuclide defined to have emission characteristics representative of a post-accident noble gas mix. Upon decay, a pseudo noble gas nuclide emits one gamma ray with energy 0.8 MeV and one beta particle with endpoint energy 1.68 MeV and average energy 0.56 MeV.

No automatic isolation or control functions are performed by this monitor. Pertinent information on this monitor is provided in the LaSalle UFSAR Section 11.5.2.2.1.

2.5.2 Standby Gas Treatment System Effluent Monitor

Monitor 0PLD2J (Wide Range Noble Gas Monitor) continuously monitors the final effluent from the standby gas treatment system (SGTS) stack.

The SGTS stack monitor has isokinetic sampling, gaseous grab sampling, particulate and iodine sampling, and post accident sampling capability.

In normal operation the low range noble gas channel is on line and active. The midrange channel replaces the low-range channel at a concentration of 0.01 μCi/cc png and the high-range channel replaces the mid-range channel at a concentration of 10 μCi/cc png.

The low-range and mid/high-range iodine and particulate samples operate in a similar manner. In normal operation, the low-range samples are on-line. At a concentration of 0.001 μCi/cc png the mid/high-range samplers are brought on-line, and at a concentration of 0.1 μCi/cc png the low-range sample pump is turned off.

No automatic isolation or control functions are performed by this monitor.

Pertinent information on this monitor is provided in the LaSalle UFSAR Section 11.5.2.2.2.

2.5.3 Reactor Building Ventilation Monitors

Monitors 1(2)D18-N009 continuously monitor the effluent from the Unit 1(2) reactor building. On high alarm, the monitors automatically initiate the following actions:

A. Shutdown and isolation of the reactor building vent system

B. Startup of the standby gas treatment system

C. Isolation of primary containment purge and vent lines

Pertinent information on these monitors is provided in LaSalle UFSAR Section 11.5.2.1.1.

2.5.4 Condenser Air Ejector Monitors

Monitors 1(2)D18-N002/N012 (pre-treatment) and 1(2)D18-N903A/B (post-treatment) continuously monitor gross gamma activity downstream of the steam jet air ejector and prior to release to the main stack.

On a "high-high-high" alarm, monitor 1(2)D18-N903A/B automatically initiates closure of valve 1(2)N62-F057 terminating the associated offgas release.

Although all isolation signals remain unchanged, and no changes were made to the redundant trip circuitry of the valves, EC 387161 and 387237 have changed the failure mode of 1N62-F057 and 2N62-F057, respectively, from "fail closed" to "fail open". These failure mode changes eliminate vulnerabilities, such as loss of air and loss of power, that would inadvertently cause the valves to close resulting in a SCRAM on loss of condenser vacuum. Administrative controls are in place to verify that the 1(2)N62-F057 close(s) upon a valid isolation signal and to manually close 1(2)N62-F057, if necessary. Manual closure of the valve(s) is a time sensitive activity to ensure that off-site doses, as determined in Design Analysis L-003884, remain valid.

Pertinent information on these monitors is found in LaSalle UFSAR Sections 11.5.2.1.2 and 11.5.2.1.3.

2.5.5 Turbine Building Trackway and North Service building

In order to quantify releases via either the (1) Turbine Building Trackway or (2) North Service Building (when the ventilation systems are aligned to support the unit 2 egress) at times of positive pressure in the Turbine Building, airborne sampling shall be continuously collected using an air sampler appropriately located. The air sampler collecting shall begin within 20 hours of the turbine building being at positive pressure, and then continuously for as long as the turbine building remains at positive pressure. The samples collected should be counted on a weekly basis. Air sampling to identify noble gas, iodine and particulate monitoring (either as a grab sampler or continuous sampling) is designed to ensure evaluation of releases emanating from the Turbine Building.

The curie content of any contaminated material warehouse is maintained current by site administrative procedures. If a fire were to occur, the actual curie content of the warehouse would be used in determining the ground level release.

2.6 Gaseous Radiation Effluent Alarm and Trip Setpoints

2.6.1 Reactor Building Vent Effluent Monitor

The setpoint for the reactor building vent effluent monitor is established at 10 mR/hr.

2.6.2 Condenser Air Ejector Monitors

Pre-Treatment Monitor

The high trip setpoint is established at 1.5 times the normal full power background rate, including nitrogen-16 (N-16) to help ensure that effluents are maintained ALARA.

The high-high trip setpoint is established at < 100 µCi/sec per MW-th (3.4E+05 µCi/sec per Technical Specification 3.7.6).

Post-Treatment Monitor

The off-gas isolation setpoint is conservatively set at or below one-half the release limit calculated using the more conservative value obtained from equations (2-5) and (2-6) below.

The off gas isolation setpoint is converted into the monitor units of counts per second (cps) as follows:

$$P \leq Q_{SVS} \times E \times [R_{png} / R_{OG}] \div F_{OG} \qquad (2\text{-}4)$$

P Off-gas Post-treatment Monitor Isolation Setpoint. [cps]

The off-gas post-treatment monitor setpoint which initiates isolation of flow of offgas to the station vent stack.

Q_{SVS} Actual Station Vent Stack High Alarm Setpoint [μCi/sec of png]
The actual high alarm setpoint of the Station Vent Stack wide range gas monitor in units of μCi/sec of png (pseudo noble gas). This is determined by using Equations (2-5) and (2-6) and then converting the result to units of μCi/sec of png.

E Efficiency of the Off-Gas Post Treatment Monitor
[cps/(μCi/sec of off gas mix)]

R_{png} Response of the Station Vent Stack WRGM to Pseudo Noble Gas
[cpm per μCi/cc of pseudo noble gas]

R_{OG} Response of the Station Vent Stack WRGM to Off Gas
[cpm per μCi/cc of off gas]

F_{OG} Maximum Off-Gas Flow Rate [cc/sec]

2.6.3 Station Vent Stack Effluent Monitor

The high alarm setpoint for the station vent stack effluent monitor is conservatively set at or below one-half the calculated release limit calculated using the more conservative value obtained from equations (2-5) and (2-6) below. These equations yield the release limit in units of μCi/sec of the mix specified in Table 2-1. For consistency with the monitor readout, this calculated release limit is converted to units of μCi/sec of pseudo noble gas before being entered into the monitor data base.

2.6.4 Standby Gas Treatment Stack Monitor

The high alarm setpoint for the standby gas treatment system effluent monitor is conservatively set at or below one-half the release limit calculated using the more conservative value obtained from equations (2-5) and (2-6) below. These equations yield the release limit in units of μCi/sec of the mix specified in Table 2-1. For consistency with the monitor readout, this calculated release limit is converted to units of μCi/sec of pseudo noble gas before being entered into the monitor data base.

2.6.5 Release Limits

Alarm and trip setpoints of gaseous effluent monitors are established to ensure that the release rate limits of RECS are not exceeded. The release limit Q_{ts} is found by solving Equations (2-5) and (2-6).

$$(1.11)\ Q_{ts} \sum \{f_i\ \bar{S}_i\} < 500 \text{ mrem/yr} \qquad (2\text{-}5)$$

$$Q_{ts}\ \Sigma\{L_i\ f_i\ (X/Q)_s\ \exp(-\lambda_i\ R/3600\ U_s)\ \dagger + (1.11)(f_i)S_i\} < 3000\ mrem/yr \qquad (2\text{-}6)$$

The summations are over noble gas radionuclides i.

f_i Fractional Radionuclide Composition:

The release rate of noble gas radionuclide i divided by the total release rate of all noble gas radionuclides (contribution). Reference Table 2-1.

Q_{ts} Total Allowed Release Rate, Stack Release [µCi/sec of ODCM mix]

The total allowed release rate of all noble gas radionuclides released as stack releases in units of µCi/sec of the mix specified in section 2.6.6.

S_i Gamma Air Dose Factor [(mrad/yr)/(uCi/sec)]

The gamma air dose rate (S) at a specified location per unit of radioactivity release rate for radionuclide, i, from a stack release point. Reference Table 4-6.

$\bar{S}_i$ Whole Body Gamma Dose Factor [(mrad/yr)/(uCi/sec)]

The gamma whole body dose rate (SBAR) at a specified location per unit of radioactivity release rate for radionuclide, i, from a stack release point. Reference Table 4-6.

1.11 Conversation Factor [mrem/mrad]

Converts mrad to mrem

L_i Beta Skin Dose Factor [(mrem/yr)/(uCi/m^3)]

The beta skin dose rate per unit of radioactivity concentration for radionuclide, i. Reference Table 4-13.

$(X/Q)_s$ Relative Concentration Factor [sec/m^3]

The radioactivity concentration at a specified location per unit of radioactivity release rate for a stack release. Reference Table 4-3

† $\exp(-\lambda_i R/3600\ U_s)$ is conservatively set equal to 1.0 for purposes of determining setpoints.

Equation (2-5) is based on Equation 4-1 of Section 4.2.1.1 and the RECS restriction on whole body dose rate (500 mrem/yr) due to noble gases released in gaseous effluents . Equation (2-6) is based on Equation 4-2 of Section 4.2.1.2 and the RECS restriction on skin dose rate (3000 mrem/yr) due to noble gases released in gaseous effluents.

The more conservative solution from Equations (2-5) and (2-6) is used as the limiting noble gas release rate.

Calibration methods and surveillance frequency for the monitors will be conducted as specified in the RECS.

2.6.6 Release Mixture

In the determination of alarm and trip set points, the radioactivity mixture in the exhaust air is assumed to have the radionuclide composition in Table 2-1, taken from Table 3-3 of GE NEDO-10871, March 1973.

2.6.7 Conversion Factors

The conversion factors used to establish gaseous effluent monitor setpoints are obtained as follows.

Station vent stack effluent monitor.

Calibrations compare the response of station detectors to that of a reference detector using NIST traceable sources. Conversion factors for the station detectors are obtained from the response to noble gas or solid sources.

Condenser air ejector monitor.

Pretreatment Monitor

The value is determined using noble gas radionuclides identified in a representative sample, the offgas release rate and monitor response at the time the sample is taken.

Post-treatment Monitor

The value is determined using noble gas radionuclides identified in a representative sample, the offgas concentration and monitor response at the time the sample is taken.

Standby gas treatment system monitor.

Calibrations compare the response of station detectors to that of a reference detector using NIST traceable sources. Conversion factors for the station detectors are obtained from the response to noble gas or solid sources.

2.6.8 HVAC Flow Rates

The main stack flow rate is obtained from either the process computer or Monitor RM-23.

The SGTS flow rate is obtained from either the process computer or chart recorders in the main control room.

2.6.9 Allocation of Effluents from Common Release Points

Radioactive gaseous effluents released from the main chimney are comprised of contributions from both units. Under normal operating conditions, it is difficult to allocate the radioactivity between units due to fuel performance, in-plant leakage, power history, and other variables. Consequently, no allocation is normally made between the units. Instead, the entire release is treated as a single source.

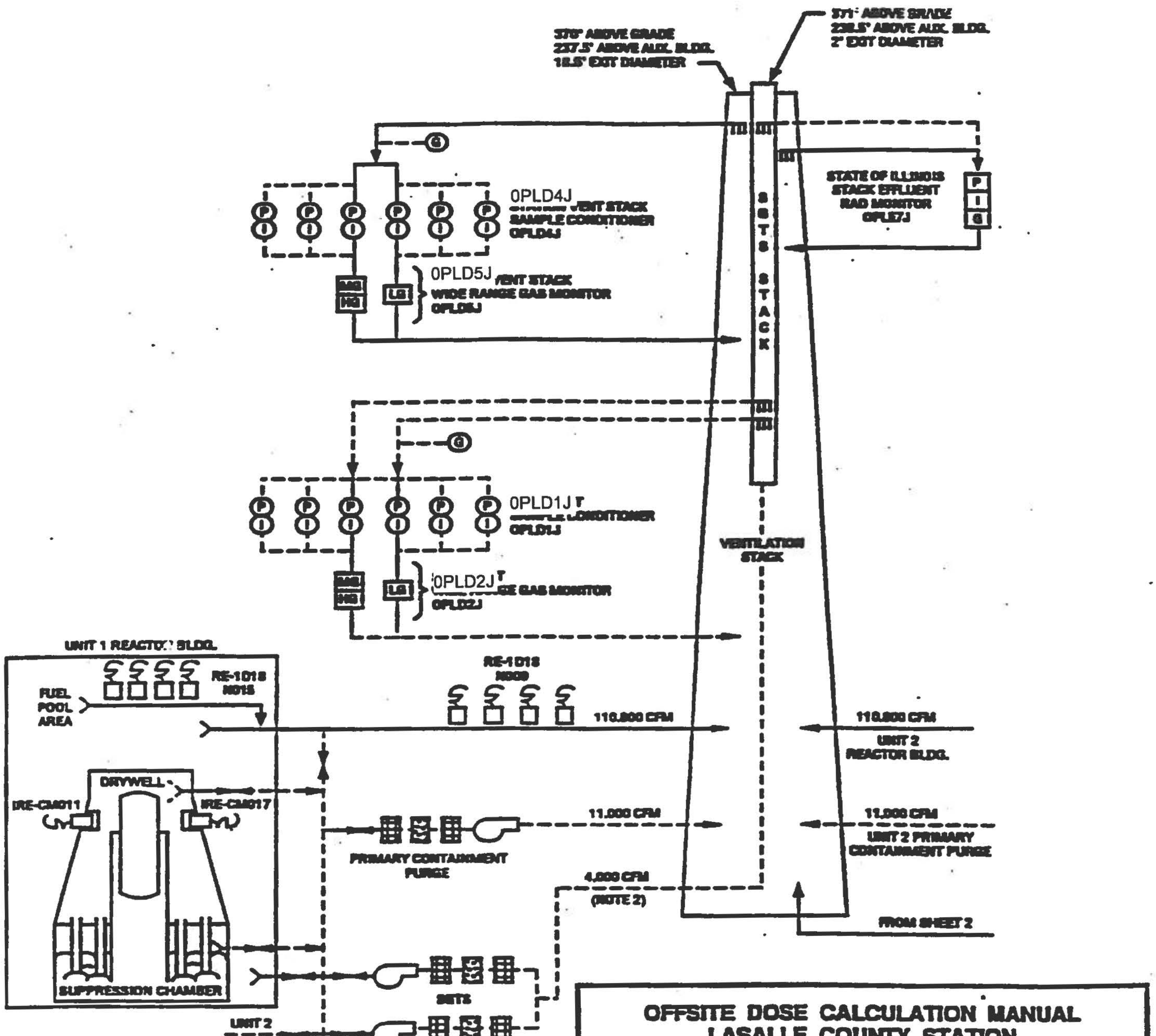
2.6.10 Dose Projections

Because the gaseous releases are continuous, the doses are routinely calculated in accordance with the RECS.

Table 2-1

Assumed Composition of the LaSalle Station Noble Gas Effluent
(From GE NEDO – 10871 Table 3.3)

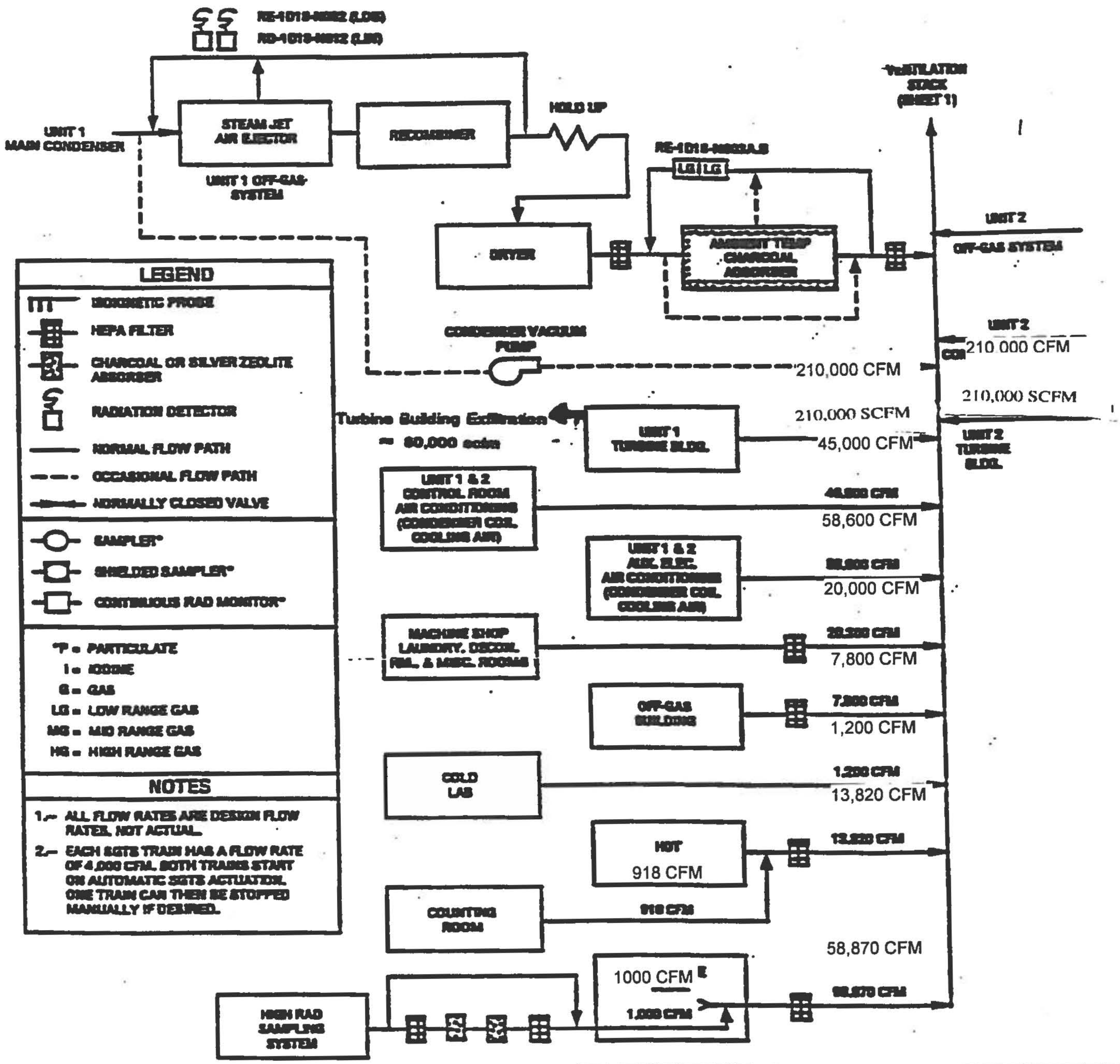
Nuclide	T1/2	uCi/s @ T=0	Contribution	% Contribution
Kr83m	1.86h	3.40E+03	4.50E-03	0.45%
Kr85m	4.4h	6.10E+03	8.08E-03	0.81%
Kr85	10.74h	2.00E+01	2.65E-05	0.00%
Kr87	76m	2.00E+04	2.65E-02	2.65%
Kr88	2.79h	2.00E+04	2.65E-02	2.65%
Kr89	3.18m	1.30E+05	1.72E-01	17.22%
Kr90	32.3s	2.80E+05	3.71E-01	37.08%
Xe131m	11.96d	1.50E+01	1.99E-05	0.00%
Xe133m	2.26d	2.90E+02	3.84E-04	0.04%
Xe133	5.27d	8.20E+03	1.09E-02	1.09%
Xe135m	15.7m	2.60E+04	3.44E-02	3.44%
Xe135	9.16h	2.20E+04	2.91E-02	2.91%
Xe137	3.82m	1.50E+05	1.99E-01	19.87%
Xe138	14.2m	8.90E+04	1.18E-01	11.79%
Total		7.55E+05	1.00E+00	100.00%



OFFSITE DOSE CALCULATION MANUAL
LASALLE COUNTY STATION

FIGURE 2-1

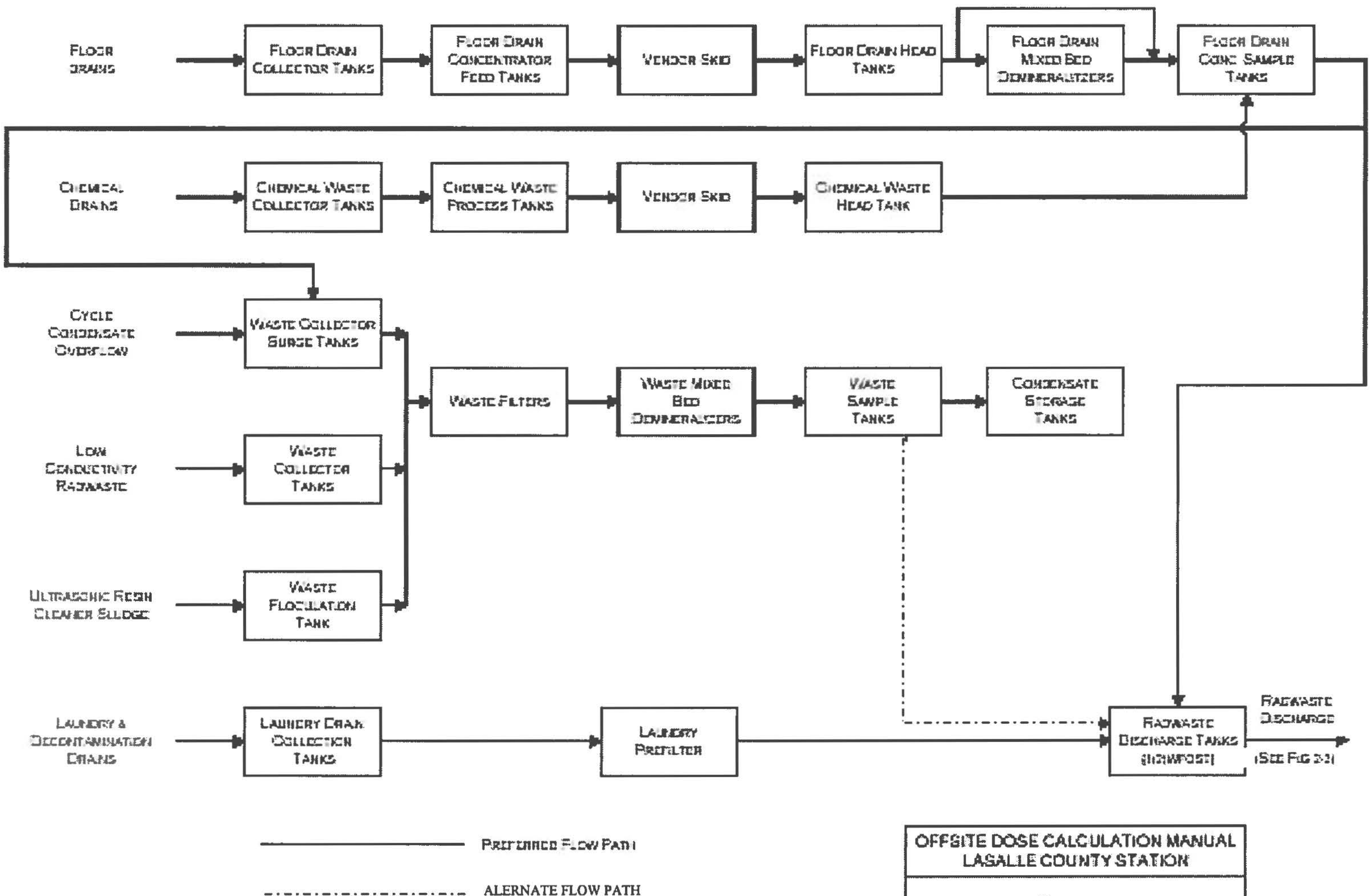
SIMPLIFIED GASEOUS RADWASTE AND GASEOUS EFFLUENT FLOW DIAGRAM (SHEET 1 OF 2)



OFFSITE DOSE CALCULATION MANUAL
LASALLE COUNTY STATION

FIGURE 2-1

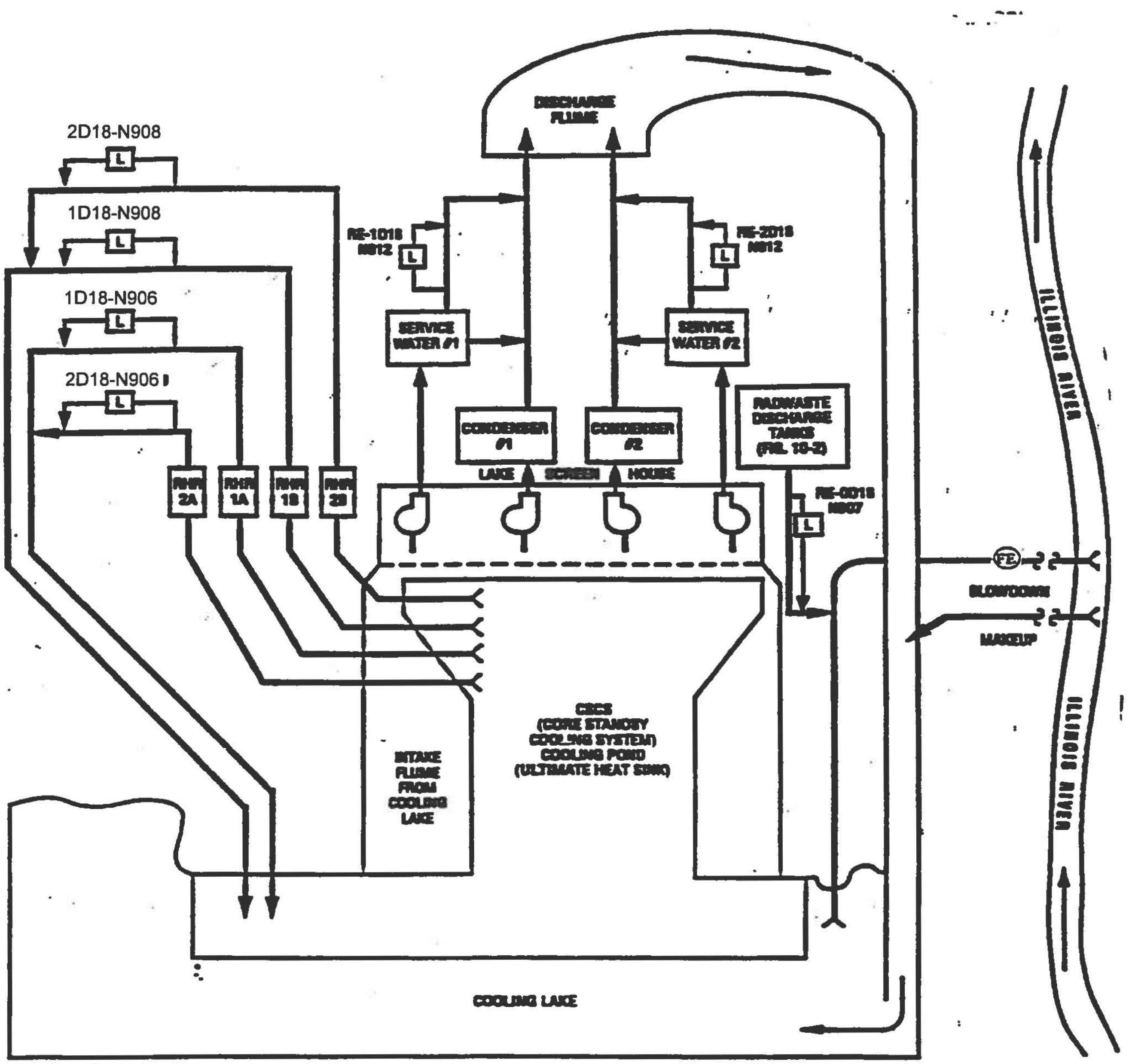
SIMPLIFIED GASEOUS RADWASTE AND GASEOUS EFFLUENT FLOW DIAGRAM
(SHEET 2 OF 2)



OFFSITE DOSE CALCULATION MANUAL
LASALLE COUNTY STATION

FIGURE 2-2

SIMPLIFIED LIQUID RADWASTE PROCESSING DIAGRAM



LEGEND AND NOTES	
L	LIQUID RADIATION MONITOR
FE	FLOW ELEMENT

OFFSITE DOSE CALCULATION MANUAL
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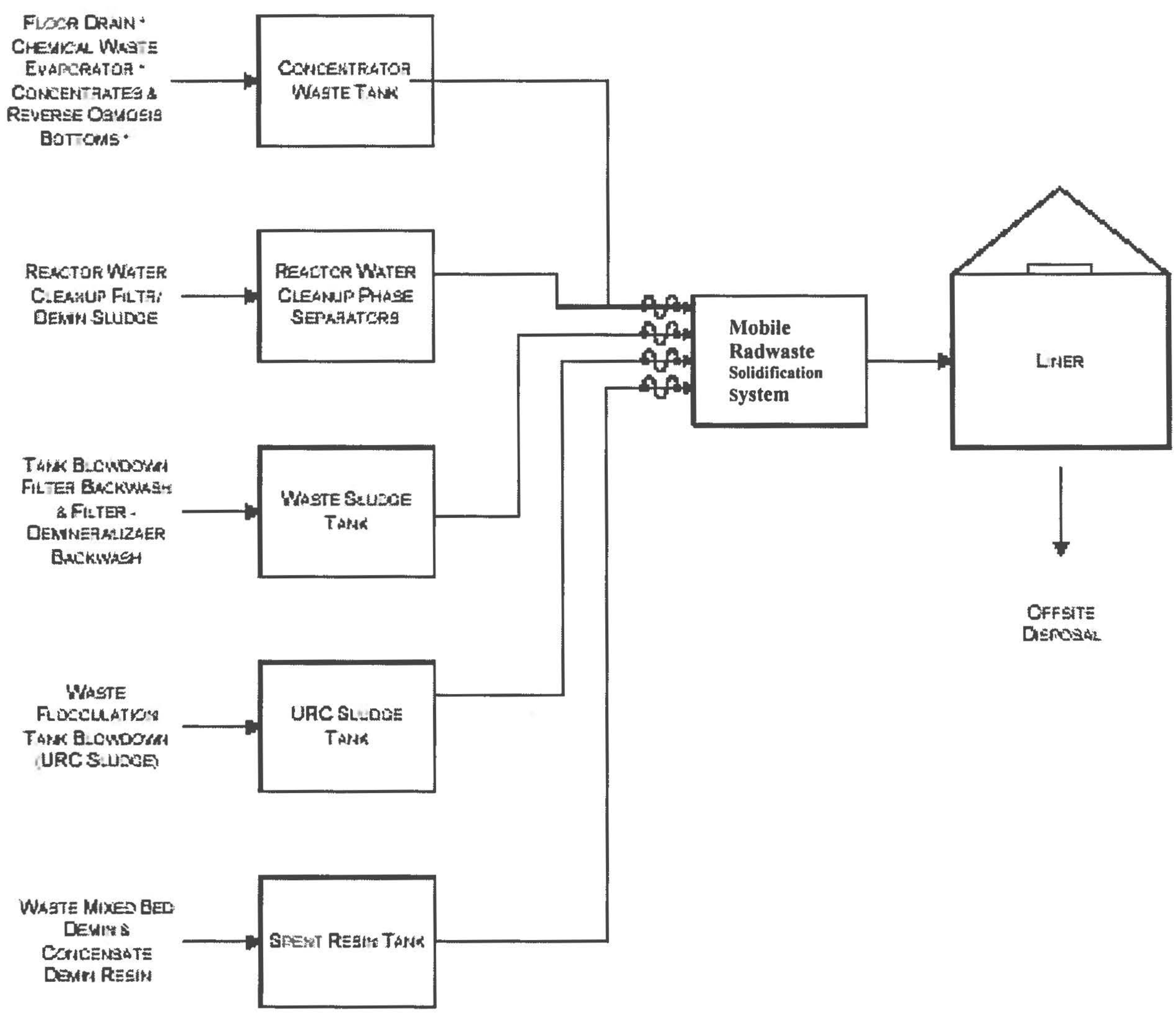
FIGURE 2-3

SIMPLIFIED LIQUID EFFLUENT FLOW DIAGRAM



LEGEND AND NOTES

FLEXIBLE HOSE

URC = ULTRASONIC RESIN CLEANER

* = ABANDONED IN PLACE

OFFSITE DOSE CALCULATION MANUAL
LASALLE COUNTY STATION

FIGURE 2-4

SIMPLIFIED SOLID RADWASTE PROCESSING DIAGRAM

3.0 LIQUID EFFLUENTS

3.1 Liquid Effluent Releases – General Information

3.1.1 The design objectives of 10CFR50, Appendix I and RECS provide the following limits on the dose to a member of the public from radioactive materials in liquid effluents released from each reactor unit to restricted area boundaries:

- During any calendar quarter, less than or equal to 1.5 mrem to the total body and less than or equal to 5 mrem to any organ.
- During any calendar year, less than or equal to 3 mrem to the total body and less than or equal to 10 mrem to any organ.

3.1.2 The organ doses due to radioactivity in liquid effluents are also used as part of the 40CFR190 compliance and are included in the combination of doses to determine the total dose used to demonstrate 10CFR20 compliance. (See Section 5.0, Total Dose)

3.1.3 Dose assessments for 10CFR20 and 40CFR190 compliance are made for an adult using Federal Guidance Report No. 11 (Reference 93) dose conversion factors. Dose assessments for 10CFR50 Appendix I compliance are made for four age groups (adult/teenager/child/infant) using Regulatory Guide 1.109 (Reference 6) dose conversion factors.

3.1.4 To limit the consequences of tank overflow, the RECS/Technical Specifications may limit the quantity of radioactivity that may be stored in unprotected outdoor tanks. Unprotected tanks are tanks that are not surrounded by liners, dikes, or walls capable of holding the tank contents and that do not have tank overflows and surrounding area drains connected to the liquid radwaste treatment system. The specific objective is to provide assurance that in the event of an uncontrolled release of a tank's contents, the resulting radioactivity concentrations beyond the unrestricted area boundary, at the nearest potable water supply and at the nearest surface water supply, will be less than the limits of 10CFR20 Appendix B, Table 2; Column 2.

The Technical Specifications and RECS may contain a somewhat similar provision. For most nuclear power stations, specific numerical limits are specified on the number of curies allowed in affected tanks.

3.1.5 Cases in which normally non-radioactive liquid streams (such as the Service Water) are found to contain radioactive material are non-routine will be treated on a case specific basis if and when this occurs. Since the station has sufficient capacity to delay a liquid release for reasonable periods of time, it is expected that planned releases will not take place under these circumstances. Therefore, the liquid release setpoint calculations need not and do not contain provisions for treating multiple simultaneous release pathways.

3.2 Liquid Effluent Concentrations

3.2.1 One method of demonstrating compliance to the requirements of 10CFR20.1301 is to demonstrate that the annual average concentrations of radioactive material released in gaseous and liquid effluents do not exceed the values specified in 10CFR20 Appendix B, Table 2, Column 2. (See 10CFR 20.1302(b)(2).) However, as noted in Section 5.5, this mode of 10CFR20.1301 compliance has not been elected.

As a means of assuring that annual concentration limits will not be exceeded, and as a matter of policy assuring that doses by the liquid pathway will be ALARA; RECS provides the following restriction:

> "The concentration of radioactive material released in liquid effluents to unrestricted areas shall be limited to ten times the concentration values in Appendix B, Table 2, Column 2 to 10CFR20.1001-20.2402."

This also meets the requirement of Station Technical Specifications and RECS.

3.2.2 According to the footnotes to 10CFR20 Appendix B, Table 2, Column 2, if a radionuclide mix of known composition is released, the concentrations must be such that

$$\sum_i \left(\frac{C_i}{10\,ECL_i} \right) \leq 1 \qquad (3\text{-}1)$$

where the summation is over radionuclide **i**.

C_i Radioactivity Concentration in Liquid Effluents to the Unrestricted Area [μCi/ml]

Concentration of radionuclide **i** in liquid released to the unrestricted area.

ECL_i Effluent Concentration Limit in Liquid Effluents Released to the Unrestricted Area [µCi/ml]

The allowable annual average concentration of radionuclide **i** in liquid effluents released to the unrestricted area. This concentration is specified in 10CFR20 Appendix B, Table 2, Column 2. Concentrations for noble gases are different and are specified in the stations' Technical Specifications/RECS.

10 Multiplier to meet the requirements of Technical Specifications.

If either the identity or concentration of any radionuclide in the mixture is not known, special rules apply. These are given in the footnotes in 10CFR20 Appendix B, Table 2, Column 2.

3.2.3 When radioactivity is released to the unrestricted area with liquid discharge from a tank (e.g., a radwaste discharge tank), the concentration of a radionuclide in the effluent is calculated as follows:

$$C_i = (C_i^t)(F^r)/(F^d + F^r) \qquad (3\text{-}2)$$

C_i Concentration in Liquid effluent to the unrestricted area. [µCi/ml]

Concentration of radionuclide 'i' in liquid released to the unrestricted area.

C_i^t Concentration in the Discharge Tank [µCi/ml]

Measured concentration of radionuclide **i** in the discharge tank.

F^r Flow Rate, Tank Discharge [cfs]

Measured flow rate of liquid from the discharge tank to the initial dilution stream.

F^d Flow Rate, Initial Dilution Stream [cfs]

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

The RECS and Technical Specifications require a specified sampling and analysis program to assure that liquid radioactivity concentrations at the point of release are maintained within the required limits. To comply with this provision, samples are analyzed in accordance with the radioactive liquid waste (or effluent) sampling and analysis program in Section 12.3 of Part I, RECS. Radioactivity concentrations in tank effluents are determined in accordance with Equation 3-2. Comparison with the Effluent Concentration Limit is made using Equation 3-1.

3.3 Liquid Effluent Dose Calculation Requirements

3.3.1 RECS require determination of cumulative and projected dose contributions from liquid effluents for the current calendar quarter and the current calendar year at least once per 31 days.

For a release attributable to a processing or effluent system shared by more than one reactor unit, the dose due to an individual unit is obtained by proportioning the effluents among the units sharing the system.

3.3.2 Operability and Use of the Liquid Radwaste Treatment System

The design objectives of 10CFR50, Appendix I and RECS/Technical Specifications require that the liquid radwaste treatment system be operable and that appropriate portions be used to reduce releases of radioactivity when projected doses due to the liquid effluent from each reactor unit to restricted area boundaries exceed either of the following (see Section 12.3.3 of Part I, RECS);

- 0.06 mrem to the total body in a 31-day period.
- 0.2 mrem to any organ in a 31-day period.

3.4 Dose Methodology

3.4.1 Liquid Effluent Dose Method: General

The dose from radioactive materials in liquid effluents considers the contributions for consumption of fish and potable water. All of these pathways are considered in the dose assessment unless demonstrated not to be present. While the adult is normally considered the maximum individual, the methodology provides for dose to be calculated for all four age groups. The dose to each organ (and to the total body) is calculated by the following expressions:

3.4.1.1 NUREG – 0133 Methodology

$$D_\tau = \frac{\sum_i \left[A_{i\tau} \sum_{\ell=1}^{m} \Delta t_\ell \, C_{i_\ell} \, F_\ell \right]}{D_w} \tag{3-3}$$

where:

D_τ = The cumulative dose commitment to the total body or any organ, τ , from liquid effluents for the total time period $\sum_{\ell=1}^{m} \Delta t_\ell$,(mrem).

Δt_ℓ = The length of the ℓ th time period over which C_{i_ℓ} and F_ℓ are averaged for the liquid release, (hours).

C_{i_ℓ} = The average concentration of radionuclide, *i*, in undiluted liquid effluent during time period Δt_ℓ, from any liquid release, (uCi/ml).

F_ℓ = The near field average dilution factor for C_{i_ℓ} during any liquid effluent release. Defined as the ratio of the maximum undiluted liquid waste flow during the release to the average flow through the discharge pathway

$$F_\ell = \frac{\text{(tank volume(gallons))}}{\text{(tank volume(gallons))} + \text{(Blowdown Dilution (gallons))}}$$

D_W = The dilution factor at point of exposure or at point of withdrawal of drinking water (dimensionless).

$A_{i\tau}$ = The site specific ingestion dose commitment factor to the total body or organ, τ, for each radionuclide and pathway

3.4.2 Potable Water Pathway

3.4.2.1 NUREG – 0133 Methodology

$$A_{i\tau} = k_0 * U_W * D_{aipj} * e^{\left(-\lambda_i t_p^D\right)} \qquad (3\text{-}4)$$

k_0 = 114155, units conversion factor (1.0 E6 pCi/uCi * 1000 ml/L/ 8760 hr/yr). Note for fish units are g/kg.

U = usage factor per pathway.

D_{aipj} = dose conversion factor for nuclide, *i*, for total body or any organ, τ, (mrem/pCi).

λ_i = radioactive decay constant of nuclide 'i' (hr-1) .

t_p^D = delay time for water pathway in hours to allow for nuclide decay during transport through the water purification plant and the water distribution system.

3.4.3 Fish Ingestion Pathway

3.4.3.1 NUREG -0133 Methodology

Freshwater Fish

$$A_{i\tau} = k_0 * U_F * BF_i * D_{aipj} * e^{\left(-\lambda_i t_p^F\right)} \quad (3\text{-}5)$$

k_0 = 114155, units conversion factor (1.0 E6 pCi/uCi * 1000 ml/L/ 8760 hr/yr). Note for fish units are g/kg.

U = usage factor per pathway.

D_{aipj} = dose conversion factor for nuclide, *i*, for total body or any organ, τ , (mrem/pCi).

BF_i = bioaccumulation factor for nuclide, *i*, in fresh water fish (pCi/kg per pCi/L).

λ_i = radioactive decay constant of nuclide 'i' (hr-1).

t_p^F = delay time for fish pathway to allow for nuclide decay during transport through the food chain, as well as during food preparation.

3.4.4 Offsite Doses

Offsite doses due to projected releases of radioactive materials in liquid effluents are calculated using the equation in 3.4.1.1. Projected radionuclide release concentrations are used in place of measured concentrations, C_i.

3.4.5 Drinking Water

LaSalle Station has requirements for calculation of drinking water dose that are related to 40CFR141, the Environmental Protection Agency National Primary Drinking Water Regulations. These are discussed in Section 1.2.1.

3.5 Bioaccumulation Factors

3.5.1 There are no public potable water intakes on the Illinois River for 97 miles downstream of the station at Peoria, IL.

3.5.2 There is no irrigation occurring on the Illinois River downstream of the station.

3.5.3 Recreation includes one or more of the following: boating, water-skiing, swimming, and sport fishing.

Table 3-1

Bioaccumulation Factors (BF_i) to be Used in the Absence of Site-Specific Data

Element	BF_i for Freshwater Fish (pCi/kg per pCi/L)	Reference
H	9.0E-01	6
Be	2.8E+01	Footnote 2
C	4.6E+03	6
F	2.2E+02	Footnote 16
Na	1.0E+02	6
Mg	2.8E+01	Footnote 2
Al	2.2E+03	Footnote 13
P	1.0E+05	6
Cl	2.2E+02	Footnote 16
Ar	NA	NA
K	1.0E+03	Footnote 1
Ca	2.8E+01	Footnote 2
Sc	2.5E+01	Footnote 3
Ti	3.3E+00	Footnote 4
V	3.0E+04	Footnote 5
Cr	2.0E+02	6
Mn	4.0E+02	6
Fe	1.0E+02	6
Co	5.0E+01	6
Ni	1.0E+02	6
Cu	5.0E+01	6
Zn	2.0E+03	6
Ga	2.2E+03	Footnote 13
Ge	2.4E+03	Footnote 12
As	3.3E+04	Footnote 14
Se	4.0E+02	Footnote 15
Br	4.2E+02	6
Kr	NA	NA
Rb	2.0E+03	6
Sr	3.0E+01	6
Y	2.5E+01	6
Zr	3.3E+00	6
Nb	3.0E+04	6
Mo	1.0E+01	6
Tc	1.5E+01	6
Ru	1.0E+01	6
Rh	1.0E+01	6
Pd	1.0E+02	Footnote 9

Table 3-1(**cont.**) **Bioaccumulation Factors (BF_i) to be Used in the Absence of Site-Specific Data**		
Cd	2.0E+03	Footnote 11
In	2.2E+03	Footnote 13
Sn	2.4E+03	Footnote 12
Sb	1.0E+00	98
Ag	2.3E+00	56
Te	4.0E+02	6
I	1.5E+01	6
Xe	NA	NA
Cs	2.0E+03	6
Ba	4.0E+00	6
La	2.5E+01	6
Ce	1.0E+00	6
Pr	2.5E+01	6
Nd	2.5E+01	6
Pm	3.0E+01	98
Sm	3.0E+01	Footnote 3
Eu	1.0E+02	Footnote 3
Gd	2.6E+01	Footnote 3
Dy	2.2E+03	Footnote 3
Er	3.3E+04	Footnote 3
Tm	4.0E+02	Footnote 3
Yb	2.2E+02	Footnote 3
Lu	2.5E+01	Footnote 3
Hf	3.3E+00	Footnote 4
Ta	3.0E+04	Footnote 5
W	1.2E+03	6
Re	2.1E+02	Footnote 6
Os	5.5E+01	Footnote 7
Ir	3.0E+01	Footnote 8
Pt	1.0E+02	Footnote 9
Au	2.6E+01	Footnote 10
Hg	2.0E+03	Footnote 11
Tl	2.2E+03	Footnote 13
Pb	3.0E+02	98
Bi	2.0E+01	98
Ra	5.0E+01	98
Th	3.0E+01	98
U	1.0E+01	98
Np	1.0E+01	6
Am	3.0E+01	98

Footnotes:
NA = It is assumed that noble gases are not accumulated.

In Reference 6, see Table A-1.

A number of bioaccumulation factors could not be found in literature. In this case, the periodic table was used in conjunction with published element values. This method was used for periodic table columns except where there were no values for column 3A so the average of columns 2B and 4A was assigned.

1. Value is the average of Reference 6 values in literature for H, Na, Rb and Cs.
2. Value is the average of Ref. 6 values in literature for Sr, Ba and Ref. 98 values for Ra.
3. Value is the same as the Reference 6 value used for Y.
4. Value is the same as the Reference 6 value used for Zr.
5. Value is the same as the Reference 6 value used for Nb.
6. Value is the average of Reference 6 values in literature for Mn and Tc.
7. Value is the average of Reference 6 values in literature for Fe and Ru.
8. Value is the average of Reference 6 values in literature for Co and Rh.
9. Value is the same as the Reference 6 value used for Ni.
10. Value is the average of Reference 6 values in literature for Cu and Reference 56 value for Ag.
11. Value used is the same as the Reference 6 value used for Zn.
12. Value is the average of Reference 6 value in literature for C and Reference 98 value for Pb.
13. Value is the average of columns 2B and 4A, where column 2B is the "Reference 6 value for Zn" and column 4A is the average of "Reference 6 value for C and Reference 98 value for Pb".
14. Value is the average of Ref. 6 value found in literature for P and the Ref. 98 values for Bi and Sb.
15. Value is the same as the Reference 6 value used for Te.
16. Value is the average of Reference 6 values found in literature for Br and I.

4.0 Gaseous Effluents

4.1 Gaseous Effluents – General Information

This section reviews the offsite radiological limits applicable to the LaSalle Station and presents in detail the equations and procedures used to assess compliance with these limits. This calculational approach uses the methodology of NUREG-0133 (Reference 14), and incorporates certain simplifications such as the use of average meteorology.

4.1.1 Pre-calculated atmospheric transport parameters are based on historical average atmospheric conditions. These historical meteorological conditions have resulted in the dispersion parameters shown in Table 4-2 through Table 4-6, and Table 4-9 through Table 4-11.

4.1.2 The equations and parameters of this section are for use in calculating offsite radiation doses during routine operating conditions. They are not for use in calculating doses due to non-routine releases (e.g., accident releases).

4.1.3 An overview of the required compliance is given in Table 1-1. The dose components are itemized and referenced, and an indication of their regulatory application is noted. Additionally, the locations of dose receivers for each dose component are given in Table 1-2.

4.1.4 Airborne Release Point Classifications

The pattern of dispersion of airborne releases is dependent on the height of the release point relative to adjacent structures. Each release point is classified as one of the following three height-dependent types:

- Stack (or Elevated) Release Point (denoted by the letter S or subscript s)
- Ground Level Release Point (denoted by the letter G or subscript g)
- Vent (or Mixed Mode) Release Point (denoted by the letter V or subscript v)

4.1.5 Operability and Use of Gaseous Effluent Treatment Systems

10CFR50 Appendix I and ODCM Part I (RECS) require that the ventilation exhaust treatment system and the waste gas holdup system be used when projected offsite doses in 31 days, due to gaseous effluent releases, from each reactor unit, exceed any of the following limits:

- 0.2 mrad to air from gamma radiation.

- 0.4 mrad to air from beta radiation.
- 0.3 mrem to any organ of a member of the public.

The station must project doses due to gaseous releases from the site at least once per 31 days. The calculational methods shown in sections 4.2.2.1 and 4.2.2.2 are used for this dose projection.

4.1.6 For a release attributable to a processing or effluent system shared by more than one reactor unit, the dose due to an individual unit is obtained by proportioning the effluents among the units sharing the system.

4.2 Gaseous Effluents – Dose and Dose Rate Calculation Requirements

4.2.1 Instantaneous Dose Rates

4.2.1.1 Noble Gas: Total Body Dose Rate

RECS limits the total body dose rate due to noble gases in gaseous effluents released from a site to areas at and beyond the site boundary to less than or equal to 500 mrem/yr at all times.

In accordance with NUREG-0133 methodology, total body dose rate due to noble gases released in gaseous effluents is calculated:

$$\dot{D}_{TB} = \Sigma_i[V_i * \dot{Q}_{is} + K_i * ((\chi/Q)_v * \dot{Q}_{iv})] \qquad (4\text{-}1)$$

where:

$\dot{D}_{TB}$ is the instantaneous dose rate to the total body due to radioactive materials (noble gasses) released in gaseous effluents from the site (mrem/yr)

V_i is the constant for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume (mrem*sec/yr*µCi)

$\dot{Q}_{is}$ is the release rate of radionuclides, i, in gaseous effluents from a free standing (elevated) stack (µCi/sec)

K_i is the total body dose factor due to gamma emissions for each identified noble gas radionuclide (mrem*m^3/yr*µCi). Reference table 4-13.

$(\chi/Q)_v$ is the highest calculated annual average relative concentration for areas at or beyond the unrestricted area boundary for vent releases (sec/m^3).

$\dot{Q}_{iv}$ is the release rate of radionuclides, i, in gaseous effluents from all vent releases (µCi/sec)

To comply with this specification, the effluent radiation monitor has a setpoint corresponding to an offsite total body dose rate at or below the limit (see Part II Section 2.6). In addition, compliance is assessed by calculating offsite total body dose rate based on periodic samples obtained per station procedures.

4.2.1.2 Noble Gas: Skin Dose Rate

RECS limits the skin dose rate due to noble gases in gaseous effluents released from a site to areas at and beyond the site boundary to less than or equal to a dose rate of 3000 mrem/yr at all times. (See Part I Section 12.4.1)

In accordance with NUREG-0133 methodology, the skin dose rate due to noble gases released in gaseous effluents is calculated by the following expression:

$$\dot{D}_{Skin} = \Sigma_i[(L_i*(\chi/Q)_s + 1.1*B_i)*\dot{Q}_{is} + (L_i + 1.1*M_i)*((\chi/Q)_v*\dot{Q}_{iv})] \qquad (4-2)$$

where:

$\dot{D}_{Skin}$ is the instantaneous dose rate to the skin due to radioactive materials (noble gasses) released in gaseous effluents from the site (mrem/yr)

L_i is the skin dose factor due to beta emissions for each identified noble gas radionuclide (mrem*m^3/yr*µCi). Reference table 4-13.

$(\chi/Q)_s$ is the highest calculated annual average relative concentration for areas at or beyond the unrestricted area boundary for elevated stack releases (sec/m^3).

1.1 is the unit conversion constant to convert air dose to skin dose (mrem/mrad).

B_i is the constant for long term releases (greater than 500 hr/yr) for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume (mrad*sec/yr*µCi).

$\dot{Q}_{is}$ is the release rate of radionuclides, i, in gaseous effluents from a free standing (elevated) stack (µCi/sec).

M_i is the air dose factor due to gamma emissions for each identified noble gas radionuclide (mrad*m^3/yr*µCi). Reference table 4-13.

$(\chi/Q)_v$ is the highest calculated annual average relative concentration for areas at or beyond the unrestricted area boundary for vent releases (sec/m^3).

$\dot{Q}_{iv}$ is the release rate of radionuclides, i, in gaseous effluents from all vent releases (µCi/sec).

To comply with this specification, gaseous effluent radiation monitors have setpoints corresponding to an offsite skin dose rate at or below the limit (see Part II Section 2.6). In addition, compliance is assessed by calculating offsite skin dose rate based on periodic samples obtained per station procedures.

4.2.1.3 Non-Noble Gas Radionuclides: Organ Dose Rate

RECS limits the dose rate to any organ, due to radioactive materials in gaseous effluents released from a site to areas at and beyond the site boundary, to less than or equal to a dose rate of 1500 mrem/yr (See Part I Section 12.4.1)

Typically the adult is considered to be the limiting receptor in calculating dose rate to organs due to inhalation of non-noble gas radionuclides in gaseous effluents.

In accordance with NUREG 0133 Methodology, the dose rate to any adult organ due to inhalation is calculated by the following expression:

$$\dot{D}^{inhal}{}_{ja} = \Sigma_i P^I{}_i * [(\chi/Q)_s * \dot{Q}_{is} + (\chi/Q)_v * \dot{Q}_{iv}] \quad (4\text{-}3)$$

$\dot{D}^{inhal}{}_{ja}$ is the instantaneous dose rate to organ (j) of an individual in ager group (a) due to inhalation of non noble gas radioactive materials released in gaseous effluents from the site (mrem/yr)

$P^I{}_i$ is the inhalation dose rate factor for each identified non noble gas radionuclide, i, ($mrem*m^3/yr*\mu Ci$). P_i inhalation dose rate factors are calculated in accordance with the following:

$P^I{}_i = K'(BR)DFA_i$
where:

$P^I{}_i$ is the **inhalation** dose rate factor ($mrem*m^3/yr*\mu Ci$).

K' is a **constant** of unit conversion = 1E+06 (pCi/µCi).

BR is the **breathing** rate of the age group of interest (m^3/yr).

DFA_i is the **inhalation** dose factor (mrem/pCi)

$(\chi/Q)_s$ is the highest **calculated** annual average relative concentration for areas at or beyond the unrestricted area boundary for elevated stack releases (sec/m^3).

$\dot{Q}_{is}$ is the release rate of radionuclides, i, in gaseous effluents from a free standing (elevated) stack (µCi/sec).

$(\chi/Q)_v$ is the highest calculated annual average relative concentration for areas at or beyond the unrestricted area boundary for vent releases (sec/m^3).

$\dot{Q}_{iv}$ is the release rate of radionuclides, i, in gaseous effluents from all vent releases (µCi/sec).

RECS requires the dose rate due to non-noble gas radioactive materials in airborne effluents be determined to be within the above limit in accordance with a sampling and analysis program specified in Part I Table R12.4.1-1.

The adult organ dose rate due to inhalation is calculated in each sector at the location of the highest offsite χ/Q (see Table 4-3). The result for the sector with the highest organ inhalation dose rate is compared to the limit.

4.2.2 Time Averaged Dose from Noble Gas

4.2.2.1 Gamma Air Dose

RECS limits the gamma air dose due to noble gas effluents released from each reactor unit to areas at and beyond the unrestricted area boundary to the following:

- Less than or equal to 5 mrad per calendar quarter.
- Less than or equal to 10 mrad per calendar year.

In accordance with NUREG 0133 Methodology, the gamma air dose due to noble gases released in gaseous effluents is calculated by the following expression:

$$D_\gamma = 3.17E\text{-}08 * \Sigma_i\{M_i[(\chi/Q)_v * \overline{Q}_{iv} + (\chi/q)_v * \overline{q}_{iv}] + [B_i * \overline{Q}_{is} + b_i * \overline{q}_{is}]\} \qquad (4\text{-}4)$$

where:

D_γ is the dose to air due to gamma radiation from noble gas radiation released in gaseous effluents (mrad)

3.17E-08 is a conversion constant (yr/sec).

M_i is the air dose factor due to gamma emissions for each identified noble gas radionuclide (mrad*m^3/yr*µCi). Reference table 4-13.

$(\chi/Q)_v$ is the highest calculated annual average relative concentration for areas at or beyond the unrestricted area boundary for long term (greater than 500 hr/yr) vent releases (sec/m^3).

$\bar{Q}_{iv}$ is the average release of noble gas radionuclides in gaseous effluents, i, for long term (greater than 500 hr/yr) vent releases (μCi).

$(\chi/q)_v$ is the relative concentration for areas at or beyond the unrestricted area boundary for short term (equal to or less than 500 hr/yr) vent releases (sec/m^3).

$\bar{q}_{iv}$ is the average release of noble gas radionuclides, i, in gaseous releases, i, for short term (equal to or less than 500 hr/yr) vent releases (μCi).

B_i is the constant for long term releases (greater than 500 hr/yr) for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume (mrad*sec/yr*μCi).

$\bar{Q}_{is}$ is the average release of noble gas radionuclides in gaseous effluents, i, for long term (greater than 500 hr/yr) releases from a free standing (elevated) stack (μCi).

b_i is the constant for short term releases (equal to or less than 500 hr/yr) for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume (mrad*sec/yr*μCi).

$\bar{q}_{is}$ is the average release of noble gas radionuclides in gaseous effluents, i, for short term (equal to or less than 500 hr/yr) releases from a free standing (elevated) stack (μCi).

RECS Section 12.4.2, RSR 12.4.2.1, and Section 12.4.5, RSR 12.4.5.1 require determination of cumulative and projected gamma air dose contributions due to noble gases for the current calendar quarter and the current calendar year at least once per 31 days.

Gamma air dose is calculated for the sector with the highest offsite (χ/Q) and is compared with the RECS limits on gamma air dose.

For a release attributable to a processing or effluent system shared by more than one reactor unit, the dose due to an individual unit is obtained by proportioning the effluents among the units sharing the system.

4.2.2.2 Beta Air Dose

RECS limits beta air dose due to noble gases in gaseous effluents released from each reactor unit to areas at and beyond the unrestricted area boundary to the following:

- Less than or equal to 10 mrad per calendar quarter.
- Less than or equal to 20 mrad per calendar year.

In accordance with NUREG 0133 Methodology, the beta air dose due to noble gases released in gaseous effluents is calculated by the following expression:

$$D_\beta = 3.17E\text{-}08 * \Sigma_i\{N_i[(\chi/Q)_v * \bar{Q}_{iv} + (\chi/q)_v * \bar{q}_{iv} + (\chi/Q)_s * \bar{Q}_{is} + (\chi/q)_s * \bar{q}_{is}]\} \quad (4\text{-}5)$$

where:

D_β is the dose to air due to beta radiation from noble gas radiation released in gaseous effluents (mrad)

3.17E-08 is a conversion constant (yr/sec).

N_i is the air dose factor due to beta emissions for each identified noble gas radionuclide (mrad*m^3/yr*µCi). Reference table 4-13.

$(\chi/Q)_v$ is the highest calculated annual average relative concentration for areas at or beyond the unrestricted area boundary for long term (greater than 500 hr/yr) vent releases (sec/m^3).

$\bar{Q}_{iv}$ is the average release of noble gas radionuclides in gaseous effluents, i, for long term (greater than 500 hr/yr) vent releases (µCi).

$(\chi/q)_v$ is the relative concentration for areas at or beyond the unrestricted area boundary for short term (equal to or less than 500 hr/yr) vent releases (sec/m^3).

$\bar{q}_{iv}$ is the average release of noble gas radionuclides, i, in gaseous releases, i, for short term (equal to or less than 500 hr/yr) vent releases (µCi).

$(\chi/Q)_s$ is the highest calculated annual average relative concentration for areas at or beyond the unrestricted area boundary for long term (greater than 500 hr/yr) releases from a free standing (elevated) stack (sec/m^3).

$\bar{Q}_{is}$ is the average release of noble gas radionuclides in gaseous effluents, i, for long term (greater than 500 hr/yr) releases from a free standing (elevated) stack (µCi).

$(\chi/q)_s$ is the relative concentration for areas at or beyond the unrestricted area boundary for short term (equal to or less than 500 hr/yr) releases from a free standing (elevated) stack (sec/m^3).

$\bar{q}_{is}$ is the average release of noble gas radionuclides in gaseous effluents, i, for short term (equal to or less than 500 hr/yr) releases from a free standing (elevated) stack (µCi).

RECS Section 12.4.2, RSR 12.4.2.1, and Section 12.4.5, RSR 12.4.5.1 require determination of cumulative and projected beta air dose contributions due to noble gases for the current calendar quarter and the current calendar year at least once per 31 days.

Beta air dose is calculated for the sector with the highest offsite **(χ/Q)** and is compared with the RECS limit on beta air dose.

For a release attributable to a processing or effluent system shared by more than one reactor unit, the dose due to an individual unit is obtained by proportioning the effluents among the units sharing the system.

4.2.2.3 Whole Body Dose

The total (or whole) body dose, to any receiver is due, in part, to gamma radiation emitted from radioactivity in airborne effluents. This component is added to others to demonstrate compliance to the requirements of 40CFR190 and 10CFR20.

In accordance with NUREG 0133 Methodology, the total body dose component due to gamma radiation from noble gases released in gaseous effluents is calculated by the following expression:

$$D_{TB} = 3.17E\text{-}08 * t * \dot{D}_{TB} \qquad (4\text{-}6)$$

where:

D_{TB} is the total (or whole) body dose due to gamma radiation from noble gas radionuclides released in gaseous effluents (mrem)

3.17E-08 is a conversion constant (yr/sec).

t is the number of seconds in the period of interest (sec)

$\dot{D}_{TB}$ is the instantaneous dose rate to the total body due to radioactive materials (noble gasses) released in gaseous effluents from the site (mrem/yr)

The total body dose is also calculated for the 40CFR190 and 10CFR20 compliance assessments. In some cases, the total body dose may be required in 10CFR50 Appendix I assessments (See Part II Table 1-1).

4.2.2.4 Skin Dose

There is no regulatory requirement to evaluate skin dose. However, this component is evaluated for reference as there is skin dose design objective contained in 10CFR50 Appendix I. Note that in the unlikely event that if beta air dose guideline is exceeded, then the skin dose will require evaluation.

In accordance with NUREG 0133 Methodology, the part of skin dose due to noble gases released in gaseous effluents is calculated by the following expression:

$$D_{Skin} = 3.17E\text{-}08 * t * \dot{D}_{Skin} \qquad (4\text{-}7)$$

where:

D_{Skin} is the skin dose due to beta and gamma radiation from noble gas radionuclides released in gaseous effluents (mrem)

3.17E-08 is a conversion constant (yr/sec).

t is the number of seconds in the period of interest (sec)

$\dot{D}_{Skin}$ is the instantaneous dose rate to the total body due to radioactive materials (noble gasses) released in gaseous effluents from the site (mrem/yr)

4.2.3 Time Averaged Dose from Non-Noble Gas Radionuclides

RECS provides the following limits, based on 10CFR50 Appendix I, on the dose to a member of the public from specified non-noble gas radionuclides in gaseous effluents released from each reactor unit to areas at and beyond the unrestricted area boundary:

- Less than or equal to 7.5 mrem to any organ during any calendar quarter
- Less than or equal to 15 mrem to any organ during any calendar year

The individual dose components are also required as part of the 40CFR190 assessments and combined as part of the 10CFR20 assessment (Part II Table 1-1). The dose due to radionuclides deposited on the ground is considered to be a component of the deep dose equivalent for 10CFR20 and 40CFR190 compliance and an organ (and total body) dose component for 10CFR50 Appendix I compliance.

The dose is calculated for releases in the time period under consideration.

In accordance with NUREG-0133 methodology, time averaged dose from non noble gas radionuclides can be calculated using the following equation and the pathway specific "R" dose factor defined in the subsections below:

$$D^{NNG} = 3.17E\text{-}08 * \Sigma_i\{R_i[W_s * \bar{Q}_{is} + w_s * \bar{q}_{is} + W_v * \bar{Q}_{iv} + w_v * \bar{q}_{iv}]\} \quad (4\text{-}8)$$

Where:

D^{NNG} is the committed dose equivalent (CDE) due to non noble gas radionuclides in gaseous effluents (mrem)

3.17E-08 is a conversion constant (yr/sec).

R_i is the dose factor for each identified radionuclide, i (m^2*mrem*sec/yr*μCi for (D/Q) calculations, or mrem*m^3/yr*μCi for (χ/Q) calculations)

W is the dispersion parameter for estimating the dose to an individual at the controlling location for long term (greater than 500 hr/yr) releases:

W = (χ/Q) for the inhalation pathway (sec/m^3)
W = (D/Q) for the food and ground pathways (m^{-2})

$\bar{Q}_i$ is the release of radionuclides, radioactive materials in particulate form, and radionuclides other than noble gasses in gaseous effluents, i, for long term (greater than 500 hr/yr) releases (μCi).

w is the dispersion parameter for estimating the dose to an individual at the controlling location for long term (equal to or less than 500 hr/yr) releases:

w = (χ/q) for the inhalation pathway (sec/m^3)
w = (D/q) for the food and ground pathways (m^{-2})

$\bar{q}_i$ is the release of radionuclides, radioactive materials in particulate form, and radionuclides other than noble gasses in gaseous effluents, i, for short term (equal to or less than 500 hr/yr) releases (μCi).

RECS Section 12.4.3, RSR 12.4.3.1, and Section 12.4.5, RSR 12.4.5.1 require cumulative and projected dose contributions for the current calendar quarter and the current calendar year for the specified non-noble gas radionuclides in airborne effluents to be determined at least once per 31 days.

To comply with this specification, each nuclear power station obtains and analyzes samples in accordance with the radioactive gaseous waste or gaseous effluent sampling and analysis program in its RETS. For each organ of each age group considered (adult/teenager/child/infant), the dose for each pathway is calculated in every sector (except for sectors over water bodies). The calculation is based on the location assumptions discussed below in conjunction with the pathway equations. For each organ of each age group, the doses are summed in each sector over all pathways. The result for the sector with the highest total dose is compared to the limit. The values used for (X/Q) and (D/Q) are shown in Table 4-3 through Table 4-5 and correspond to the applicable pathway location.

For a release attributable to a processing or effluent system shared by more than one reactor, the dose due to an individual unit is obtained by proportioning the effluents among the units sharing the system.

The dose evaluated is also included as part of the 10CFR20 and 40CFR190 assessment (See Part II Section 5).

4.2.3.1 Ground Plane

The dose due to ground deposition of radioactivity is considered to be a total body dose component.

Dose due to the ground plane pathway can be calculated using the methodology described in 4.2.3 and the ground plane dose factor (R^G_i) defined below:

$$R^G_i = K'*K''*SF*DFG_i*(1-\exp(-\lambda_i*t))/\lambda_i \quad (4\text{-}9)$$

where:

R^G_i is the ground plane dose factor for each identified radionuclide, i (m^2*mrem*sec/yr*µCi)

K' is a constant of unit conversion = 1E+06 (pCi/µCi)

K" is a constant of unit conversion = 8760 (hr/yr)

SF is the shielding factor (dimensionless)

DFG_i is the ground plane dose conversion factor for the ith radionuclide (mrem*m^3/hr*pCi)

λ_i is the decay constant for the ith radionuclide (sec^{-1})

t is the exposure time (sec)

Note that ground plane dose factors are only given for the total body and no age group. Doses to other organs are assumed to be equal to the total body dose. All age groups are assumed to receive the same dose.

The deep dose equivalent (DDE) due to ground deposition is determined for each sector using the highest calculated offsite value of **D/Q** for that sector.

The ground plane exposure pathway is considered to exist at all locations.

4.2.3.2 Inhalation

The committed dose equivalent (CDE) due to the inhalation pathway can be calculated using the methodology described in 4.2.3 and the inhalation dose factor (R^I_i) defined below:

$$R^I_i = K'*(BR)_a*(DFA_i)_a \qquad (4\text{-}10)$$

where:

R^I_i is the inhalation dose factor for each identified radionuclide, i (mrem*m^3/yr*μCi)

K' is a constant of unit conversion = 1E+06 (pCi/μCi)

$(BR)_a$ is the breathing rate of the receptor age group (a) (m^3/yr)

$(DFA_i)_a$ is the organ inhalation dose factor for the receptor of age group (a) for the ith radionuclide (mrem/pCi)

The inhalation exposure pathway is considered to exist at all locations.

The CDE due to inhalation is determined for each sector using the highest calculated offsite value of X/Q for that sector.

4.2.3.3 Ingestion: Vegetation

Food ingestion pathway doses are calculated at locations indicated by the land use census survey. If no real pathway exists within 5 miles of the station, the cow-milk pathway is assumed to be located at 5 miles. Food pathway calculations are not made for sectors in which the offsite regions near the station are over bodies of water.

Dose due to the vegetation ingestion pathway can be calculated using the methodology described in 4.2.3 and the vegetation dose factor (R^V_i) defined below:

$$R^V_i = K'*[r/(Y_v*(\lambda_i+\lambda_w))]*DFL_{ia}*[(U^L_a*f_L*\exp(-\lambda_i*t_L)) + (U^S_a*f_g*\exp(-\lambda_i*t_h))] \quad (4\text{-}11a)$$

or in the case of tritium:

$$R^V_i = K' * K''' * [(U^L_a * f_L) + (U^S_a * f_g)] *(DFL_i)_a * [0.75(0.5/H)] \quad (4\text{-}11b)$$

or in the case of C-14:

$$R^V_i = K' * K''' * [(U^L_a * f_L) + (U^S_a * f_g)] *(DFL_i)_a * p * [0.11 / 0.16] \quad (4\text{-}11c)$$

where:

R^V_i is the vegetation dose factor for each identified radionuclide, i (m^2*mrem*sec/yr*µCi)

K' is a constant of unit conversion = 1E+06 (pCi/µCi)

r is the fraction of deposited activity retained on vegetation/grass (dimensionless)

Y_v is the vegetation areal density (kg/m^2)

λ_i is the decay constant for the ith radionuclide (sec^{-1})

λ_w is the decay constant for removal of activity on leaf and plant surfaces by weathering = 5.73E-07 (sec^{-1})

$(DFL_i)_a$ is the organ ingestion dose factor for the ith radionuclide for the receptor in age group (a) (mrem/pCi)

U^L_a is the consumption rate of fresh leafy vegetation by the receptor in age group (a) (kg/yr)

f_L is the fraction of the annual intake of fresh leafy vegetation grown locally (dimensionless)

t_L is the average time between harvest of leafy vegetation and its consumption (sec)

U^S_a is the consumption rate of stored vegetation by the receptor in age group (a) (kg/yr)

f_g is the fraction of the annual intake of stored vegetation grown locally (dimensionless)

t_h is the average time between harvest of stored vegetation and its consumption (sec)

K''' is a constant of unit conversion = 1E+03 (g/kg)

H is the absolute humidity of the atmosphere (g/m^3)

0.75 is the fraction of total feed that is water (dimensionless)

0.5 is the ratio of the specific activity of the feed water to atmospheric water (dimensionless)

p is the fractional equilibrium ratio (4400 hrs/8760 hrs). The ratio of total annual release time (for C-14 atmospheric releases) to the total annual time during which photosynthesis occurs (taken to be 4400 hrs), under the condition that the value of p should never exceed unity. For continuous C-14 releases, p is taken to be unity.

0.11 is the fraction of total plant mass that is natural carbon (dimensionless)

0.16 is the concentration of natural carbon in the atmosphere (g/m^3)

4.2.3.4 Ingestion: Milk

Dose due to the milk ingestion pathway can be calculated using the methodology described in 4.2.3 and the milk dose factor (R^C_i) defined below:

$$R^C_i = K'*((Q_F*U_{ap})/(\lambda_i+\lambda_w))*F_m*r*(DFL_i)_a*[((f_p*f_s)/Y_p) + (((1-f_p*f_s)*exp(-\lambda_i*t_h))/Y_s)]*exp(-\lambda_i*t_f) \quad (4\text{-}12a)$$

or in the case of tritium:

$$R^C_i = K'*K'''*F_m*Q_F*U_{ap}*(DFL_i)_a*[0.75(0.5/H)] \quad (4\text{-}12b)$$

or in the case of C-14:

$$R^C_i = K' * K''' * F_m * Q_F * U_{ap} * (DFL_i)_a * p * [0.11 / 0.16] \quad (4\text{-}12c)$$

where:

R^C_i is the milk dose factor for each identified radionuclide, i (m^2*mrem*sec/yr*µCi or mrem*m^3/yr*µCi)

K' is a constant of unit conversion = 1E+06 (pCi/µCi)

QF	is the animal's consumption rate (kg/day, wet weight)
Uap	is the receptor's milk consumption rate for age group (a) (L/yr)
λi	is the decay constant for the ith radionuclide (sec-1)
λ_w	is the decay constant for removal of activity on leaf and plant surfaces by weathering = 5.73E-07 (sec^{-1})
F_m	is the stable element transfer coefficient (day/L)
r	is the fraction of deposited activity retained on vegetation/grass (dimensionless)
$(DFL_i)_a$	is the organ ingestion dose factor for the ith radionuclide for the receptor in age group (a) (mrem/pCi)
f_p	is the fraction of the year that the animal is on pasture (dimensionless)
f_s	is the fraction of the feed that is pasture grass while the animal is on pasture (dimensionless)
Y_p	is the agricultural productivity by unit area of pasture feed grass (kg/m2)
t_h	is the transport time from pasture, to harvest, to animal, to milk, to receptor (sec)
Y_s	is the agricultural productivity by unit area of stored feed (kg/m^2)
t_f	is the transport time from pasture, to animal, to milk, to receptor (sec)
K'''	is a constant of unit conversion = 1E+03 (g/kg)
H	is the absolute humidity of the atmosphere (g/m^3)
0.75	is the fraction of total feed that is water (dimensionless)
0.5	is the ratio of the specific activity of the feed water to atmospheric water (dimensionless)
p	is the fractional equilibrium ratio (4400 hrs/8760 hrs). The ratio of total annual release time (for C-14 atmospheric releases) to the total annual time during which photosynthesis occurs (taken to be 4400 hrs), under the condition that the value of p should never exceed unity. For continuous C-14 releases, p is taken to be unity.

0.11 is the fraction of total plant mass that is natural carbon (dimensionless)

0.16 is the concentration of natural carbon in the atmosphere (g/m^3)

4.2.3.5 Ingestion: Meat

Dose due to the meat ingestion pathway can be calculated using the methodology described in 4.2.3 and the meat dose factor (R^M_i) defined below:

$$R^M_i = K'*((Q_F*U_{ap})/(\lambda_i+\lambda_w))*F_f*r*DFL_{ia}*[((f_p*f_s)/Y_p) + (((1-f_p*f_s)*\exp(-\lambda_i*t_h))/Y_s)]*\exp(-\lambda_i*t_f) \quad (4\text{-}13a)$$

or in the case of tritium:

$$R^M_i = K' * K''' * F_f * Q_F * U_{ap} * (DFL_i)_a * [0.75(0.5/H)] \quad (4\text{-}13b)$$

or in the case of C-14:

$$R^M_i = K' * K''' * F_f * Q_F * U_{ap} * (DFL_i)_a * p *[0.11 / 0.16] \quad (4\text{-}13c)$$

where:

R^M_i is the meat dose factor for each identified radionuclide, i (m^2*mrem*sec/yr*µCi)

K' is the animal's consumption rate (kg/day, wet weight)

QF is the animal's consumption rate (kg/day, wet weight)

U_{ap} is the receptor's meat consumption rate for age group (a) (kg/yr)

λi is the decay constant for the ith radionuclide (sec-1)

λ_w is the decay constant for removal of activity on leaf and plant surfaces by weathering = 5.73E-07 (sec^{-1})

F_f is the stable element transfer coefficient (day/kg)

r is the fraction of deposited activity retained on vegetation/grass (dimensionless)

$(DFL_i)_a$ is the organ ingestion dose factor for the ith radionuclide for the receptor in age group (a) (mrem/pCi)

f_p is the fraction of the year that the animal is on pasture (dimensionless)

f_s is the fraction of the feed that is pasture grass while the animal is on pasture (dimensionless)

Y_p is the agricultural productivity by unit area of pasture feed grass (kg/m^2)

t_h is the transport time from crop field to receptor (sec)

Y_s is the agricultural productivity by unit area of stored feed (kg/m^2)

t_f is the transport time from pasture to receptor (sec)

K''' is a constant of unit conversion = 1E+03 (g/kg)

H is the absolute humidity of the atmosphere (g/m^3)

0.75 is the fraction of total feed that is water (dimensionless)

0.5 is the ratio of the specific activity of the feed water to atmospheric water (dimensionless)

p is the fractional equilibrium ratio (4400 hrs/8760 hrs). The ratio of total annual release time (for C-14 atmospheric releases) to the total annual time during which photosynthesis occurs (taken to be 4400 hrs), under the condition that the value of p should never exceed unity. For continuous C-14 releases, p is taken to be unity.

0.11 is the fraction of total plant mass that is natural carbon (dimensionless)

0.16 is the concentration of natural carbon in the atmosphere (g/m^3)

Table 4-1

Critical Ranges

Direction	Unrestricted Area Boundary[a] (m)	Restricted Area Boundary (m)	Nearest Resident[b] (m)	Nearest Dairy Farm within 5 miles[c] (m)
N	1036	1036	6300	None
NNE	1378	1378	2575	None
NE	2408	1609	3400	None
ENE	4450	1079	5300	None
E	1996	833	5200	None
ESE	1465	845	2300	None
SE	969	969	2700	None
SSE	838	698	2900	None
S	829	620	2400	None
SSW	835	835	1100	None
SW	628	628	1600	None
WSW	533	533	2400	None
W	524	524	2400	None
WNW	643	643	1400	None
NW	762	762	2900	None
NNW	890	890	2700	None

a Used in calculating the meteorological dose factors in Tables 4-3, 4-4, 4-6, and 4-7.

b The distances are rounded to the nearest conservative 100 meters.

c Used in calculating the D/Q values in Table 4-5. The distances are rounded to the nearest conservative 100 meters. A default value of 8000 meters is used when there are no dairies within 5 miles.

Table 4-2

Average Wind Speeds

Downwind Direction	Average Wind Speed (m/sec)[a]		
	Elevated	Vent	Ground Level
N	9.7	7.7	4.9
NNE	10.1	8.0	5.1
NE	9.2	7.4	4.9
ENE	9.0	7.2	4.8
E	9.5	7.8	5.2
ESE	9.7	8.4	5.9
SE	8.1	7.4	5.9
SSE	7.4	8.7	5.0
S	6.7	5.9	4.3
SSW	5.6	3.7	2.9
SW	5.5	4.1	3.1
WSW	6.9	5.4	3.9
W	7.6	6.5	4.5
WNW	7.5	6.3	4.3
NW	7.5	6.2	3.9
NNW	8.3	6.7	4.3

[a] Based on LaSalle site meteorological data, January 1978 through December 1987. See Sargent & Lundy, Analysis and Technology Division, LaSalle calculation no. ATD-0164, revisions 0, 1, 2, and 3.

Table 4-3

X/Q and D/Q Maxima at or Beyond the Unrestricted Area Boundary

	Ground Level Release			Mixed Mode (Vent)			Elevated (Stack)			
Direction	Distance (meters)	X/Q (sec/m3)	D/Q (m-2)	Distance (meters)	X/Q (sec/m3)	D/Q (m-2)	Distance (meters)	X/Q (sec/m3)	Distance (meters)	D/Q (m-2)
N	1036	1.43E-06	9.09E-09	1036	4.73E-07	5.23E-09	6437	5.15E-09	1609	3.97E-10
NNE	1378	9.84E-07	6.85E-09	1378	4.01E-07	4.38E-09	5633	6.21E-09	1609	5.08E-10
NE	2408	4.43E-07	2.72E-09	2408	2.13E-07	1.81E-09	5633	6.42E-09	2408	1.74E-10
ENE	4450	1.70E-07	7.55E-10	4450	8.62E-08	4.89E-10	5633	5.38E-09	4450	1.53E-10
E	1996	5.52E-07	3.45E-09	1996	2.29E-07	2.24E-09	5633	6.60E-09	1996	1.84E-10
ESE	1465	9.07E-07	7.12E-09	1465	3.78E-07	4.92E-09	5633	8.46E-09	1609	6.75E-10
SE	969	1.05E-06	8.48E-09	969	3.80E-07	5.16E-09	5633	8.16E-09	1609	6.70E-10
SSE	838	1.16E-06	1.09E-08	838	4.68E-07	7.21E-09	6437	5.76E-09	1609	4.57E-10
S	829	1.40E-06	9.82E-09	829	3.76E-07	4.69E-09	6437	5.71E-09	1609	4.51E-10
SSW	835	1.21E-06	8.31E-09	835	3.00E-07	3.58E-09	6437	5.50E-09	1609	4.13E-10
SW	628	1.32E-06	1.32E-08	628	5.01E-07	8.29E-09	5633	6.52E-09	1609	5.47E-10
WSW	533	1.59E-06	1.70E-08	533	6.77E-07	1.13E-08	6437	6.13E-09	1609	4.80E-10
W	524	3.29E-06	2.33E-08	524	9.40E-07	1.13E-08	6437	4.32E-09	1609	2.99E-10
WNW	643	2.22E-06	1.26E-08	643	5.31E-07	5.80E-09	6437	3.41E-09	1609	2.53E-10
NW	762	1.88E-06	9.48E-09	762	4.33E-07	4.12E-09	7242	3.03E-09	1609	2.07E-10
NNW	890	1.63E-06	8.40E-09	890	4.18E-07	3.90E-09	7242	3.38E-09	1609	2.30E-10

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Table 4-4

X/Q and D/Q Maxima at or Beyond the Restricted Area Boundary

Direction	Ground Level Release			Mixed Mode (Vent)			Elevated (Stack)			
	Distance (meters)	X/Q (sec/m3)	D/Q (m-2)	Distance (meters)	X/Q (sec/m3)	D/Q (m-2)	Distance (meters)	X/Q (sec/m3)	Distance (meters)	D/Q (m-2)
N	1036	1.43E-06	9.09E-09	1036	4.73E-07	5.23E-09	6437	5.15E-09	1609	3.97E-10
NNE	1378	9.84E-07	6.85E-09	1378	4.01E-07	4.38E-09	5633	6.21E-09	1609	5.08E-10
NE	1609	7.99E-07	5.44E-09	1609	3.48E-07	3.53E-09	5633	6.42E-09	1609	5.43E-10
ENE	1079	1.28E-06	8.67E-09	1079	4.49E-07	5.11E-09	5633	5.38E-09	1609	4.62E-10
E	833	2.13E-06	1.50E-08	833	6.95E-07	9.04E-09	5633	6.60E-09	1609	5.23E-10
ESE	845	2.14E-06	1.78E-08	845	7.66E-07	1.18E-08	5633	8.46E-09	1609	6.75E-10
SE	969	1.05E-06	8.48E-09	969	3.80E-07	5.16E-09	5633	8.16E-09	1609	6.70E-10
SSE	698	1.52E-06	1.46E-08	698	5.88E-07	9.45E-09	6437	5.76E-09	1609	4.57E-10
S	620	2.16E-06	1.56E-08	620	5.25E-07	6.94E-09	6437	5.71E-09	1609	4.51E-10
SSW	835	1.21E-06	8.31E-09	835	3.00E-07	3.58E-09	6437	5.50E-09	1609	4.13E-10
SW	628	1.32E-06	1.32E-08	628	5.01E-07	8.29E-09	5633	6.52E-09	1609	5.47E-10
WSW	533	1.59E-06	1.70E-08	533	6.77E-07	1.13E-08	6437	6.13E-09	1609	4.80E-10
W	524	3.29E-06	2.33E-08	524	9.40E-07	1.13E-08	6437	4.32E-09	1609	2.99E-10
WNW	643	2.22E-06	1.26E-08	643	5.31E-07	5.80E-09	6437	3.41E-09	1609	2.53E-10
NW	762	1.88E-06	9.48E-09	762	4.33E-07	4.12E-09	7242	3.03E-09	1609	2.07E-10
NNW	890	1.63E-06	8.40E-09	890	4.18E-07	3.90E-09	7242	3.38E-09	1609	2.30E-10

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Table 4-5 (Page 1 of 2)

X/Q and D/Q at the Nearest Meat Animal Locations Within 5 Miles

Direction	Distance		Ground Level Release		Mixed Mode (Vent)		Elevated (Stack)	
			X/Q	D/Q	X/Q	D/Q	X/Q	D/Q
	miles	meters	(sec/m3)	(m-2)	(sec/m3)	(m-2)	(sec/m3)	(m-2)
N	4.0	6400	1.11E-07	3.87E-10	5.69E-08	2.45E-10	5.15E-09	1.12E-10
NNE	1.7	2800	3.54E-07	2.03E-09	1.70E-07	1.35E-09	4.33E-09	3.44E-10
NE	3.5	5600	1.43E-07	6.19E-10	8.01E-08	4.21E-10	6.42E-09	1.75E-10
ENE	3.8	6116	1.11E-07	4.29E-10	6.01E-08	2.81E-10	5.39E-09	1.37E-10
E	5.0	8000	8.34E-08	2.99E-10	4.69E-08	2.05E-10	6.25E-09	1.07E-10
ESE	5.0	8000	8.37E-08	3.64E-10	5.10E-08	2.71E-10	7.82E-09	1.41E-10
SE	4.7	7600	5.41E-08	2.39E-10	3.66E-08	1.67E-10	7.71E-09	1.54E-10
SSE	4.7	7600	4.46E-08	2.41E-10	3.32E-08	1.93E-10	5.58E-09	1.06E-10
S	4.7	7600	5.45E-08	2.14E-10	3.86E-08	1.45E-10	5.60E-09	1.01E-10
SSW	5.0	8000	4.39E-08	1.67E-10	3.27E-08	1.10E-10	5.38E-09	8.37E-11
SW	5.0	8000	3.02E-08	1.69E-10	2.44E-08	1.37E-10	6.20E-09	1.11E-10
WSW	1.5	2400	1.69E-07	1.40E-09	1.10E-07	1.10E-09	2.75E-09	4.02E-10
W	3.0	4800	1.25E-07	5.58E-10	7.21E-08	3.33E-10	3.97E-09	1.34E-10
WNW	3.0	4800	1.15E-07	4.14E-10	5.35E-08	2.33E-10	3.17E-09	1.09E-10
NW	4.0	6400	8.73E-08	2.46E-10	4.06E-08	1.30E-10	3.02E-09	6.37E-11
NNW	4.6	7403	8.11E-08	2.15E-10	3.83E-08	1.16E-10	3.38E-09	5.50E-11

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Table 4-5 (Page 2 of 2)

X/Q and D/Q at the Nearest Milk Cow Locations Within 5 Miles

Direction	Distance		Ground Level Release		Mixed Mode (Vent)		Elevated (Stack)	
			X/Q	D/Q	X/Q	D/Q	X/Q	D/Q
	miles	meters	(sec/m3)	(m-2)	(sec/m3)	(m-2)	(sec/m3)	(m-2)
N	5.0	8000	8.26E-08	2.59E-10	4.43E-08	1.65E-10	4.96E-09	7.82E-11
NNE	5.0	8000	8.80E-08	3.16E-10	5.06E-08	2.15E-10	5.82E-09	9.32E-11
NE	5.0	8000	8.95E-08	3.27E-10	5.28E-08	2.24E-10	6.05E-09	1.01E-10
ENE	5.0	8000	7.76E-08	2.65E-10	4.42E-08	1.75E-10	5.12E-09	8.92E-11
E	5.0	8000	8.34E-08	2.99E-10	4.69E-08	2.05E-10	6.25E-09	1.07E-10
ESE	5.0	8000	8.37E-08	3.64E-10	5.10E-08	2.71E-10	7.82E-09	1.41E-10
SE	5.0	8000	5.03E-08	2.17E-10	3.44E-08	1.53E-10	7.56E-09	1.41E-10
SSE	5.0	8000	4.14E-08	2.20E-10	3.11E-08	1.76E-10	5.49E-09	9.73E-11
S	5.0	8000	5.06E-08	1.95E-10	3.62E-08	1.33E-10	5.52E-09	9.30E-11
SSW	5.0	8000	4.39E-08	1.67E-10	3.27E-08	1.10E-10	5.38E-09	8.37E-11
SW	5.0	8000	3.02E-08	1.69E-10	2.44E-08	1.37E-10	6.20E-09	1.11E-10
WSW	5.0	8000	2.86E-08	1.67E-10	2.33E-08	1.38E-10	5.89E-09	1.01E-10
W	5.0	8000	6.20E-08	2.24E-10	4.01E-08	1.36E-10	4.25E-09	6.30E-11
WNW	5.0	8000	5.82E-08	1.66E-10	3.07E-08	9.52E-11	3.35E-09	5.15E-11
NW	5.0	8000	6.52E-08	1.64E-10	3.20E-08	8.77E-11	2.99E-09	4.45E-11
NNW	5.0	8000	7.34E-08	1.87E-10	3.53E-08	1.01E-10	3.34E-09	4.83E-11

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