ZION ANNEX INDEX

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CHAPTER 10

RADIOACTIVE EFFLUENT TREATMENT AND MONITORING

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RADIOACTIVE EFFLUENT TREATMENT AND MONITORING

10.1 AIRBORNE RELEASES

10.1.1 System Description

A simplified gaseous radwaste and gaseous effluent flow diagram is provided in Figure 10-1. The principal release points for potentially radioactive airborne effluents are the two auxiliary building vent stacks (designated Unit 1 Vent Stack and Unit 2 Vent Stack in Figure 10-1). In the classification scheme of Section 4.1.4, each is classified as a ground level release point (see Table A-1 of Appendix A).

10.1.1.1 Waste Gas Holdup System

The waste gas holdup system is designed and installed to reduce radioactive gaseous effluents by collecting reactor coolant system off-gases from the reactor coolant system and providing for delay or holdup to reduce the total radioactivity by radiodecay prior to release to the environment. The system is described in Section 11.1.2.3 of the Zion FSAR.

10.1.1.2 Ventilation Exhaust Treatment System

Ventilation exhaust treatment systems are designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in gaseous effluents 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 10-1.

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

10.1.2 Radiation Monitors

10.1.2.1 Final Vent Stack Effluent Monitors

Monitors 1RIA-PR49 (Unit 1) and 2RIA-PR49 (Unit 2) continuously monitor the final effluent from the auxiliary building vent stacks. Both vent stack monitors feature automatic isokinetic sampling and grab sampling.

In normal operation all three noble gas channels (low, mid-range, high) are on line and active. On a high alarm from the mid-and/or high range channels the particulate, iodine, low range noble gas and mid-range noble gas channels are isolated, and only the high range noble gas channel remains active.

No automatic isolation or control functions are performed by these monitors. On high alarm, the control room operator will notify the health physics group and reduce the release rate as appropriate. Because of the conservatism built into the setpoint calculations (Section 10.1.3), there is an adequate margin between the setpoint and release limit to accommodate this procedure.

Pertinent information on these monitors is provided in UFSAR Table 11.5-1.

10.1.2.2 Auxiliary Building Vent Effluent Monitors

Monitors 1RT-PR25 (Unit 1), 2RT-PR25 (Unit 2) and ORE-0014 (common) continuously monitor the effluent from the auxiliary building vent fans.

No automatic isolation or control functions are performed by these monitors. On high alarm, the control room operator will notify the health physics group and reduce the release rate as appropriate. Because of the conservatism built into the setpoint calculations (Section 10.1.3) there is an adequate margin between the setpoint and release limit to accommodate this procedure.

Pertinent information on monitor 0RE-0014 is provided in UFSAR Table 11.5-2.

10.1.2.3 Containment Purge Effluent Monitors

Monitors 1RT-PR09 (Unit 1) and 2RT-PR09 (Unit 2) continuously monitor the effluent from the Unit 1

and Unit 2 containments, respectively. On high alarm, the monitors automatically initiate closure of the four air-operated butterfly valves (RV0001/2/3/4 purge valves for each unit).

Pertinent information on these monitors is provided in UFSAR Tables 11.5-1 and 11.5-2. Monitors 1(2)RIA-PR40 continuously monitor the Unit 1(2) atmosphere. On high alarm, the monitors automatically initiate closure of valves RV0001-RV0006 inclusive.

10.1.2.4 Waste Gas Decay Tank Monitors

Monitors 0RT-PR10A/B continuously monitor the noble gas activity released from the gas decay tanks.

On high alarm, the monitors automatically initiate closure of the valve 0RCV-WG014 thus terminating the release.

Pertinent information on these monitors is provided in UFSAR Table 11.5-2.

10.1.2.5 Condenser Air Ejector Monitors

Monitors 1RE-0015 and 2RE-0015 continuously monitor the condenser air ejector gas from Units 1 and 2, respectively. No control device is initiated by these channels.

Pertinent information on these monitors is provided in UFSAR Table 11.5-2.

10.1.2.6 Service Building Ventilation Monitor

Monitor 0RT-PR22 continuously monitors noble gas activity in the service building ventilation system. No control device is initiated by this channel.

Pertinent information on this monitor is provided in UFSAR Table 11.5-2.

10.1.2.7 Miscellaneous Ventilation Monitors

Monitor 0RT-PR18B continuously monitors noble gas activity in the ventilation exhaust from the auxiliary equipment room, computer room, laboratories, decontamination room and other miscellaneous areas. No control device is initiated by this channel.

Pertinent information on this monitor is provided in UFSAR Table 11.5-2.

10.1.3 Alarm and Trip Setpoints

10.1.3.1 Setpoint Calculation

The effluent noble gas monitor setpoints are conservatively based on the assumption that a release is occurring simultaneously for all seven gaseous release points at the maximum expected flow rate for each pathway. Furthermore, the setpoints are chosen such that an occurrence of simultaneous high alarms on all seven pathways would correspond to a station release rate of one half of the RETS limit.

$$P_{MP} \leq 0.5 \times Q_{tv} \times 1/F^{P} \times K^{P} \times C^{M} \quad (10\text{-}1)$$

P_{MP} = Setpoint for monitor, M, on release path, P [cpm]

0.5 = Factor to reduce release rate by 50%.

Q_{tv} = Total Allowed Release Rate, Vent Release [µCi/sec]

F^{P} = Flow rate through Release Path, P. [cc/sec]

K^{P} = Factor to apportion a fraction of the total release rate, Q_{tv}, to release path, P.

C^{M} = Conversion Factor for monitor, M [cpm per µCi/cc]

10.1.3.2 Release Limits

Alarm and trip setpoints of gaseous effluent monitors are established to ensure that the release rate limits of the RETS Section 12.4 are not exceeded. The release limits are found by solving Equations 10-2 and 10-3 for the total allowed release rate of vent releases, Q_{tv}.

$$(1.11)Q_{tv} \sum (\overline{V_i} f_i) < 500^{b}\ mrem/yr \quad (10\text{-}2)$$

$$Q_{tv} \sum \{ (f_i) [\overline{L_i}(X/Q)_v \exp(-\lambda_i R/3600u_v) + 1.11\ V_i] \} < 3000^{b} mrem/yr \quad (10\text{-}3)$$

b Upon Technical Specification (TS) approval (submittal dated Nov. 10,1993), this value may be used. Prior to TS approval, section 6.2 of TS's specify the valid limits.

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.

Q_{tv} Total Allowed Release Rate, Vent Release [µCi/sec]

The total allowed release rate of all noble gas radionuclides released as vent releases.

The remaining parameters in Equation 10-2 have the same definitions as in Equation A-8 of Appendix A. The remaining parameters in Equation 10-3 have the same definition as in Equation A-9 of Appendix A.

Equation 10-2 is based on Equation A-8 of Appendix A and the RETS restriction on whole body dose rate (500[b] mrem/yr) due to noble gases released in gaseous effluents (see Section A.1.3.1 of Appendix A). Equation 10-3 is based on Equation A-9 of Appendix A and the RETS restriction on skin dose rate (3000 mrem/yr) due to noble gases released in gaseous effluents (see Section A.1.3.2 of Appendix A).

Equations 10-2 and 10-3 can each be solved for a value of Q_{tv}. The monitor alarm and trip setpoints will be established based on the equation which yields the smaller release limit, Q_{tv}. The exact settings are selected to ensure that RETS limits are not exceeded.

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

10.1.3.3 Release Mixture

In the determination of alarm and trip setpoints, the radioactivity mixture in exhaust air is assumed to have the radionuclide composition of Table 10-1. This mixture was conservatively chosen based on station isotopic release data averaged over a period of 7 years (1977 through June 1984).

10.1.3.4 Conversion Factors

The response curves used to determine the monitor count rates are chosen in order to best match the reference noble gas mix.

Example curves are shown in Figure 10-5.

10.1.3.5 HVAC Flow Rates

HVAC flow rates are computed for 1(2)RT-PR25, ORE-0014 and 1(2)RIA-PR49 based on the number of operating fans in the monitored flow path.

$$F_M = \sum_p \sum_i F_{ip} \times N_i \qquad (10\text{-}4)$$

F_M = Total Flow In Monitored Flow Path [cc/sec]

F_{ip} = Flow from fan i in path p. [cc/sec]

N_i = Number of fans, in operation

The maximum flow for each fan is used for setpoint calculations because this maximizes the flow, and therefore minimizes the calculated monitor sensitivity which is conservative.

Pertinent data for the fans is provided in Table 10-2.

HVAC flows for the remaining monitors are conservatively fixed at upper bound values. They are listed below.

Monitor	Flow in cc/sec
ORT-PR10A/B	6.60E5
1(2)RE-0015	7.32E5
ORT-PR22	5.96E6
1RT-PR09A	1.65E6 (vent mode)
"	1.46E6 (mini-purge mode)
"	1.46E7 (purge mode)
2RT-PR09A	4.35E6 (vent mode)*
"	4.11E6 (mini-purge mode)
"	1.99E7 (purge-mode)
"	2.70E6 (routine, hot lab only)

*Flow greater than Unit 1 due to "hot lab" hood exhaust fan flow.

10.1.4 Allocation of Effluents from Common Release Points

Radioactive gaseous effluents released from the auxiliary building miscellaneous ventilation system and the gas decay tanks are comprised of contributions from both units. Under normal operating conditions, it is difficult to apportion the radioactivity between the units. Consequently, allocation normally is made evenly between units.

10.1.5 Dose Projections for Batch Releases

The 10CFR20 dose limits have been converted into a station administrative release rate limit using the methodology in the ODCM. Compliance is verified prior to release by determining that the release rate of the batch release is within the above limits. Compliance is also verified through conservative radiation monitor setpoints which have been set in accordance with the methodology of the ODCM and RETS dose limits. Per procedure, representative samples are obtained and analyzed, and the doses are calculated on a monthly basis to verify compliance with 10CFR50.

10.2 LIQUID RELEASES

10.2.1 System Description

A simplified liquid waste processing diagram is provided in Figure 10-2. A simplified liquid effluent flow diagram is provided in Figure 10-3.

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 demineralizer for the purpose of reducing the total radioactivity prior to release to the environment. The system is described in Section 11.1.3 of the Zion FSAR.

10.2.1.1 Lake Discharge Tanks

There are two lake discharge tanks (0A and 0B, 30,000-gallon capacity each) which receive liquid waste before discharge to Lake Michigan.

10.2.1.2 Turbine Building Fire Sump

The turbine building floor and equipment drain tanks receive turbine building waste which is released to the fire sump for processing by the waste water treatment facility and ultimate discharge into Lake Michigan. The discharge constitutes a low level radioactive release.

10.2.2 Radiation Monitors

10.2.2.1 Lake Discharge Tank Monitors

Monitors 0RT-PR04 and 0RT-PR05 are used to monitor all releases from the lake discharge tanks. On high alarm, the monitor automatically initiates closure of a valve to prevent further releases. The valve is located over 250 feet downstream of the monitor to allow closure prior to exceeding release limits. The monitor setpoints are found by solving Equation 10-5 for release setpoint P.

Pertinent information on these monitors is provided in UFSAR Table 11.5-3.

10.2.2.2 Turbine Building Fire Sump Monitor

Monitor 0RT-PR25 continuously monitors the discharge line from the fire sump pumps to the waste water treatment facility. On high alarm, the monitor automatically trips all of the fire sump pumps, thereby containing the liquid in the turbine building. The monitor setpoints are found by solving Equation 10-5 for release setpoint P.

Pertinent information on the monitor is provided in UFSAR Table 11.5-3.

10.2.3 Alarm and Trip Setpoints

10.2.3.1 Setpoint Calculation

Alarm and trip setpoints of liquid effluent monitors at the principal release points are established to ensure that the limits of the RETS are not exceeded in the unrestricted area. The monitor setpoints are found by solving Equation 10-5 for a conservative mixture of radionuclides found in liquid effluents.

$$P \leq K \times C^{M} \times (10^{n} * DWC_{i})(F^{d}/F^{i}) \qquad (10\text{-}5)$$

P Release Setpoint [µCi/mL]

The alarm setpoint for radioactivity to be released in liquid effluents.

DWC_i Derived Water Concentration of radionuclide i [µCi/mL]

The concentration of radionuclide i given in Table 2 of Appendix B to §§ 20.1001 - 20.2401.

Upon Technical Specification (TS) approval (submittal dated Nov. 10,1993), the "10" may be used. Prior to TS approval, TS section 6.2 specifies the valid limits.

C^M Conversion Factor for monitor M to µCi/ml

C^M = 1, unless monitor is in units of cpm then conversion is needed from µCi/ml.

10 Multiplier

F^d Dilution Flow Rate [gpm]

The flow rate of the radwaste dilution stream (condenser cooling water).

F^r Discharge Flow Rate [gpm]

The flow rate from the lake discharge tank or fire sump as appropriate.

K Factor of conservatism.
K ≤ 1.0

10.2.3.2 Discharge Flow Rates

10.2.3.2.1 Lake Discharge Tank Discharge Flow Rate

Prior to each batch release, the water is recirculated, sampled, and analyzed.

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

$$F^r_{max} = (10^a * DWC_i)(F^d_{act}/C) \quad (10\text{-}6)$$

F^r_{max} Maximum Permitted Discharge Flow Rate [gpm]

The maximum permitted flow rate from the lake discharge tank. [gpm]

F^d_{act} Actual Dilution Flow Rate [gpm]

The actual flow rate of the radwaste dilution stream (based on pump curves).

C Sample Radioactivity Concentration [µCi/mL]

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

Upon Technical Specification (TS) approval (submittal dated Nov. 10,1993), the "10" may be used. Prior to TS approval, TS section 6.2 specifies the valid limits.

DWC_i Derived Water Concentration of radionuclide i [µCi/mL]

The concentration of radionuclide i given in Table 2 of Appendix B to §§ 20.1001 - 20.2401.

10 Multiplier

10.2.3.2.2 Turbine Building Fire Sump Discharge Flow Rate

This release path is a continuous discharge. Consequently, the release rate F^r in Equation 10-6 is set equal to maximum design capacity for the pumps on the effluent of the waste water treatment facility.

10.2.3.3 Release Limits

Release limits are determined from RETS.

10.2.3.4 Release Mixture

The release mixture used for setpoint determination is the worst case radionuclide mix chosen on the basis of station isotopic analysis data.

10.2.3.5 Conversion Factors

The conversion factor for ORT-PR25 (fire sump monitor) is based on detector response curves for I-131. The conversion factors for monitor ORT-PR04 and ORT-PR05 are based on detector response curves for Cs-137.

10.2.3.6 Liquid Dilution Flow Rates

Dilution flow rates are computed based on the number of operating pumps in the flow path.

$$P^d = \sum F_i^d \times N_i \qquad (10\text{-}7)$$

P^d = Dilution Flow Rate [gpm]

F_i^d = Dilution Flow Rate from pump i [gpm]

N_i = Number of pumps of type i operating

Pertinent flow data for the pumps is provided in Table 10-3.

10.2.4 Allocation of Effluents from Common Release Points

Radioactive liquid effluents released from the lake discharge tank and turbine building fire sump are comprised of contributions from both units. Under normal operating conditions, it is difficult to apportion the radioactivity between the units. Consequently, allocation is based on the unit discharge canal used for dilution.

10.2.5 Projected Concentrations for Releases

Projected concentrations are calculated before initiating liquid discharges. Per procedure, a representative sample is obtained and analyzed and the projected concentrations are calculated using conservative dilution flows prior to release. Because the fire sump is a continuous release, it is sampled daily and isotopic analyses are performed weekly.

Doses due to liquid effluents are calculated as required by the RETS.

10.3 SOLIDIFICATION OF WASTE/PR0CESS 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.

Table 10-1

Assumed Composition of the Zion Station
Noble Gas Effluent

Isotope	Percent of Effluent
Ar-41	1.92E-1
Kr-83m	1.0E-4
Kr-85m	2.24E-1
Kr-85	5.50E-2
Kr-87	1.22
Kr-88	3.19
Kr-89	1.0E-4
Xe-131m	1.85
Xe-133m	7.56E-1
Xe-133	8.36E1
Xe-135m	1.03E-1
Xe-135	8.79
Xe-137	1.0E-4
Xe-138	4.37E-3

Note: Based on station isotopic release data averaged over 7 years (1977 through June 1984).

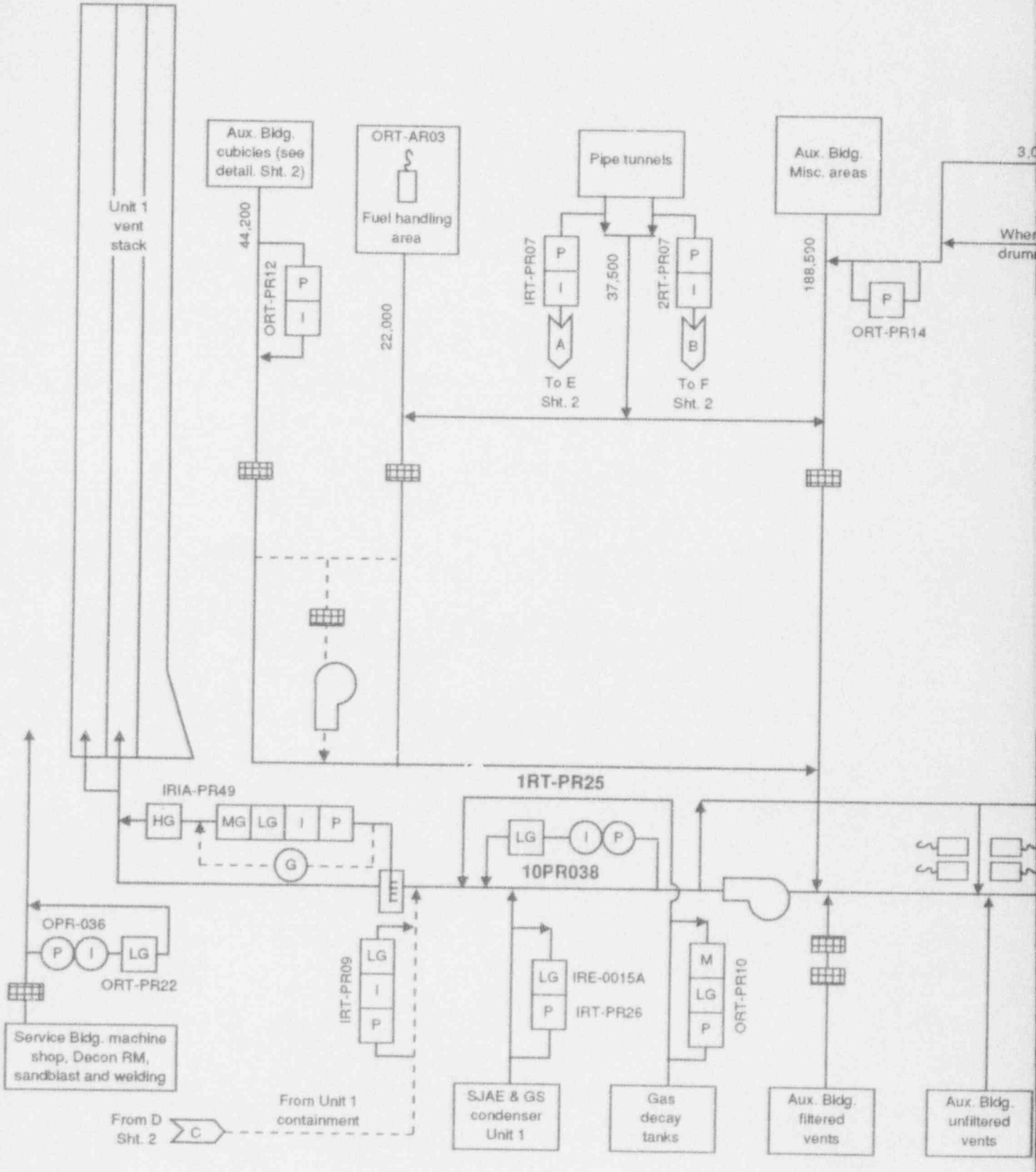
TABLE 10-2
HVAC EXHAUST FAN CAPACITIES

FAN	CC/SEC	CFM	CFH
#1 Aux. Bldg			
0A Exh. Fan	3.16×10^{7}	6.70×10^{4}	4,020,000
0B Exh. Fan	3.16×10^{7}	6.70×10^{4}	4,020,000
0C Exh. Fan	3.16×10^{7}	6.70×10^{4}	4,020,000
#2 Aux. Bldg.			
0D Exh. Fan	3.16×10^{7}	6.70×10^{4}	4,020,000
0E Exh. Fan	3.16×10^{7}	6.70×10^{4}	4,020,000
0F Exh. Fan	3.16×10^{7}	6.70×10^{4}	4,020,000
#1 Purge Exh.			
1A Purge Fan	1.46×10^{7}	3.10×10^{4}	1,860,000
1B Purge Fan	1.46×10^{7}	3.10×10^{4}	1,860,000
H_2 Purge Fan 1A	1.70×10^{5}	3.60×10^{2}	21,600
H_2 Purge Fan 1B	1.75×10^{5}	3.40×10^{2}	22,200
Mini Purge	1.46×10^{6}	3.09×10^{3}	185,600
#2 Purge Exh.			
2A Purge Fan	1.65×10^{7}	3.50×10^{4}	2,1[illegible]400
2B Purge Fan	1.72×10^{7}	3.65×10^{4}	2,1[illegible]800
H_2 Purge Fan 2A	1.82×10^{5}	3.85×10^{2}	23,100
H_2 Purge Fan 2B	1.75×10^{5}	3.71×10^{2}	22,260
Hot Lab Exh. 0A	1.50×10^{6}	3.18×10^{3}	191,000
Hot Lab Exh. 0B	1.18×10^{6}	2.51×10^{3}	150,600
Mini Purge	1.42×10^{6}	3.01×10^{3}	181,000
Misc. Exh.			
Comp & Misc. Exh. 0A	2.81×10^{6}	5.95×10^{3}	357,000
Comp & Misc. Exh 0B	2.81×10^{6}	5.95×10^{3}	357,000
Ser. Bldg.			
Decon. Rm. Exh.	1.91×10^{6}	4.04×10^{3}	242,580
Welding Rm. Exh.	1.09×10^{6}	2.30×10^{3}	138,000
Sandblast Rm. Exh.	9.44×10^{5}	2.00×10^{3}	120,000
Cave Exh.	6.14×10^{5}	1.30×10^{3}	78,000

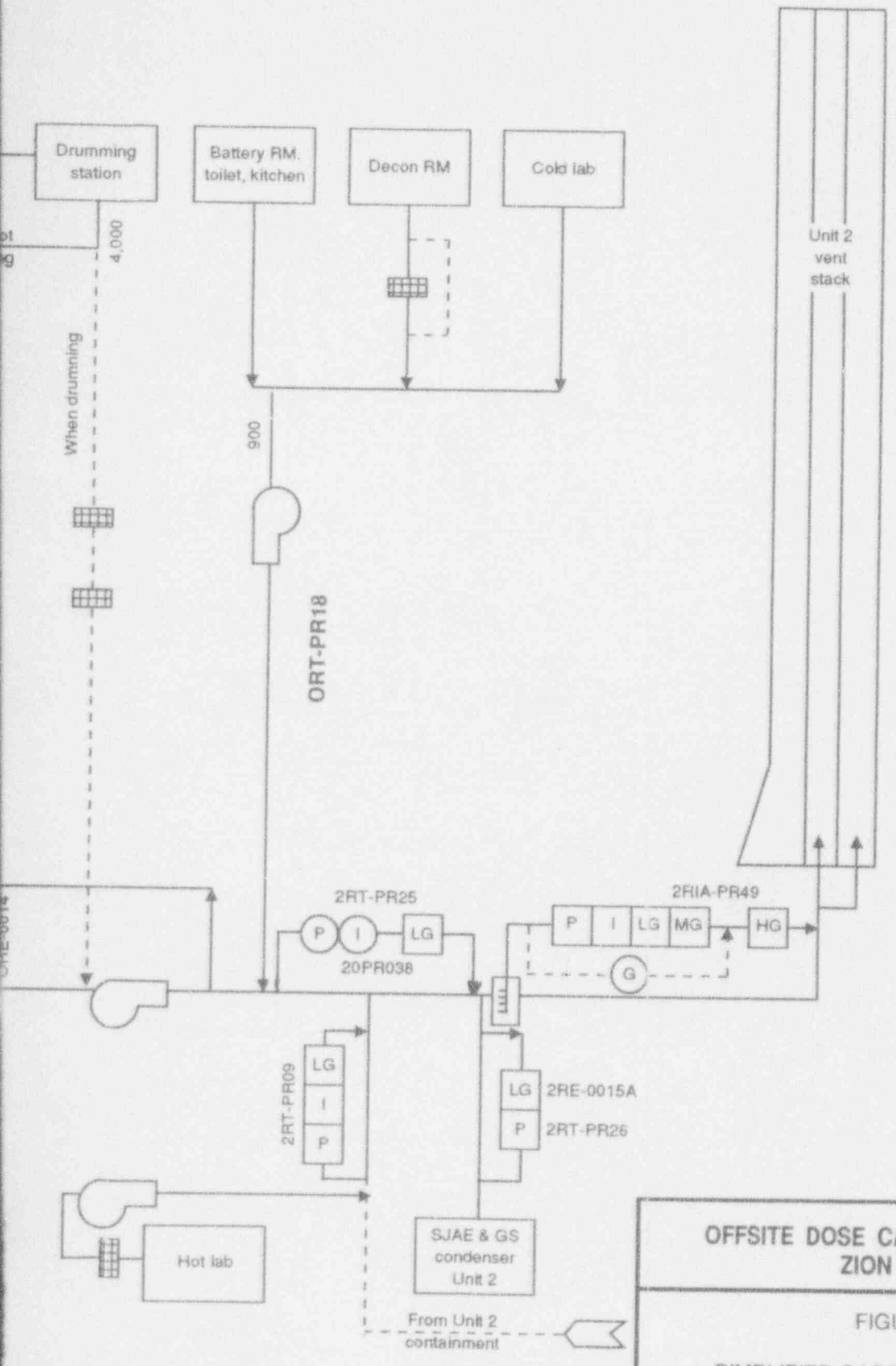
TABLE 10-3

LIQUID DILUTION FLOW PUMP CAPACITIES

PUMP	NUMBER OF PUMPS RUNNING	DILUTION FLOW
CIRCULATING WATER	1	250,000 gpm
CIRCULATING WATER	2	530,000 gpm
CIRCULATING WATER	3	640,000 gpm
SERVICE WATER	1	13,500 gpm
SERVICE WATER	2	27,000 gpm
SERVICE WATER	3	40,500 gpm



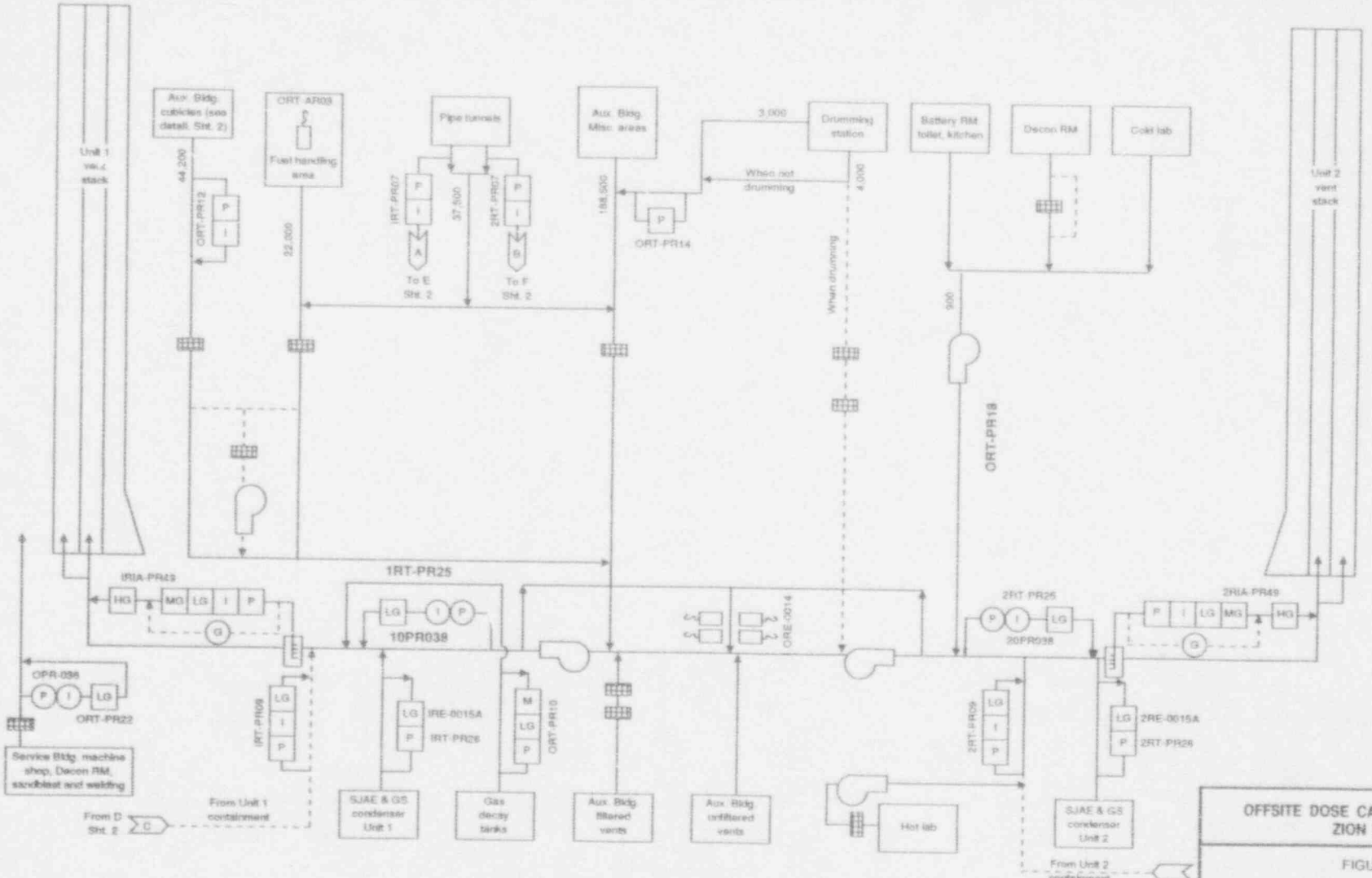
M5839.021 06-93



OFFSITE DOSE CALCULATION MANUAL
ZION STATION

FIGURE 10-1

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

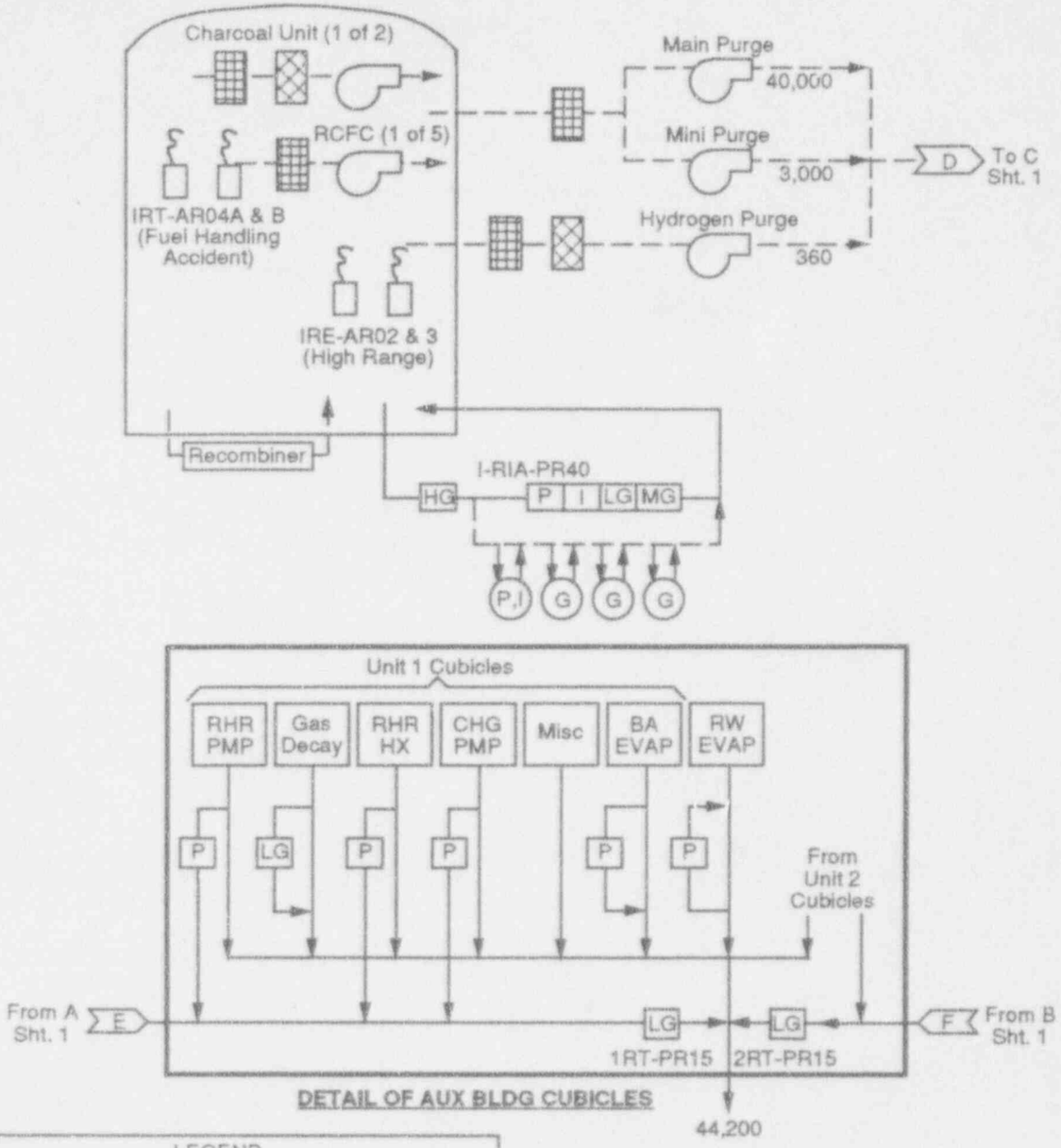


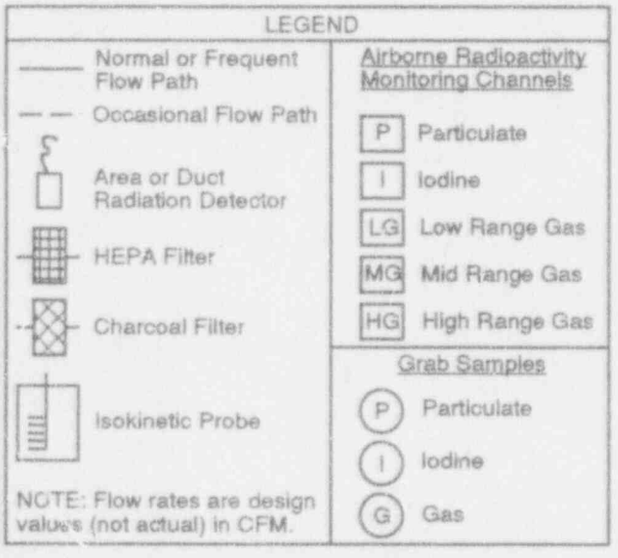
MR#36.051 06.93

OFFSITE DOSE CALCULATION MANUAL
ZION STATION

FIGURE 10-1

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





OFFSITE DOSE CALCULATION MANUAL
ZION STATION

FIGURE 10-1

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

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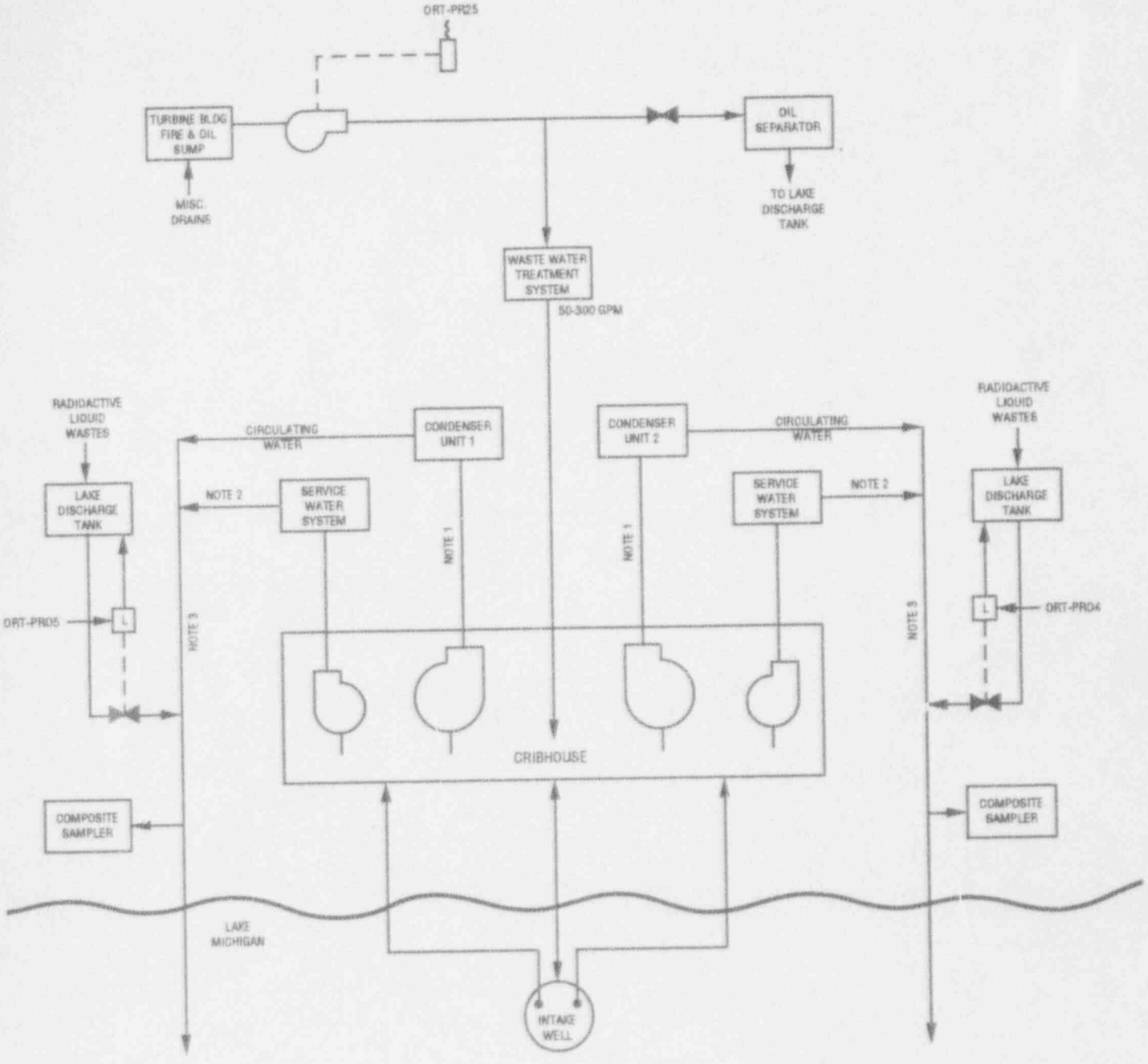


LEGEND

- L — LIQUID RAD MONITOR
- RADIATION MONITOR
- FLOW PATH
- CONTROL PATH
- NORMALLY CLOSED VALVE

NOTES

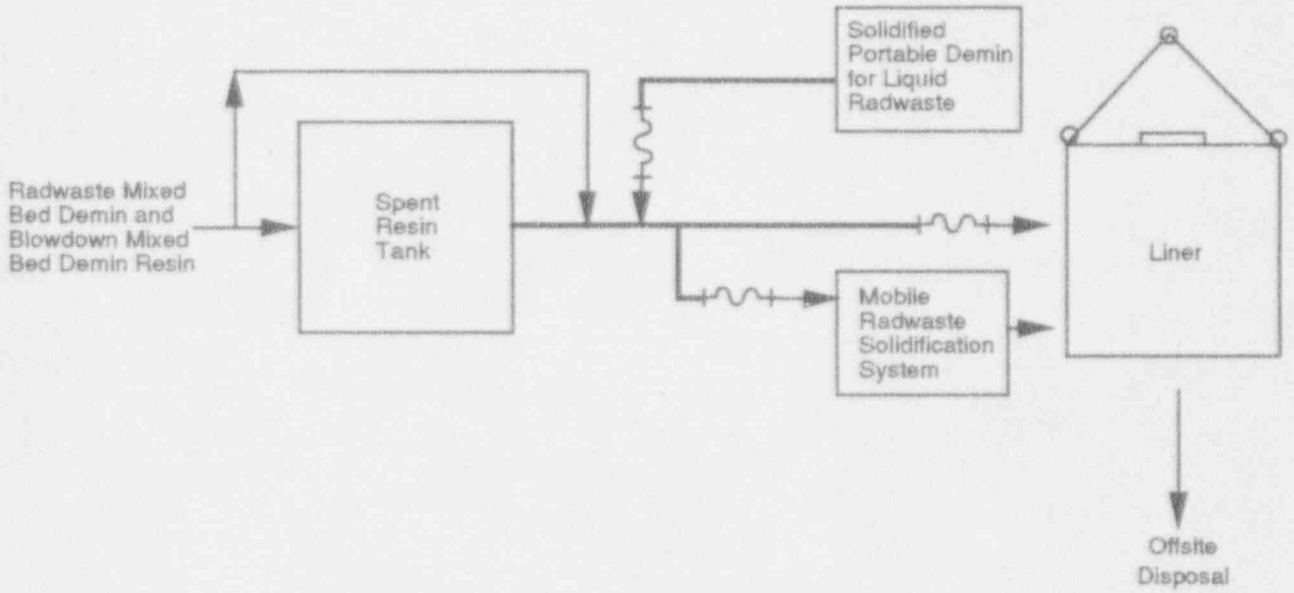
1. FLOW = 0-735,000 GPM
2. MIN FLOW = 44,000 GPM
3. FLOW DETERMINED BY PUMP CURVES

M5839.024 06-93

OFFSITE DOSE CALCULATION MANUAL
ZION STATION

FIGURE 10-3

SIMPLIFIED LIQUID EFFLUENT FLOW DIAGRAM



LEGEND	
+∿∿+	Flexible Hose

OFFSITE DOSE CALCULATION MANUAL
ZION STATION

FIGURE 10-4

SIMPLIFIED SOLID RADWASTE
PROCESSING DIAGRAM

M5839.026 6-93

NMC MONITOR RESPONSE

1(2)RT-PR25
1(2)RT-PR09A
ORT-PR18B
ORT-PR10A
ORT-PR22

1 - 100% Kr-85
2 - 50% Xe-133/50% Kr-85
3 - 67% Xe-133/33% Kr-85
4 - 90% Xe-133/10% Kr-85
5 - 100% Xe-133

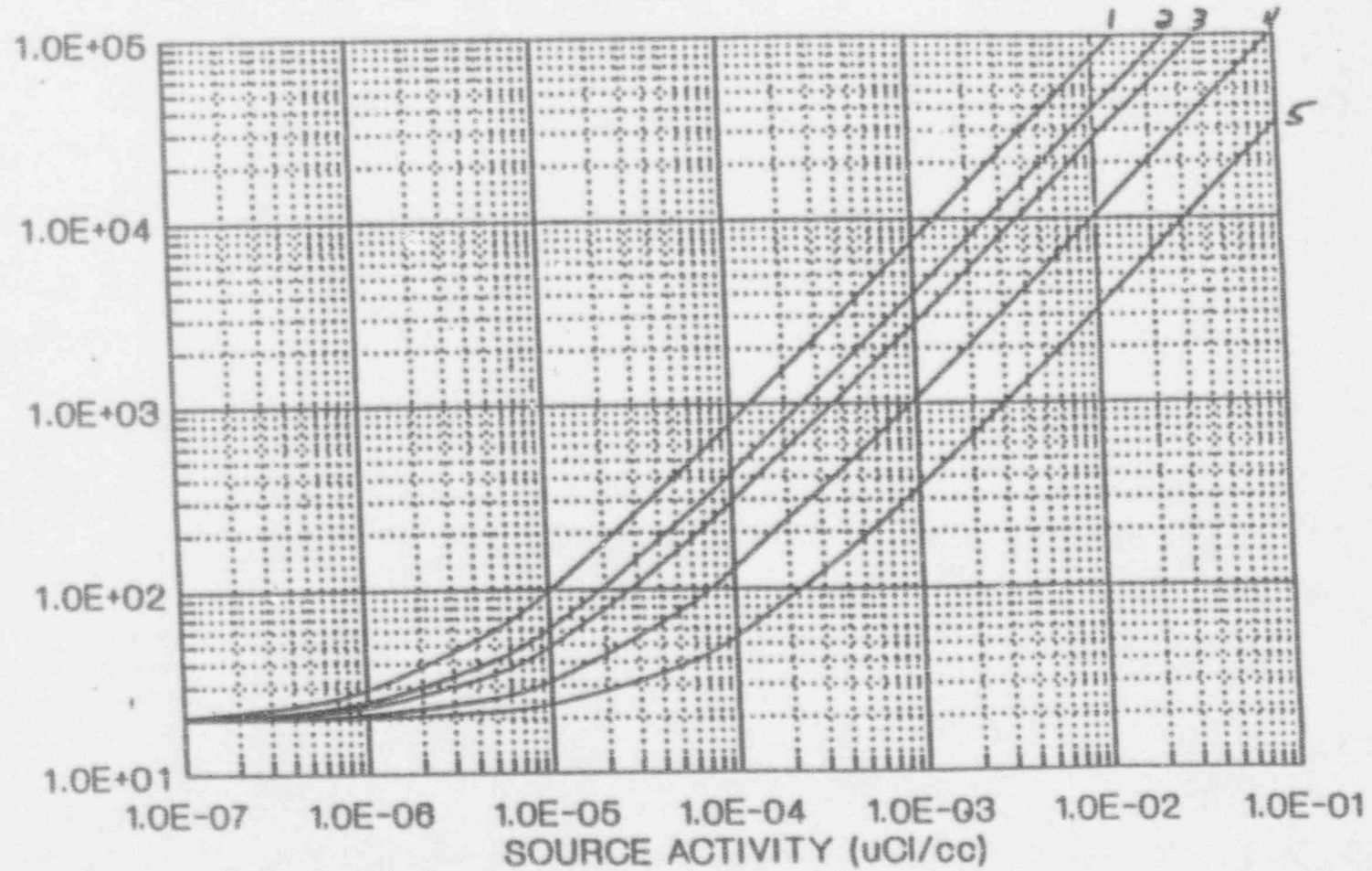


FIGURE 10-5

EXAMPLE NMC MONITOR RESPONSE

ZION ANNEX INDEX

CHAPTER 11

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

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RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

The parameters of the radiological environmental monitoring program for the environs around Zion Station are given in Table 11-1.

Figure 11-1 shows the 13 fixed air sampling sites, water sample locations, and milk sample locations. Figure 11-2 shows the inner ring TLD locations (those approximately 2 miles from the station). Figure 11-3 shows the outer ring TLD locations (those approximately 5 miles distant) and additional water sample locations. The TLDs are code numbered as follows:

XYY-N

X = 1 means inner ring,

X = 2 means outer ring, and

YY-N is an identification code.

The reporting levels for radioactivity concentrations in environmental samples are given in Table 11-2. The lower limits of detection for this program are given in Table 11-3.

Table 11-1

Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Sampling or Monitoring Locations[a]	Sampling or Collection Frequency	Type and Frequency of Analysis
1. Airborne Radioiodine and Particulates	a. Onsite and Near Field[b] Z-01 Onsite No. 1 South side, 0.3 mi S (0.5 km J) Z-02 Onsite No. 2 West side, 0.2 mi W (0.3 km N) Z-03 Onsite No. 3 North side, 0.2 mi NNW (0.3 km R)	Continuous sampler operation with particulate filter collection weekly and radioiodine canister collection biweekly[c]	Particulate Sampler: Gross beta analysis following filter change[d] Radioiodine Canister: I-131 analysis biweekly[c] Sampling Train: Test and maintenance weekly
	b. Far Field[b] Z-04 Zion (W), 5.0 mi W (8.0 km N) Z-05 Zion (SW), 3.5 mi WSW (5.6 km M) Z-06 Zion (WNW), 2.5 mi WNW (4.0 km P) Z-07 Winthrop Harbor Marina Drive, 2.5 mi NNW (4.0 km R) Z-08 Kenosha Road (Coleman), 3.6 mi W (5.8 km N) Z-09 Waukegan, 4.5 mi SSW (7.2 km K) Z-10 North Chicago, 8.0 mi SSW (12.9 km K)	Continuous sampler operation with particulate filter collection weekly and radioiodine canister collection biweekly[c]	Particulate Sampler: Gross beta and gamma isotopic analysis when analyses are made[e] Radioiodine Canister: I-131 when analyses are made[e]

Table 11-1
Radiological Environmental Monitoring Program - Cont.

Exposure Pathway and/or Sample	Sampling or Monitoring Locations[a]	Sampling or Collection Frequency	Type and Frequency of Analysis
1. Airborne (Cont'd)	Z-11 WEPCO Southport Substation, 7.7 mi N (11.2 km A) Z-12 Flood Farm, 11.0 SW (17.7 km L) Z-13 Pleasant Prairie DC, 10.0 NW (16.1 km Q)		Sampling Train: Test and maintenance weekly
2. Direct Radiation	a. At Air Sampler Sites[b] Same locations as fixed air sampling locations in Item 1.	Quarterly	Gamma dose quarterly
	b. Inner Ring[f]	Quarterly	Gamma dose quarterly
	Z-104-1 0.1 mi ENE (0.2 km D) Z-104-2 0.1 mi ENE (0.2 km D) Z-105-1 0.1 mi E (0.2 km E) Z-105-2 0.1 mi E (0.2 km E) Z-107-1 0.1 mi SE (0.2 km G) Z-107-2 0.1 mi SE (0.2 km G) Z-110-1 0.2 mi SSW (0.3 km K) Z-110-2 0.2 mi SSW (0.3 km K) Z-111-1 0.3 mi SW (0.5 km L) Z-111-2 0.3 mi SW (0.5 km L) Z-112-1 0.7 mi WSW (1.1 km M) Z-112-2 0.7 mi WSW (1.1 km M) Z-113-1 0.6 mi W (1.0 km N) Z-113-2 0.6 mi W (1.0 km N) Z-114-1 0.6 mi WNW (1.0 km P) Z-114-2 0.6 mi WNW (1.0 km P) Z-115-1 0.4 mi NW (0.6 km Q) Z-115-2 0.3 mi NW (0.5 km Q)		

Table 11-1
Radiological Environmental Monitoring Program - Cont.

Exposure Pathway and/or Sample	Sampling or Monitoring Locations[a]	Sampling or Collection Frequency	Type and Frequency of Analysis
2. Direct Radiation (Cont'd)	c. Outer Ring[a]	Quarterly	Gamma dose quarterly
	Z-209-1 4.6 mi S (7.4 km J) Z-209-2 4.6 mi S (7.4 km J) Z-210-1 4.7 mi SSW (7.6 km K) Z-210-2 4.7 mi SSW (7.6 km K) Z-211-1 4.6 mi SW (7.4 km L) Z-211-2 4.6 mi SW (7.4 km L) Z-212-1 4.5 mi WSW (7.2 km M) Z-212-2 4.5 mi WSW (7.2 km M) Z-213-1 4.6 mi W (7.4 km N) Z-213-2 4.6 mi W (7.4 km N) Z-214-1 4.4 mi WNW (7.1 km P) Z-214-2 4.4 mi WNW (7.1 km P) Z-215-1 4.0 mi NW (6.4 km Q) Z-215-2 4.0 mi NW (6.4 km Q) Z-216-1 3.0 mi NNW (4.8 km R) Z-216-2 3.0 mi NNW (4.8 km R)		
3. Waterborne			
a. Public Water[b]	Z-14 Kenosha Water Works, 10.0 mi N (16.0 km A) Z-15 Lake County Water Works, 1.4 mi NNW (2.2 km R) Z-16 Waukegan Water Works, 6.1 mi S (9.8 km J) Z-17 North Chicago Water Works, 9.0 mi S (14.4 km J) Z-18 Lake Forest Water Works, 12.9 mi S (20.8 km J)	Weekly collection composited monthly	Gamma isotopic analysis monthly. Composite for tritium analysis quarterly.

Table 11-1
Radiological Environmental Monitoring Program - Cont.

Exposure Pathway and/or Sample	Sampling or Monitoring Locations[a]	Sampling or Collection Frequency	Type and Frequency of Analysis
3. Waterborne (Cont'd)	Z-19 Great Lakes Naval Training Center Water Works, 9.9 mi S (15.8 km J)		
b. Cooling Water Sample[g]	Z-22 Unit 1 inlet at station Z-23S Unit 1 discharge at station Z-23N Unit 2 discharge at station	Weekly	Gross beta analysis weekly. Composite for tritium analysis quarterly.
c. Shoreline Sediments[g]	Z-25 Lake Michigan, Illinois Beach State Park, 2.0 mi S (3.2 km J)	Semiannually	Gamma isotopic analysis semiannually
4. Ingestion			
a. Fish[b]	Z-24 Lake Michigan near site at station	Semiannually	Gamma isotopic analysis on edible portions of each sample.
b. Milk[b]	Z-21 Steinbrink Dairy, 8.1 mi NW (13.0 km Q) Z-27 Doolittle Farm, 11.0 mi W (17.7 km N)	Semimonthly: May to October Monthly: November to April	Gamma isotopic and I-131 analysis on each sample
c. Food Products			
Indicators			
Samples of three different kinds of broadleaf vegetation	Grown nearest each of two different offsite locations of highest predicted annual average ground level D/Q (see Table F-5)	Monthly when available and required; required only if milk sampling not performed	Gamma isotopic and I-131 analysis

Table 11-1
Radiological Environmental Monitoring Program - Cont.

Exposure Pathway and/or Sample	Sampling or Monitoring Locations[1]	Sampling or Collection Frequency	Type and Frequency of Analysis
4. Ingestion (Cont'd)			
Controls			
One sample each of broadleaf vegetation similar to that collected for the above requirement	From a location 15 to 30 km from the station in direction of least prevalent wind direction	Monthly when available and required; required only if milk sampling not performed	Gamma isotopic and I-131 analysis
5. Land Use Census			
a. Milch Animals	1. Site boundary to 2 miles	Annually during grazing season	Enumeration by a door-to-door or equivalent counting technique.
	2. 2 to 5 miles	Annually during grazing season	Enumeration by using referenced information from county agricultural agencies or other reliable sources.
	3. At dairies listed in Item 4.b.	Annually during grazing season practices: a. Pasture only. b. Feed and chop only.	Inquire as to feeding

Table 11-1
Radiological Environmental Monitoring Program - Cont.

Exposure Pathway and/or Sample	Sampling or Monitoring Locations[a]	Sampling or Collection Frequency	Type and Frequency of Analysis
5. Land Use Census (Cont'd)			c. Pasture and feed; if both, ask farmer to estimate fraction of food from pasture: <25%, 25-50% 50-75%, or >75%.
b. Nearest Resident	In all 16 sectors up to 5 miles.	Annually	

[a] See Table D-16 for definitions of sector codes used with kilometer distances.

[b] See Figure 11-1, "Location of Fixed Air, Water and Milk Samples."

[c] Biweekly means every two weeks.

[d] A gamma isotopic analysis shall be performed wherever the gross beta concentration in a sample exceeds by five times (5x) the average concentration of the preceding calendar quarter for the sample location.

[e] Far field samples are analyzed when near field results are inconsistent with previous measurements and radioactivity is confirmed as having its origin in airborne effluents released from the station, or at the discretion of the Emergency Preparedness Director.

[f] See Figure 11-2, "Inner Ring TLD Locations".

[g] See Figure 11-3, "Location of Outer Ring TLDs and Water Samples".

Table 11-2

Reporting Levels for Radioactivity Concentrations in Environmental Samples

Analysis	Water (pCi/L)	Airborne Particulate or Gases (pCi/m³)	Fish (pCi/kg, wet)	Milk (pCi/L)	Food Products (pCi/kg, wet)
H-3	20,000[a]				
Mn-54	1000		30,000		
Fe-59	400		10,000		
Co-58	1000		30,000		
Co-60	300		10,000		
Zn-65	300		20,000		
Zr-Nb-95	400[b]				
I-131	2	0.9		3	100
Cs-134	30	10	1000	60	1000
Cs-137	50	20	2000	70	2000
Ba-La-140	200[b]			300[b]	

[a] For drinking water samples. This is 40 CFR Part 141 value.

[b] Total for parent and daughter.

Table 11-3

Maximum Values for the Lower Limits of Detection (LLD)

Analysis	Water (pCi/L)	Airborne Particulate or Gases (pCi/m³)	Fish (pCi/kg, wet)	Milk (pCi/L)	Food Products (pCi/kg,wet)	Sediment (pCi/kg, dry)
gross beta	4*	0.01				
gamma isotopic		0.01				
H-3	2000 (1000*)					
Mn-54	15		130			
Fe-59	30		260			
C0-58,60	15		130			
Zn-65	30		260			
Zr-Nb-95	15*					
I-131	1*	0.07		1	60	
Cs-134,137	15 (10*),18	0.01	130	15	60	150
Ba-La-140	15*			15*		

Table 11-3 (Cont'd)
Maximum Values for the Lower Limits of Detection (LLD)

General Notes:

1. The LLD is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with only 5% probability of falsely concluding its presence.

   For a particular measurement system (which may include radiochemical separation):

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

   LLD The lower limit of detection as defined above (as pCi per unit mass or volume).

   s_b The square root of the background count or of the count of a blank sample as appropriate (as counts per minute).

   A The number of gamma-rays emitted per disintegration for gamma-ray radionuclide analysis (A = 1.0 for gross alpha and tritium measurements).

   E The counting efficiency (as counts per gamma).

   V The sample size (in units of mass or volume).

   2.22 The number of transformations per minute per picocurie.

   Y The fractional radiochemical yield when applicable (otherwise Y = 1.0).

   λ The radioactive decay constant for the particular radionuclide.

   Δt The elapsed time between sample collection and analysis.

Table 11-3 (Cont'd)
Maximum Values for the Lower Limits of Detection (LLD)

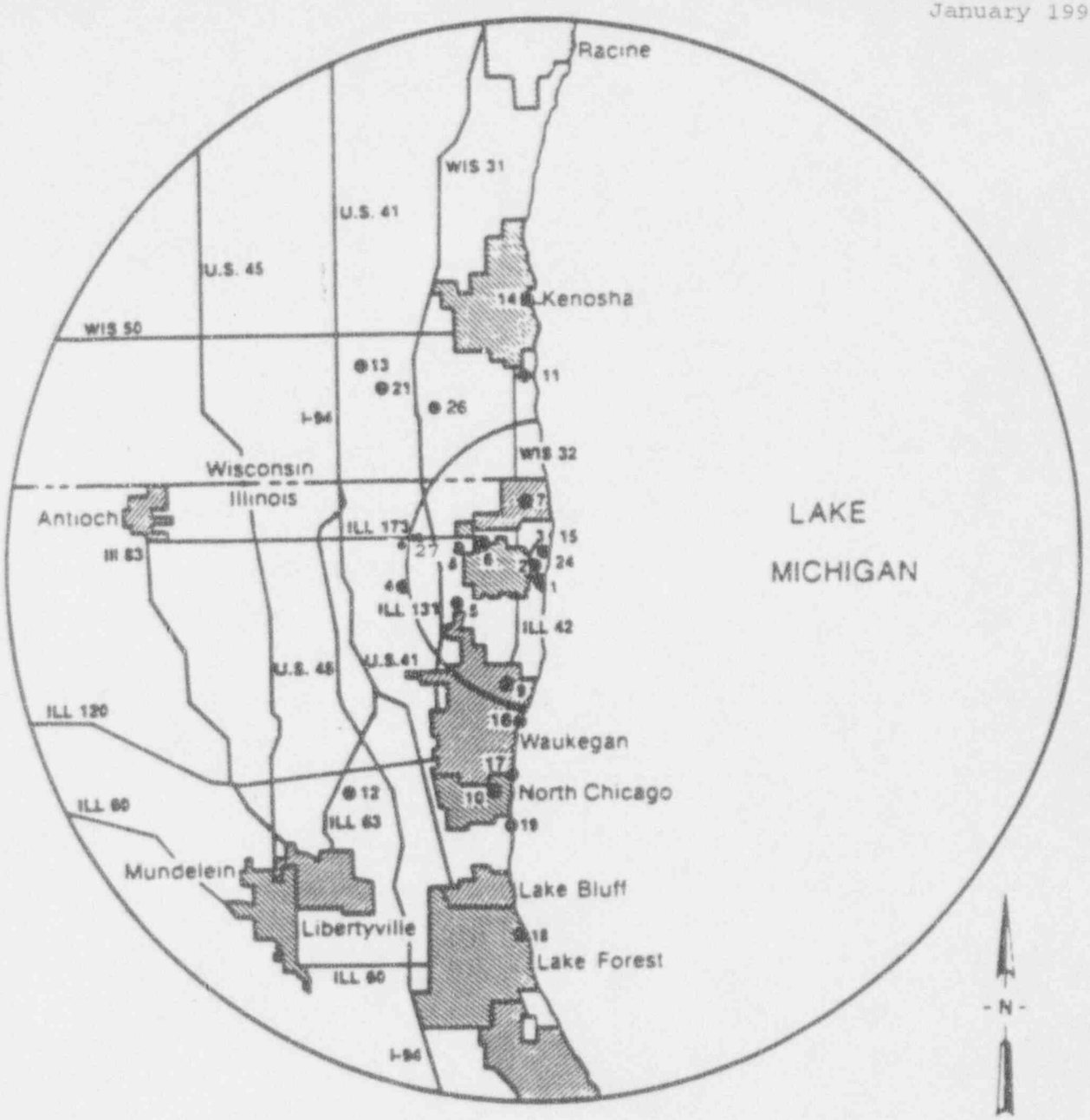
The value of s_b used in the calculation of the LLD for a detection system shall be based on the actual observed background count or on the count of the blank samples (as appropriate) rather than on an unverified theoretically predicted value. Typical values of E, V, Y, Δt, shall be used in the calculation.

For gamma-ray radionuclide analyses, the background counts are determined from the total counts in the channels which are within plus or minus one FWHM (Full Width at Half Maximum) of the gamma-ray photopeak energy normally used for the quantitative analysis for that radionuclide. Typical values of the FWHM shall be used in the calculation.

2. The LLD for environmental measurement 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.

Footnotes:

*LLD for drinking water.



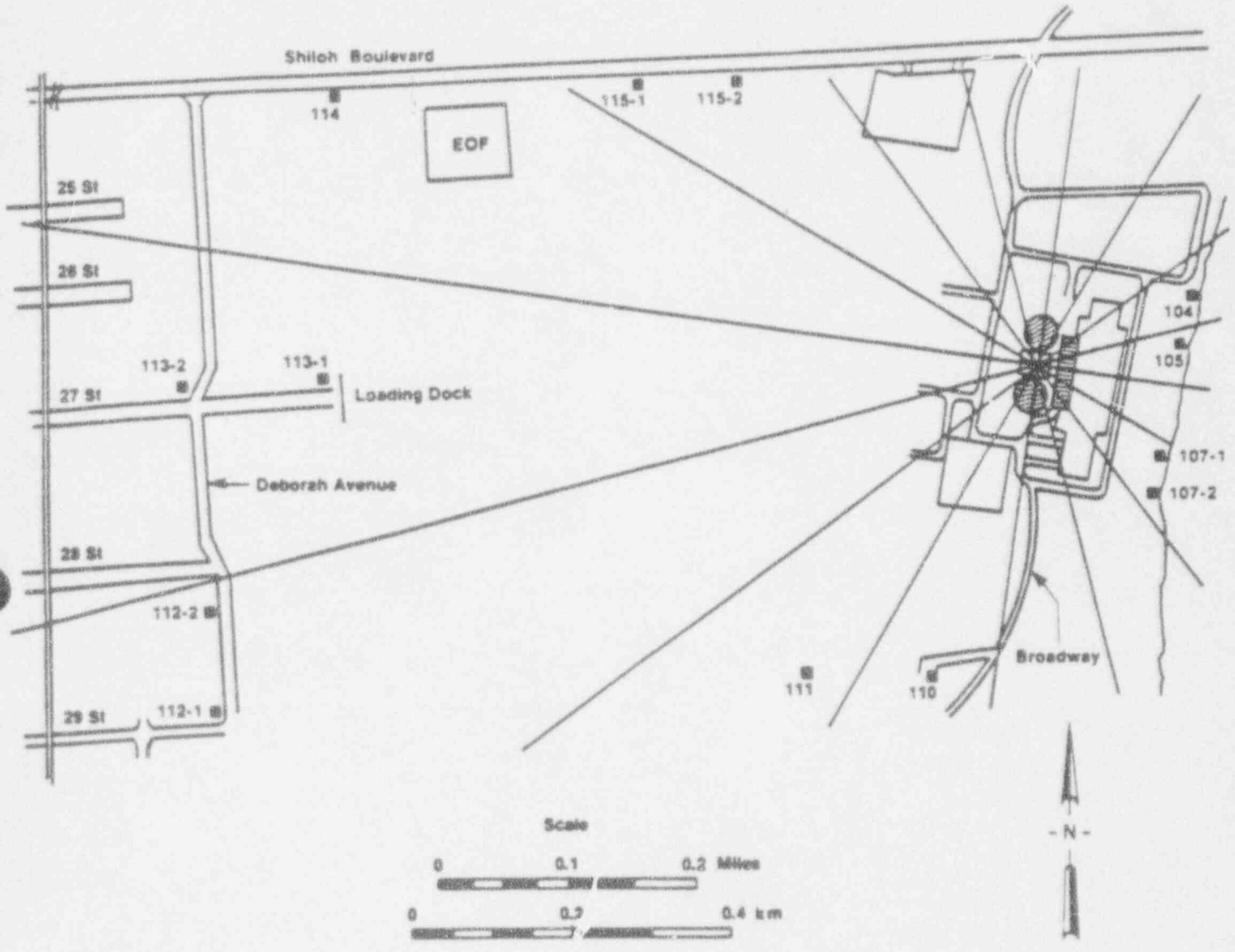
• Sampling Location

OFFSITE DOSE CALCULATION MANUAL
ZION STATION

FIGURE 11-1

LOCATION OF FIXED AIR, WATER AND MILK SAMPLES

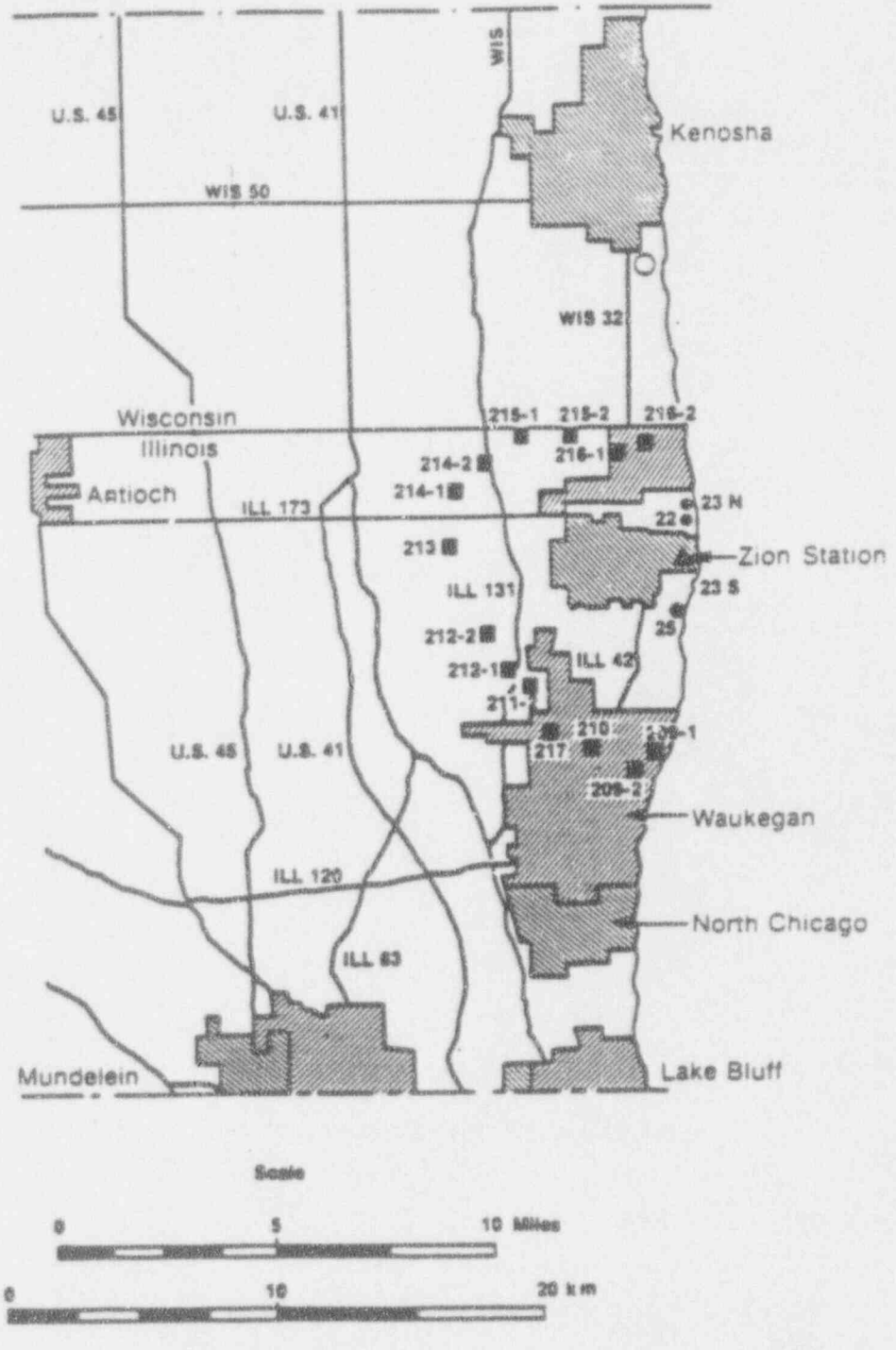
6202-2
08-85—347



■ TLD Location

OFFSITE DOSE CALCULATION MANUAL ZION STATION
FIGURE 11-2 INNER RING TLD LOCATIONS

5202-1
06-86—347



• Sample Location

■ TLD Location

OFFSITE DOSE CALCULATION MANUAL
ZION STATION

FIGURE 11-3

LOCATION OF OUTER RING TLDS AND WATER SAMPLES

6202-3
08-85—347

SPECIAL NOTE

The transfer of the Radiological Effluent Technical Specifications (RETS) to the ODCM from the Zion Station Technical Specifications has been approved by the Nuclear Regulatory Commission as of July 12, 1993 in amendments 147 (Unit 1) and 135 (Unit 2).

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12 - 53	1.0

CHAPTER 12

RADIOACTIVE EFFLUENT TECHNICAL STANDARDS (RETS) TABLE OF CONTENTS

CHAPTER 12

RADIOACTIVE EFFLUENT TECHNICAL STANDARDS (RETS) LIST OF TABLES

12.1 DEFINITIONS

12.1.1 ACTION shall be that part of the sections which prescribes remedial measures required under designated conditions.

12.1.2 A BATCH RELEASE is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated and then thoroughly mixed to assure representative sampling.

12.1.3 A CHANNEL CALIBRATION, shall be the adjustment, as necessary, of the channel such that it responds with the necessary range and accuracy to known values of input. The CHANNEL CALIBRATION shall encompass the entire channel including the sensors (where possible), alarm interlock and/or trip functions and shall include the CHANNEL FUNCTIONAL TEST. The CHANNEL CALIBRATION may be performed by any series of sequential, overlapping, or total channel steps such that the entire channel is calibrated.

12.1.4 A CHANNEL CHECK shall be the qualitative assessment of channel behavior during operation by observation. This determination shall include, where possible, comparison of the channel indication and/or status with other indications and/or status derived from independent INSTRUMENT CHANNELS measuring the same parameter.

12.1.5 A CHANNEL FUNCTIONAL TEST shall be:

a. Instruments - The injection of a simulated signal(s) into the channel as close to the primary sensor(s) as practicable to verify OPERABILITY, including all channel outputs, as appropriate.

b. Logics - The application of input signals, or the operation of relays or switch contacts, in all the combinations required to produce the required decision outputs including the operation of all ACTUATION DEVICES. Where practicable, the test shall include the operation of the ACTUATED EQUIPMENT as well (i.e. pumps will be started, valves operated, etc.).

12.1.6 A COMPOSITE SAMPLE is one in which the quantity of liquid sample is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen which is representative of the liquids released.

12.1.7 A CONTINUOUS RELEASE is the discharge of liquid or gaseous wastes of a nondiscrete volume (e.g. from a volume or system that has an input flow during the release).

12.1.8 A GASEOUS RADWASTE TREATMENT SYSTEM any system designed and installed to reduce radioactive gaseous effluents by collecting off-gases from the Reactor Coolant System and providing for delay or holdup for the purpose of reducing the total radioactivity prior to release to the environment.

12.1.9 MEMBER(S) OF THE PUBLIC means an individual in a controlled or unrestricted area. However, an individual is not a member of the public during any period in which the individual receives occupational dose.

12.1.10 A system, subsystem, train, component or device shall be OPERABLE or have OPERABILITY when it is capable of performing its specified function(s), and when all necessary attendant instrumentation, controls, electrical power, cooling or seal water, lubrication or other auxiliary equipment that are required for the system, subsystem, train, component, or device to perform its function(s) are also capable of performing their related support function(s).

12.1.11 An OPERATIONAL MODE (i.e., Mode) shall correspond to any one inclusive combination of core reactivity condition, power level, and average reactor coolant temperature specified in Table 1.1 of the Technical Specifications, when fuel assemblies are present in the reactor vessel.

12.1.12 The PROCESS CONTROL PROGRAM (PCP) shall contain the current formulas, sampling, analyses, test, and determinations to be made to ensure that processing and packaging of solid radioactive wastes based on demonstrated processing of actual or simulated wet solid wastes will be accomplished in such a way as to assure compliance with 10CFR Parts 20, 61, and 71, State regulations, burial ground requirements, and other requirements governing the disposal of solid radioactive waste.

12.1.13 PURGE OR PURGING is the controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner, that replacement air or gas is required to purify the confinement.

12.1.14 The SITE BOUNDARY shall be that line beyond which the land is not owned, leased or otherwise controlled by the licensee.

12.1.15 A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a radioactive source.

12.1.16 The SURVEILLANCE FREQUENCY NOTATION specified for the performance of Surveillance Requirements shall correspond to the intervals defined in Table 12.1-1.

12.1.17 An UNRESTRICTED AREA an area, access to which is neither limited nor controlled by the licensee.

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

12.1.19 VENTING is the controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or gas is not provided or required during venting. Vent, used in system names, does not imply a venting process.

TABLE 12.1-1

SURVEILLANCE FREQUENCY NOTATION

NOTATION		FREQUENCY *
S	(Shiftly)	At least once per scheduled shift
D	(Daily)	At least once per 24 hours
W	(Weekly)	At least once per 7 days
M	(Monthly)	At least once per 31 days
Q	(Quarterly)	At least once per 92 days
SA	(Semiannually)	At least once per 184 days
R	(Refueling Cycle)	At least once per 18 months
S/U	(Startup)	Prior to reactor startup
P	(Prior)	Complete prior to start of release
EFPM		At least once per effective full power month
N.A.		Not Applicable

* Each Surveillance Requirement shall be performed within the specified time interval with a maximum allowable extension not to exceed 25% of the surveillance interval.

12.2 INSTRUMENTATION

12.2.1 Radioactive Liquid Effluent Monitoring Instrumentation

Operability Requirements

12.2.1.A The radioactive liquid effluent monitoring instrumentation channels shown in Table 12.2-1 shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of Section 12.3.1.A are met.

Applicability: At all times.

Action

1. With a radioactive liquid effluent monitoring instrument channel trip setpoint less conservative than the value necessary to prevent violating the limits of Section 12.3.1.A, immediately suspend the release of radioactive liquid effluents monitored by the affected channel or declare the channel inoperable.

2. With one or more radioactive liquid effluent monitoring instrumentation channels inoperable, take the ACTION shown in Table 12.2-1.

Surveillance Requirements

12.2.1.B.1 The setpoints shall be determined in accordance with procedures as described in the ODCM.

12.2.1.B.2 Each radioactive liquid effluent monitoring instrumentation channel shall be demonstrated OPERABLE by performance of a CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION and CHANNEL FUNCTIONAL TEST at the frequencies shown in Table 12.2-2.

Bases

12.2.1.C The radioactive liquid effluent instrumentation is provided to monitor and control, as applicable, the release of radioactive materials in liquid effluents. The alarm/trip setpoints for these instruments shall be calculated in accordance with the procedures in the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of RETS. The OPERABILITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63 and 64 of Appendix A to 10CFR Part 50.

TABLE 12.2-1

RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION TABLE

INSTRUMENT	MINIMUM CHANNELS OPERABLE	ACTION #	APPLICABLE MODES
1. Gross Activity Monitors Providing Automatic Termination of Release			
A. Lake Discharge Tank (LDT)			
1. OR-PR04	See ACTION 1	1	All
2. OR-PR05	See ACTION 1	1	All
B. Turbine Bldg.			
1. OR-PR25	1	2	All
2. Continuous Composite Sampler			
A. Turbine Building Fire Sump	1	2	All
3. Flow Rate Monitors			
A. Lake Discharge Tank			
1. OF-WD63	1	3	All
2. OF-WD67	1	3	All

TABLE 12.2-1

RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION
(Cont'd)

ACTION 1 With one of the LDT monitors Inoperable, all LDT releases shall be made through the OPERABLE monitored pathway. If both monitors are inoperable, effluent releases from the tank may continue, for up to 14 days provided that prior to initiating the release:

1. At least two independent samples of the tank's contents are analyzed, in accordance with Section 12.3.1.B and

2. At least two technically qualified members of the facility staff independently verify the release rate calculations and discharge flow path valving;

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION 2 With the number of channels OPERABLE less the minimum number required, effluent releases via this pathway may continue, provided that at least once per shift grab samples are analyzed for gross radioactivity (beta /gamma or isotopic) at a lower limit of detection (LLD) as specified in Table 12.3-2.

ACTION 3 With the number of channels OPERABLE less than the minimum number required, effluent releases via this pathway may continue, for up to 30 days provided the flow rate is estimated at least once per 4 hours during actual releases. Pump curves may be used to estimate flow.

TABLE 12.2-2

RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION(1)	CHANNEL FUNCTIONAL TEST (2)
1. Gross Activity Monitors Providing Automatic Termination Of Release				
A. Lake Discharge Tank (LDT)				
1. OR-PR04	P	P	R	Q
2. OR-PR05	P	P	R	Q
B. Turbine Bldg.				
1. OR-PR25	D[3]	M	R	Q
2. Continuous Composite Sampler				
A. Turbine Building Fire Sump	D	N/A	N/A	N/A
3. Flow Rate Monitors				
A. Lake Discharge Tank				
1. OF-WD63	D[3]	N/A	R*	N/A
2. OF-WD67	D[3]	N/A	R*	N/A

(1) CHANNEL CALIBRATION shall include performance of a CHANNEL FUNCTIONAL TEST and a SOURCE CHECK.

(2) The CHANNEL FUNCTIONAL TEST shall also demonstrate that any automatic isolation of this pathway occurs and that control room alarm annunciation occurs if any of the following conditions exist. (if the capability is installed):
a) Instrument indicates levels above the alarm setpoints.
b) Circuit failure.
c) Instrument indicates a downscale failure.
d) Instrument controls not set in operate mode.

(3) CHANNEL CHECK shall be made at least once daily on any day on which continuous, periodic, or BATCH RELEASES are made.

* Does not include flow sensor.

12.2.2 Radioactive Gaseous Effluent Monitoring Instrumentation

Operability Requirements

12.2.2.A The radioactive gaseous effluent monitoring instrumentation channels shown in Table 12.2-3 shall be OPERABLE with their alarm/trip setpoints set in accordance with the method prescribed in the ODCM to ensure that the limits of Section 12.4.1.A are met.

Applicability: At all times, except as indicated in Table 12.2-3.

Action

1. With a radioactive gaseous effluent monitoring instrumentation channel alarm/trip setpoint less conservative than required by the above Section, immediately suspend the release of radioactive gaseous effluents monitored by the affected channel or declare the channel inoperable.

2. With one or more radioactive gaseous effluent monitoring instrumentation channels inoperable, take ACTION as shown in Table 12.2-3.

Surveillance Requirements

12.2.2.B.1 The setpoints shall be determined in accordance with procedures as described in the ODCM.

12.2.2.B.2 Each radioactive gaseous effluent monitoring instrumentation channel shall be demonstrated OPERABLE by performance of a CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION and CHANNEL FUNCTIONAL TEST at the frequencies shown in Table 12.2-4.

Bases

12.2.2.C The radioactive gaseous effluent instrumentation is provided to monitor, record and control, as applicable, the release of radioactive materials in gaseous effluents during actual or potential releases. The alarm/trip setpoints for these instruments shall be calculated in accordance with the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of RETS.

TABLE 12.2-3

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

INSTRUMENT	MINIMUM CHANNELS OPERABLE	ACTION	APPLICABLE MODES
1. Gas Decay Tank			
A. Gas Activity Monitor			
1. OR-PR10A Low range gas	1	5	All
2. OR-PR10B High range gas	1	5	All
B. Particulate/Iodine Monitor			
1. OR-PR10C	1	5	All
C. Flow Rate Monitor			
1. OF-WG03	1	9	All
2. Air Ejector Off-Gas			
A. Gas Activity Monitor			
1. 1R-0015 Gas	1	6	1,2,3,4,7
2. 2R-0015 Gas	1	6	1,2,3,4,7
B. Particulate/Iodine Monitor			
1. 1R-PR26	1	6	1,2,3,4,7
2. 2R-PR26	1	6	1,2,3,4,7
C. Flow Rate Monitor			
1. 1F-0G10	1	12	1,2,3,4,7
2. 2F-0G10	1	12	1,2,3,4,7
3. Containment Purge or Vent			
A. Gas Activity Monitor			
1. 1R-PR09A Gas	1	6[1], 7[2]	All
2. 2R-PR09A Gas	1	6[1], 7[2]	All
3. 1R-PR40E (Channel 5)	1	6[1], 7[2]	All
4. 2R-PR40E (Channel 5)	1	6[1], 7[2]	All
B. Iodine Monitor			
1. 1R-PR09B Iodine	1	6[1], 7[2]	All
2. 2R-PR09B Iodine	1	6[1], 7[2]	All
3. 1R-PR40C (Channel 3)	1	6[1], 7[2]	All
4. 2R-PR40C (Channel 3)	1	6[1], 7[2]	All

[1] During VENTING
[2] During PURGING

TABLE 12.2-3

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION
(Cont'd)

INSTRUMENT	MINIMUM CHANNELS OPERABLE	ACTION	APPLICABLE MODES
3. Containment and Purge or Vent			
C. Particulate Monitor			
1. 1R-PR09C Particulate	1	6[1], 7[2]	All
2. 2R-PR09C Particulate	1	6[1], 7[2]	All
3. 1R-PR40A (Channel 1)	1	6[1], 7[2]	All
4. 2R-PR40A (Channel 1)	1	6[1], 7[2]	All
4. Auxiliary Building Ventilation and Miscellaneous Ventilation Stack			
A. Gas Activity Monitor			
1. OR-0014 or	1	6	All
2. 1R-PR25 and 2R-PR25	1	6	All
3. OR-PR18B Gas	1	6	All
4. 1R-PR49E (Channel 5)	1	6	All
5. 2R-PR49E (Channel 5)	1	6	All
B. Iodine Monitor			
1. 1R-PR49C (Channel 3)	1	8	All
2. 2R-PR49C (Channel 3)	1	8	All
C. Particulate Monitor			
1. OR-PR18A Particulate	1	6	All
1. 1R-PR49A (Channel 1)	1	8	All
2. 2R-PR49A (Channel 1)	1	8	All
D. Flow Rate Monitor			
1. 1LP-084	1	9	All
2. 2LP-084	1	9	All
5. Service Building Ventilation			
A. Gas Activity Monitor			
1. OR-PR22	1	8	All
B. Particulate/Iodine Monitor			
1. OR-PR36	1	8	All

[1] During Venting
[2] During Purging

TABLE 12.2-3

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION
(Cont'd)

INSTRUMENT	MINIMUM CHANNELS OPERABLE	ACTION	APPLICABLE MODES
6. Steam Generator Atmospheric Relief and Safety Valves			
A. 1R-PR58	1	10	1,2,3,7
B. 2R-PR58	1	10	1,2,3,7
C. 1R-PR59	1	10	1,2,3,7
D. 2R-PR59	1	10	1,2,3,7
E. 1R-PR60	1	10	1,2,3,7
F. 2R-PR60	1	10	1,2,3,7
G. 1R-PR61	1	10	1,2,3,7
H. 2R-PR61	1	10	1,2,3,7
7. Accident Monitoring			
A. Containment			
1. 1R-PR40G (Channel 7)	1	10	1,2,3,4,7
2. 2R-PR40G (Channel 7)	1	10	1,2,3,4,7
3. 1R-PR40I (Channel 9)	1	10	1,2,3,4,7
4. 2R-PR40I (Channel 9)	1	10	1,2,3,4,7
B. Miscellaneous Vent Stack			
1. 1R-PR49G (Channel 7)	1	10	1,2,3,4,7
2. 2R-PR49G (Channel 7)	1	10	1,2,3,4,7
3. 1R-PR49I (Channel 9)	1	10	1,2,3,4,7
4. 2R-PR49I (Channel 9)	1	10	1,2,3,4,7
C. Containment Fuel Handling Area Monitor*			
1. 1R-AR04A	1	11	6
2. 1R-AR04B	1	11	6
3. 2R-AR04A	1	11	6
4. 1R-AR04B	1	11	6

* When purging during fuel handling operations

TABLE 12.2-3

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION
(Cont'd)

TABLE NOTATIONS

ACTION 5 - With the number of channels OPERABLE less than the minimum number required, the contents of the tank may be released to the environment provided that prior to initiating the release:

1. At least two independent samples of the tank's content are analyzed, and

2. At least two technically qualified members of the facility staff independently verify the release rate calculations and discharge flow path valving;

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION 6 - With the number of channels OPERABLE less than the minimum number required, effluent releases via this pathway may continue for up to 30 days provided grab samples are taken at least once per shift and these samples are analyzed for gross activity within 24 hours.

ACTION 7 - With the number of channels OPERABLE less than the minimum number required, and no redundant monitor OPERABLE in this flow path, immediately suspend PURGING of radioactive effluents via this pathway.

ACTION 8 - With the number of channels OPERABLE less than the minimum number required, effluent releases via this pathway may continue for up to 30 days, provided samples are continuously collected with auxiliary sampling equipment as required in Table 12.4-1.

ACTION 9 - With the number of OPERABLE channels less than the minimum number required, effluent releases via this pathway may continue provided the flow rate is estimated at least once per shift while release is in progress.

ACTION 10 - With the number of channels OPERABLE less than the minimum number required, restore the inoperable monitor to OPERABLE status within 30 days or establish an alternate means of monitoring the parameter.

ACTION 11 - With the number of OPERABLE channels less than the minimum number required, suspend vent and purge operations and close each vent and purge valve providing direct access from the containment atmosphere to the outside atmosphere or suspend the movement of nuclear fuel and reactor components in the vicinity of the reactor, refueling cavity, and transfer canal (containment side).

ACTION 12 - With the number of OPERABLE channels less than the minimum number required, effluent releases via this pathway may continue provided the effluent flow is being accounted for in the total plant effluent.

TABLE 12.2-4

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE

	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION (1)	CHANNEL FUNCTIONAL TEST (2)
1. Gas Decay Tank				
A. Gas Activity Monitor				
1. OR-PR10A Low range gas	P	P	R	Q
2. OR-PR10B High range gas	P	P	R	Q
B. Particulate/Iodine Monitor				
1. OR-PR10C	P	P	R	Q
C. Flow Rate Monitor				
1. OF-WG03	P	N/A	N/A	Q (5)
2. Air Ejector Off-Gas				
A. Gas Activity Monitor				
1. 1R-0015 Gas	D	M	R	Q
2. 2R-0015 Gas	D	M	R	Q
B. Particulate/Iodine Monitor				
1. 1R-PR26	D	M	R	Q
2. 2R-PR26	D	M	R	Q
C. Flow Rate Monitor				
1. 1F-0G10	D	N/A	R	N/A
2. 2F-0G10	D	N/A	R	N/A

TABLE 12.2-4

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE
(Cont'd)

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION (1)	CHANNEL FUNCTIONAL TEST (2)
3. Containment Purge or Vent				
A. Gas Activity Monitor				
1. 1R-PR09A	D	M	R	Q
2. 2R-PR09A	D	M	R	Q
3. 1R-PR40E (Channel 5)	D	M	R	Q
4. 2R-PR40E (Channel 5)	D	M	R	Q
B. Iodine Monitor				
1. 1R-PR09B	D	M	R	Q
2. 2R-PR09B	D	M	R	Q
3. 1R-PR40C (Channel 3)	D	M	R	Q
4. 2R-PR40C (Channel 3)	D	M	R	Q
C. Particulate Monitor				
1. 1R-PR09C	D	M	R	Q
2. 2R-PR09C	D	M	R	Q
3. 1R-PR40A (Channel 1)	D	M	R	Q
4. 2R-PR40A (Channel 1)	D	M	R	Q

TABLE 12.2-4

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE
(Cont'd)

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION (1)	CHANNEL FUNCTIONAL TEST (2)
4. Auxiliary Building Ventilation and Miscellaneous Ventilation Stack				
A. Gas Activity Monitor				
1. 0R-0014 Gas or	D	M	R	Q
2. 1RT-PR25 and 2RT-PR25	D	M	R	Q
3. OR-PR18B	D	M	R	Q
4. 1R-PR49E (Channel 5)	D	M	R	Q
5. 2R-PR49E (Channel 5)	D	M	R	Q
B. Iodine Monitor				
1. 1R-PR49C (Channel 3)	D	M	R	Q
2. 2R-PR49C (Channel 3)	D	M	R	Q
C. Particulate Monitor				
1. OR-PR18A	D	M	R	Q
2. 1R-PR49A (Channel 1)	D	M	R	Q
3. 2R-PR49A (Channel 1)	D	M	R	Q
D. Flow Rate Monitor				
1. 1LP-084	D	N/A	R	Q
2. 2LP-084	D	N/A	R	Q
5. Service Building Ventilation				
A. Gas Activity Monitor				
1. OR-PR22	D	M	R	Q
B. Particulate/Iodine Monitor				
1. OR-PR36	N/A	N/A	N/A	N/A

TABLE 12.2-4

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE
(Cont'd)

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION (1)	CHANNEL FUNCTIONAL TEST (2)
6. Steam Generator Atmospheric Relief and Safety Valves				
1. 1R-PR58	D	M	R	Q
2. 2R-PR58	D	M	R	Q
3. 1R-PR59	D	M	R	Q
4. 2R-PR59	D	M	R	Q
5. 1R-PR60	D	M	R	Q
6. 2R-PR60	D	M	R	Q
7. 1R-PR61	D	M	R	Q
8. 2R-PR61	D	M	R	Q
7. Accident Monitoring				
A. Containment				
1. 1R-PR40G (Channel 7)	ND/A	N/A	R	Q
2. 2R-PR40G (Channel 7)	ND/A	N/A	R	Q
3. 1R-PR40I (Channel 9)	N/A	N/A	R	Q
4. 2R-PR40I (Channel 9)	N/A	N/A	R	Q
B. Miscellaneous Vent Stack				
1. 1R-PR49G (Channel 7)	N/A	N/A	R	Q
2. 2R-PR49G (Channel 7)	N/A	N/A	R	Q
3. 1R-PR49I (Channel 9)	N/A	N/A	R	Q
4. 2R-PR49I (Channel 9)	N/A	N/A	R	Q
C. Fuel Handling Area				
1. 1R-AR04A	D	M(3)	R	Q(4)
2. 1R-AR04B	D	M(3)	R	Q(4)
3. 2R-AR04A	D	M(3)	R	Q(4)
4. 2R-AR04B	D	M(3)	R	Q(4)

Table 12.2-4

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE
(Cont'd)

TABLE NOTATIONS

(1) CHANNEL CALIBRATION shall include performance of a CHANNEL FUNCTIONAL TEST.

(2) The CHANNEL FUNCTIONAL TEST shall also demonstrate that any automatic isolation occurs; and that Control Room alarm annunciation occurs if any of the following conditions exist (if the capability is installed):

a) Instrument indicates measured levels above the alarm setpoint.
b) Circuit failure.
c) Instrument indicates a downscale failure.
d) Instrument controls not set in "operate" mode.

(3) Daily when PURGING the containment during fuel handling operations.

(4) Within 72 hours prior to commencing refueling operations.

(5) OPERABILITY test only.

12.3 LIQUID EFFLUENTS

12.3.1 Concentration

Operability Requirements

12.3.1.A.1 The concentration of radioactive material released from the site (see Zion Station ODCM Annex, Appendix F, Figure F-1) shall be limited to 10 times* the concentration values in Appendix B, Table 2, Column 2 to 10CFR20.1001-20.2402 for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the limit is shown in Table 12.3-1.

12.3.1.A.2 During the release of radioactive liquid wastes, a minimum dilution water flow rate of 44,000 gpm is required.

Applicability: At all times.

Action

1. With the concentration of radioactive materials released from the site to UNRESTRICTED AREAS exceeding the limits specified in Section 12.3.1.A, immediately decrease the release rate of radioactive materials and/or increase the dilution flow rate to restore the concentration to within the above limits.

Surveillance Requirements

12.3.1.B.1 The radioactivity content of each batch of radioactive liquid waste shall be determined prior to release by sampling and analysis in accordance with Table 12.3-2. The results of pre-release analyses shall be used with the calculational methods in the ODCM to assure that the concentration at the point of release is maintained within the limits of Section 12.3.1.A.

12.3.1.B.2 Post-release analyses of samples composited from BATCH RELEASES shall be performed in accordance with Table 12.3-2. The results of the previous post-release analyses shall be used with the calculational methods in the ODCM to assure that the concentrations at the point of release were maintained within the limits of Section 12.3.1.A.

12.3.1.B.3 The radioactivity concentration of liquids discharged from continuous release points shall be determined by collection and analysis of samples in accordance with Table 12.3-2. The results of the analysis shall be used with the calculational methods in the ODCM to assure that the concentrations at the point of release are maintained within the limits of Section 12.3.1.A.

12.3.1.B.4 At least two service water pumps or a circulating water pump shall be operational on the discharge path.

* Upon Technical Specification (TS) approval (submittal dated Nov. 10, 1993), the "10 times" may be used. Prior to TS approval, TS section 6.2 specifies the valid limits.

Bases

12.3.1.C This Section is provided to ensure that the concentration of radioactive materials released in liquid waste effluents from the site will be less than ten (10) times* the concentration levels specified in Appendix B, Table 2, Column 2 to 10CFR20.1001-20.2402. This limitation provides additional assurance that the levels of radioactive materials in bodies of water outside the site will result in exposures within (1) the Section II.A design objectives of Appendix I, 10 CFR 50, to an individual, and (2) the limits of 10CFR20.1301.

* Upon Technical Specification (TS) approval (submittal dated Nov. 10, 1993), the "10 times" may be used. Prior to TS approval, TS section 6.2 specifies the valid limits.

TABLE 12.3-1

ALLOWABLE CONCENTRATION OF DISSOLVED OR ENTRAINED NOBLE GASES RELEASED FROM THE SITE TO UNRESTRICTED AREAS IN LIQUID EFFLUENTS

NUCLIDE	AC(uCi/ml)*
Kr-85m	2×10^{-4}
Kr-85	5×10^{-4}
Kr-87	4×10^{-5}
Kr-88	9×10^{-5}
Ar-41	7×10^{-5}
Xe-131m	7×10^{-4}
Xe-133m	5×10^{-4}
Xe-133	6×10^{-4}
Xe-135m	2×10^{-4}
Xe-135	2×10^{-4}

* Computed from Equation 20 of ICRP Publication 2(1959), adjusted for infinite cloud submersion in water, and R = 0.01 rem/week, density = 1.0 g/cc and Pw/Pt = 1.0.

TABLE 12.3-2

RADIOACTIVE LIQUID EFFLUENT SAMPLING & ANALYSIS SURVEILLANCE

LIQUID RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS	LOWER LIMIT [a,e] OF DETECTION (LLD) (μCi/ml)
A. Lake Discharge Tank	Prior to Each Release (c)	Prior to Each Release	Principal Gamma Emitters	5E-7
			I-131	1E-6
	P One Batch/M(c)	M	Dissolved and Entrained Gases (Gamma Emitters(d))	1E-5
	P Each Batch (c)	M Composite (b)	Tritium	1E-5
			Gross Alpha	1E-7
	P Each Batch (c)	Q Composite (b)	Sr-89, Sr-90	5E-8
			Fe-55	1E-6
B. Turbine Building Fire Sump (f)	Continuous During Release (d)	W	Principal Gamma Emitters(c)	5E-7
			I-131	1E-6
			Dissolved and Entrained Gases (Gamma Emitters)	1E-5
	Continuous (d)	M Composite (b)	Tritium	1E-5
			Gross Alpha	1E-7
	Continuous (d)	Q (b) Composite (b)	Sr-89, Sr-90	5E-8
			Fe-55	1E-6
Waste Neutralizing Tank	Prior to each Release	Prior to each Release	Principal Gamma Emitter	5E-7
			I-131	1E-6
	P Each Batch (c)	M Composite (b)	Tritium	1E-5
			Gross Alpha	1E-7

TABLE 12.3-2
TABLE NOTATIONS
RADIOACTIVE LIQUID EFFLUENT SAMPLING & ANALYSIS SURVEILLANCE
(Cont'd)

a. The LLD is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

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

Where:

LLD is the lower limit of detection as defined above in picocuries (pCi) per unit mass or volume,

s_b is the square root of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute),

A is the number of gamma-rays emitted per disintegration for gamma-ray radio-nuclide analysis (A = 1.0) for gross alpha, strontium, and tritium measurement.

E is the counting efficiency (as counts per gamma),

V is the sample size (in units of mass or volume),

2.22 is the number of disintegrations per minute per picocurie,

Y is the fractional radiochemical yield when applicable (otherwise . = 1.0)

λ is the radioactive decay constant for the particular radionuclide, and

Δt is the elapsed time between midpoint of sample collection and time of counting (for plant effluents, not environmental sample).

The value of s_b used in the calculation of the LLD for a detection system shall be based on the actual observed variance of the background counting rate or of the counting rate of the blank samples (as appropriate) rather than on an unverified theoretically predicted variance. In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background shall include the typical contributions of other radionuclides normally present in the samples. Typical values of E, V, Y, and Δt shall be used in the calculation. The background count rate is calculated from the background counts that are determined to be within $\pm$ one FWHM (Full Width at Half Maximum) energy band about the energy of the gamma-ray peak used for the quantitative analysis for that radionuclide.

TABLE 12.3-2

TABLE NOTATIONS

RADIOACTIVE LIQUID EFFLUENT SAMPLING & ANALYSIS SURVEILLANCE
(Cont'd)

For certain mixtures of gamma emitters, it may not be possible to measure radionuclides in concentrations near their sensitivity limits when other nuclides are present in the sample in much greater concentrations. Under these circumstances, it will be more appropriate to calculate the concentrations of such radionuclides using observed ratios with those radionuclides which are measurable.

b. A COMPOSITE SAMPLE is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen which is representative of the liquids released.

1) To be representative of the quantities and concentrations of radioactive materials in liquid effluents, all samples taken for the composite shall be throughly mixed in order for the composite sample to be representative of the effluent release.

2) The weekly and monthly Proportional Composite samples are not required provided that (1) the analysis required for each of these composite samples has been run on each batch discharged, and (2) a monthly record of radionuclides discharged (isotope and quantity) is maintained.

c. A BATCH RELEASE is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated, and then thoroughly mixed to assure representative sampling.

d. A CONTINUOUS RELEASE is the discharge of liquid wastes of a nondiscrete volume; e.g., from a volume of system that has an input flow during the continuous release.

e. The principal gamma emitters for which the LLD specification applies exclusively are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144. This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses shall be reported as "less than" the nuclide's LLD, and shall not be reported as being present at the LLD level for that nuclide. The "less than" values shall not be used in the required dose calculations.

f. If the fire sump composite sampler is inoperable, grab samples will be taken from the turbine building fire sump once per shift.

12.3.2 Dose

Operability Requirements

12.3.2.A The dose or dose commitment to a MEMBER OF THE PUBLIC above background from radioactive materials in liquid effluents released from the site to UNRESTRICTED AREAS (see Zion Station ODCM Annex, Appendix F, Figure F-1) shall be limited:

1. During any calendar quarter to less than or equal to 3 mrem to the total body and to less than or equal to 10 mrem to any organ, and

2. During any calendar year to less than or equal to 6 mrem to the total body and to less than or equal to 20 mrem to any organ.

Applicability: At all times.

Action

1. With the calculated dose from the release of radioactive materials in liquid effluents exceeding twice the limits specified in Section 12.3.2.A, limit the subsequent releases such that the dose or dose commitment to a MEMBER OF THE PUBLIC from all uranium fuel cycle sources is limited to less than or equal to 25 mrem to the total body or any organ (except thyroid, which is limited to less than or equal to 75 mrem) over 12 consecutive months. Demonstrate that radiation exposures to all MEMBERS OF THE PUBLIC from all uranium fuel cycle sources (including all effluent pathways and direct radiation) are less than the 40CFR Part 190 and 40CFR Part 141 Standard, otherwise obtain a variance from the Commission to permit releases which exceed the 40CFR Part 141 or 190 Standard. The radiation exposure analysis shall use methods prescribed in the ODCM.

Surveillance Requirements

12.3.2.B Dose Calculations - Cumulative dose contributions from liquid effluents shall be determined by calculation at least once per month and a cumulative summation of these total body and any organ doses shall be maintained for each calendar quarter.

Bases

12.3.2.C This Section is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10CFR Part 50. The limiting Condition of Operation implements the guides set forth in Section II.A of Appendix I. The ACTION statements provide the required OPERATING flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents will be kept "As Low As Is Reasonably Achievable". Also, for fresh water sites with drinking water supplies, which can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40CFR 141. The dose calculations in the ODCM implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of an individual through appropriate pathways is unlikely to be substantially underestimated. The equations specified in the ODCM for calculating the dose due to the actual release rate of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109; Calculation of Annual Doses to Man from Routine Releases of Radioactive Effluents for the Purpose of Evaluating Compliance with 10CFR Part 50, Appendix I, Revision 1, October 1977 and Regulatory Guides 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I", April 1977.

This Section applies to the release of liquid effluents from the site. For shared radwaste treatment systems, the liquid effluents from the shared systems are proportioned among the units sharing the system.

12.3.3 Liquid Radwaste Treatment System

Operability Requirements

12.3.3.A The Liquid Radwaste Treatment System shall be OPERABLE.* The appropriate portions of the system shall be used to reduce the radioactive materials in liquid wastes prior to their discharge when the projected dose due to liquid effluent releases from the site to UNRESTRICTED AREAS (see Zion Station ODCM Annex, Appendix F, Figure F-1) when averaged over 31 days would exceed 0.13 mrem to the total body or 0.42 to any organ.

* The liquid Radwaste Treatment System shall be considered OPERABLE, if liquid waste can be held up and/or discharged within applicable limits.

Applicability: At all times.

Action With the Liquid Radwaste Treatment System inoperable for more than 30 days or with radioactive liquid waste being discharged without treatment and in excess of the above limits, return the system to OPERABLE status and place the appropriate portions of the system in use.

Surveillance Requirements

12.3.3.B Doses due to liquid releases from the site to UNRESTRICTED AREAS, shall be projected at least once per month in accordance with the ODCM.

Bases

12.3.3.C The OPERABILITY of the Liquid Radwaste Treatment System ensures that the system will be available for use whenever liquid effluents require treatment prior to release to the environment. The requirement that the appropriate portions of this system be used when specified, provides assurance that the releases of radioactive materials in liquid effluents will be kept "As Low As Is Reasonably Achievable". This Section implements the requirements of 10CFR Part 50.36a, General Design Criterion to of Appendix A to 10CFR Part 50 and the design objective given in Section II.D of Appendix I to 10CFR Part 50. The specified limits governing the use of appropriate portions of the Liquid Radwaste Treatment System were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10CFR Part 50, for liquid effluents.

12.4 GASEOUS EFFLUENTS

12.4.1 Dose Rate

Operating Requirements

12.4.1.A The dose rate due to radioactive materials released in gaseous effluents from the site (see Zion Station ODCM Annex, Appendix F, Figure F-1), shall be limited to the following:

1. For noble gases: Less than or equal to a dose rate of 500 mrem/yr to the whole body and less than or equal to a dose rate of 3000 mrem/yr to the skin, and
2. For Iodine-131, Iodine-133 and for all radionuclides in particulate form with half-lives greater than 8 days: Less than or equal to a dose rate of 1500 mrem/yr to any organ.

Applicability: At all times.

Action

With a release exceeding the above limits, immediately reduce the release rate to within the above limits.

Surveillance Requirements

12.4.1.B.1 The dose rate due to radioactive materials in gaseous effluents shall be determined to be within the prescribed limits in accordance with the methods and procedures of the ODCM.

12.4.1.B.2 The dose rate due to radioactive materials, other than noble gases in gaseous effluents shall be determined to be within the prescribed limits in accordance with the methods and procedures of the ODCM by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 12.4-1.

Bases

12.4.1.C This Section is provided to ensure that the dose at the UNRESTRICTED AREA boundary from gaseous effluents from all units on the site will be within the annual dose limits stated in 10CFR20.1301. The specified release rate limits restrict, at all times, the corresponding gamma and beta dose rates above background to an individual at or beyond the UNRESTRICTED AREA boundary to a dose rate of 500 mrem/year to the total body or to less than or equal to a dose rate of 3000 mrem/year to the skin. These release rate limits also restrict, at all times, the corresponding thyroid dose rate above background via the inhalation pathway to less than or equal to a dose rate of 1500 mrem/year. For purposes of calculating dose resulting from airborne releases, the two stacks are considered a ground release.

TABLE 12.4-1

RADIOACTIVE GASEOUS EFFLUENT SAMPLING AND ANALYSIS PROGRAM

GASEOUS RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS	LOWER LIMIT OF DETECTION (LLD) (e) µCi/cc
A. Gas Decay Tank	Grab Sample Prior to Each Release	Prior to Each Release (c)	Noble Gases Pricipal Gamma Emitters (d)	1E-4
	Continuous Sample During Each Release	After Each Release (c)	Particulate Principal Gamma Emitters (d)	1E-11
			Tritium	1E-6
			I-131 (Charcoal Sample)	1E-12
			I-133 (Charcoal Sample)	1E-10
	Compcsite	Quarterly(c)	Sr-89 Particulate	1E-11
			Sr-90 Particulate	1E-11
			Gross Alpha	1E-11
B. Containment Vent and Purge	Prior to Each Release (a)	Prior to Each Release (c)	Principal Gaseous Gamma Emitters(d)	1E-4
			Particulate Gamma Emitters(d)	1E-11
			Tritium	1E-6
			I-131 (Charcoal)	1E-12
			I-133 (Charcoal)	1E-10
	Composite	Quarterly (c)	Sr-89 Particulate	1E-11
			Sr-90 Particulate	1E-11
			Gross Alpha	1E-11

TABLE 12.4-1

RADIOACTIVE GASEOUS EFFLUENT SAMPLING AND ANALYSIS PROGRAM
(Cont'd)

GASEOUS RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS	LOWER LIMIT OF DETECTION (LLD) (μCi/cc)
C. Continuous Release Points 1. Air Ejector for Both (2) Units 2. Aux Bldg Vent for Both (2) Units 3. Misc. Ventiltn. Stack 4. Serv. Bldg. Vent 5. Cont. Purge for Both (2) Units 6. Turbine Bldg.	Grab (b)	Monthly	Principal Gaseous and Gamma Emitters	1E-4
	Continuous (b)	Monthly	Tritium	1E-6
	Continuous (b)	Weekly	I-131 (Charcoal Sample)	1E-12
			I-133 (Charcoal Sample)	1E-10
	Continuous (b)	Weekly (c)	Particulate Principal Gamma Emitters	1E-11
	Composite	Quarterly (c)	Sr-89 Particulate	1E-11
			Sr-90 Particulate	1E-11
			Gross Alpha	1E-11

TABLE 12.4-1

TABLE NOTATIONS

RADIOACTIVE GASEOUS EFFLUENT SAMPLING AND ANALYSIS PROGRAM
(Cont'd)

a. Should a shutdown, startup or power change greater than 50% occur which could alter the mixture of radionuclides after sampling, another analysis shall be performed prior to release.

b. The ratio of the sample flow rate to the sampled stream flow rate shall be known for the time period in Section 12.4.1.

c. The particulate filter(s) from this/these release point shall be saved for a quarterly composite analysis for Sr-89 and Sr-90.

d. The principal gamma emitters for which the LLD specification applies exclusively are the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 for gaseous emissions, and Mn-54, Fe-59, Co-60, Zn-65, Co-58, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144 for particulate emissions. Other peaks which are measurable and identifiable by gamma-ray spectrometry, together with the above nuclides, shall also be identified and reported when an actual analysis is performed on a sample. Nuclides which are below the LLD for the analyses shall not be reported as being at the LLD level for that nuclide.

e. The LLD is defined in Notation a of Table 12.3-2.

12.4.2 Dose - Noble Gases

Operability Requirements

12.4.2.A The air dose due to noble gases released in gaseous effluents from the site (see Zion Station ODCM Annex, Appendix F, Figure F-1) shall be limited to the following:

1. During any calendar quarter: Less than or equal to 5 mrad for gamma radiation and less than or equal to 10 mrad for beta radiation, and

2. During any calendar year: Less than or equal to 10 mrad for gamma radiation and less than or equal to 20 mrad for beta radiation.

Applicability: At all times

Action

1. With the calculated air dose from gaseous effluents exceeding the above limits, define the corrective action(s) to be taken to ensure that future releases are in compliance with Section 12.4.2.A.

2. With the calculated air dose from radioactive noble gases in gaseous effluents exceeding twice the limits of Section 12.4.2.A:

   a. Limit subsequent releases such that the dose or dose commitment to a MEMBER OF THE PUBLIC from all uranium fuel cycle sources is limited to less than or equal to 25 mrem to the total body or any organ (except the thyroid, which is limited to less than or equal to 75 mrem) over 12 consecutive months.

   b. Prepare an analysis which demonstrates that radiation exposures to all MEMBERS OF THE PUBLIC from all uranium fuel cycle sources (including all effluents pathways and direct radiation) are less than the 40 CFR Part 190 Standard.

Surveillance Requirements

12.4.2.B Cumulative dose contributions for the current calendar quarter and current calendar year for noble gases shall be determined in accordance with the ODCM at least once every 31 days.

Bases

12.4.2.C This Section implements the requirements of Sections II.B, III.A and IV.A of Appendix I, 10CFR Part 50. The Operability Requirements implement the guides set forth in Section II.B of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in gaseous effluents will be kept "As Low As Is Reasonably Achievable". The Surveillance Requirements implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I is to be shown by calculation procedures based on models and data such that the actual exposure of an individual through the appropriate pathways is unlikely to be substantially underestimated.

12.4.3 Dose - Radioiodine - Particulate - Other Than Noble Gas

Operability Requirements

12.4.3.A The dose to a MEMBER OF THE PUBLIC from radioiodine and radioactive materials in particulate form and radionuclides (other than noble gases) with half-lives greater than 8 day in gaseous effluents released from the site (see Zion Station ODCM Annex, Appendix F, Figure F-1) shall be limited to the following:

1. During any calendar quarter: Less than or equal to 7.5 mrem to any organ, and

2. During any calendar year: Less than or equal to 15 mrem to any organ.

Applicability: At all times.

Action

With the calculated dose from the release of Iodine-131, Iodine-133, tritium and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents exceeding twice the limits of Section 12.4.3.A:

1. Limit subsequent releases such that the dose or dose commitment to a MEMBER OF THE PUBLIC from all uranium fuel cycle sources to less than or equal to 25 mrem to the total body or organ (except the thyroid which is limited to less than or equal to 75 mrem) over 12 consecutive months.

2. Prepare an analysis which demonstrates that radiation exposures to all MEMBERS OF THE PUBLIC from all uranium fuel cycle sources (including all effluent pathways and direct radiation) are less than the 40CFR Part 190 Standard. Otherwise, request a variance from the Commission to permit release which exceeds the 40CFR Part 190 Standard. The radiation exposure analysis shall use the methods prescribed in the ODCM.

Surveillance Requriements

12.4.3.B Cumulative dose contribution for the current calendar quarter and current calendar year for radioiodines, radioactive materials in particulate form and radionuclides (other than noble gas) with half-lives greater than 8 days shall be determined in accordance with the ODCM at least once per 31 days.

Bases

12.4.3.C This Section implements the requirements of Sections II.C, III.A and IV.A of Appendix I, 10CFR Part 50. The Operability Requirements are the guides set forth in Section II.C of Appendix I. The ACTION statements provide the required operating flexibility and at the same time, implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents will be kept "As Low As Is Reasonably Achievable". The ODCM calculation methods specified in the Surveillance Requirements implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I is to be shown by calculational procedures based on models and data such that the actual exposure of an individual through appropriate pathways is unlikely to be substantially underestimated. The release rate specifications for radioiodines, radioactive material in particulate form and radioiodines other than noble gases are dependent on the existing radionuclide pathways to man, in the UNRESTRICTED AREA. The pathways which are examined in the development of these calculations are: 1) individual inhalation of airborne radionuclides, 2) disposition of radionuclides onto green leafy vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man.

12.5 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

12.5.1 Monitoring Program

Operability Requirements

12.5.1.A The Radiological Environmental Monitoring Program shall be conducted as specified in Table 12.5-1.

Applicability: At all times.

Action

1. With the Radiological Environmental Monitoring Program not being conducted as specified in Table 12.5-1, prepare and submit to the Commission, in the Annual Radiological Environmental Operating Report, a description of the reasons for not conducting a program as required and the plans for preventing a recurrence.

   Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailibility, contractor omission which is corrected as soon as discovered, malfunction of sampling equipment, or if a person who participates in the program by providing samples goes out of business.

   If the equipment malfunctions, corrective actions shall be completed as soon as practical. If a person supplying samples goes out of business, a replacement will be found as soon as possible. All deviations from the sampling schedule shall be described in the Annual Radiological Environmental Operating Report.

2. With the level of radioactivity in an environmental sampling medium at one or more of the location specified in the ODCM exceeding the limits of Table 12.5-2, when averaged over any calendar quarter, prepare and submit to the Commission within 30 days from the end of the affected calendar quarter, a Special Report which includes an evaluation of any release conditions, environmental factors, or other aspects which caused the limits of Table 12.5-2 to be exceeded. This report is not required, if the measured level of radioactivity was not the result of plant effluents; however, in such a event, the condition shall be reported and described in the Annual Radiological Environmental Operating Report.

12.5.1 Monitoring Program - Continued

3. With milk samples unavailable from any of the sample locations required by Table 12.5-1, identify locations for obtaining replacement samples and add them to the Radiological Environmental Monitoring Program within 30 days. The locations from which samples were unavailable may then be deleted from the program. Identify the cause of the unavailability of samples in the Annual Radiological Environmental Operating Report and also include in the report a revised figure(s) and table for the ODCM reflecting the new location(s).

Surveillance Requirements

12.5.1.B.1 The Radiological Environmental Monitoring samples shall be collected from the locations specified in the ODCM and analyzed pursuant to Table 12.5-1 and the detection capabilities required by Table 12.5-3.

12.5.1.B.2 The results of analyses performed on the Radiological Environmental Monitoring Program samples shall be summarized in the Annual Radiological Environmental Operating Report. See Section 12.6.1.

Bases

12.5.1.C The Radiological Environmental Monitoring Program required by Table 12.5-1 provides for measurement of radiation and of radioactive materials in those exposure pathways and for those radionuclides, which lead to the highest potential radiation exposures of individuals resulting from the station operation. This monitoring program thereby supplements the Radiological Effluent Monitoring Program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and modeling of the environmental exposure pathways. Changes to the initially specified monitoring program may be initiated based on operational experience.

The detection capabilities required by Table 12.5-3 are state of-the-art for routine environmental measurements in industrial laboratories. The specified lower limits of detection for I-131 in water, milk and other food products correspond to approximately one-quarter of the Appendix I to 10CFR Part 50 design objective dose-equivalent of 15 mrem/year for atmospheric releases and 10 mrem/year for liquid releases to the most sensitive organ and individual. They are based on the assumption given in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR Part 50, Appendix I", October 1977, except the change for an infant consuming 330 liters/year of drinking water instead of 510 liters/year.

TABLE 12.5-1

ZION RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

SAMPLE MEDIA	COLLECTION SITE	TYPE OF ANALYSIS	FREQUENCY
1. Airborne	(A) Onsite and near field	a) Filter-gross beta[2]	a) Weekly
	(1) Onsite Station #1 (2) Onsite Station #2 (3) Onsite Station #3	b) Charcoal-I-131	b) Bi-Weekly[1]
		c) Sampling Train - Test and Maintenance	c) Weekly
	(B) Offsite - Far Field		
	10 Locations	a) Filter Exchange b) Charcoal Exchange c) Sampling Train - Test and Maintenance	a) Weekly b) Bi-Weekly[1] c) Weekly
2. Direct Radiation (TLD)	Forty locations (minimum of two TLD's per packet)	Gamma Radiation Dose	Quarterly

TABLE 12.5-1

ZION RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
(Cont'd)

EXPOSURE PATHWAY AND/OR SAMPLE MEDIA	COLLECTION SITE	TYPE OF ANALYSIS	FREQUENCY
3. Waterborne			
A. Public Water Supply	6 Locations	a) Gamma Isotopic	a) Monthly Analysis of weekly composites
		b) Tritium	b) Quarterly Composite
B. Cooling Water Sample	(1) Inlet	a) Gross Beta	a) Weekly
	(2) Discharge	b) Tritium	b) Quarterly Composite
C. Sediment	Lake Michigan Shoreline 1 Location	Gamma Isotopic	Semiannually
4. Ingestion			
A. Milk	2 Dairy Farms	I-131 and gamma isotopic	Semi-Monthly - May to Oct, Monthly at all other times.
B. Fish	Lake Michigan Near Zion Station	Gamma Isotopic on edible portions	Semiannually

TABLE 12.5-1

ZION RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
(Cont'd)

EXPOSURE PATHWAY AND/OR SAMPLE MEDIA	COLLECTION SITE	TYPE OF ANALYSIS	FREQUENCY
4. Ingestion (Continued)			
C. Food Products	Samples of three different kinds of broad leaf vegetation grown nearest each of two different offsite locations of highest predicted annual average ground-level D/Q if milk sampling is not performed.	Gamma isotopic and I-131 analysis.	Monthly when available.
	One sample of each of the similar broad leaf vegetation grown 15 to 30 km distant in the least prevalent wind direction if milk sampling is not performed.	Gamma isotopic and I-131 analysis.	Monthly when available.

Footnotes:

1. Bi-Weekly shall mean at the frequency of once every other week.

2. A gamma isotopic analysis shall be performed whenever the gross beta concentration in a sample exceeds by five times (5x) the average concentration of the proceeding calendar quarter for the sample location.

TABLE 12.5-2

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/Kg, wet)	Milk (pCi/l)	Food Products (pCi/Kg, wet)
H-3	$2x10^4$ (a)				
Mn-54	$1X10^3$		$3x10^4$		
Fe-59	$4x10^2$		$1x10^4$		
Co-58	$1x10^3$		$3x10^4$		
Co-60	$3x10^3$		$1x10^4$		
Zn-65	$3x10^2$		$2x10^4$		
Zr-Nb-95	$4x10^2$ (b)				
I-131	2	0.9		3	$1x10^2$
Cs-134	30	10	$1x10^3$	60	$1x10^3$
Cs-137	50	20	$2x10^3$	70	$2x10^3$
Ba-La-140	$2x10^2$ (b)			$3x10^2$	

(a) For drinking water samples. This is 40 CFR Part 141 value.

(b) Total for parent and daughter

TABLE 12.5-3

MAXIMUM VALUES FOR THE LOWER LIMITS OF DETECTION

(LLD) a,b

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/Kg, wet)	Milk (pCi/l)	Food Products (pCi/Kg, wet)	Sediment (pCi/kg, dry)
gross Beta	4[b]	$1x10^{-2}$				
gamma isotopic		$1x10^{-1}$			---	
H-3	2000(1000[b])					
Mn-54	15		130			
Fe-59	30		260			
Co-58,60	15		130			
Zn-65	30		260			
Zr-Nb-95	15[c]					
I-131	1[b]	$7x10^{-2}$		1	60	
Cs-134,137	15(10[b]),18	$1x10^{-2}$	130	15	60	150
Ba-La-140	15[c]			15[c]		

TABLE 12.5-3

TABLE NOTATIONS
(Cont'd)

a. The LLD is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with only 5% probability of falsely concluding its presence.

For a particular measurement system (which may include radiochemical separation):

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

Where:

LLD is the lower limit of detection as defined above (as pCi per unit mass or volume)

s_b is the square root of the background count or of the count of a blank sample as appropriate (as counts per minute)

A is the number of gamma-rays emitted per disintegration for gamma-ray radio-nuclide analysis
(A = 1.0 for gross alpha, strontium, and tritium measurements)

E is the counting efficiency (as counts per gamma)

V is the sample size (in units of mass or volume)

2.22 is the number of transformations per minute per picocurie

Y is the fractional radiochemical yield when applicable (otherwise Y = 1.0)

λ is the radioactive decay constant for the particular radionuclide, and

Δt is the elapsed time between sample collection and analysis.

The value of s_b used in the calculation of the LLD for a detection system shall be based on the actual observed background count or of the count of the blank samples (as appropriate) rather than on an unverified theoretically predicted value. Typical values of E, V, Y, Δt, shall be used in the calculation.

TABLE 12.5-3

TABLE NOTATIONS
(Cont'd)

a. (Cont'd)

For gamma ray radionuclide analyses the background counts are determined from the total counts in the channels which are within plus or minus one FWHM (Full Width at Half Maximum) of the gamma ray photopeak energy normally used for the quantitative analysis for that radionuclide. Typical values of the FWHM shall be used in the calculation.

b. The LLD for environmental measurement 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.

c. LLD for drinking water.

12.5.2 Land Use Census

Operability Requirements

12.5.2.A A Land Use Census shall be conducted to identify the location of the nearest residences and of animals producing milk for human consumption in each of the following meteorological sectors, A, J, K, L, M, N, P, Q and R within a distance of 5 miles.

Applicability: At all times.

Action

1. With a Land Use Census identifying a location which yields an ODCM calculated dose or dose commitment greater than the values currently being calculated in Section 12.4.3.A, this new location shall be added to the Radiological Environmental Monitoring Program within 30 days. The sampling location excluding the control station location having the lowest calculated dose or dose commitment (via the same exposure pathways), may be deleted from this monitoring program after October 31 of the year in which this Land Use Census was conducted.

Surveillance Requirements

12.5.2.B.1 The Land Use Census shall be conducted at least once per 12 months between the dates of June 1 and October 1, by a door-to-door survey, road survey, aerial survey, or by consulting local agriculture authorities.

12.5.2.B.2 The results of the Land Use Census shall be included in the Annual Radiological Environmental Operating Report.

Bases

12.5.2.C The Land Use Census Section is provided to ensure that changes in the use of UNRESTRICTED AREAS are identified and that the modifications to the monitoring program are made, if required, by the results of this census. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10CFR Part 50.

12.5.3 Interlaboratory Comparison Program

Operability Requirements

12.5.3.A Analysis shall be performed on radioactive materials supplied as part of an Interlaboratory Comparison Program which has been approved by the Commission.

Applicability: At all times.

Action

1. With analysis not being performed as required above, report the corrective actions taken to prevent a recurrence to the Commission in the Annual Radiological Environmental Operating Report.

Surveillance Requirements

12.5.3.B A summary of the results obtained as part of the above required Interlaboratory Comparison Program and in accordance with the ODCM shall be included in the Annual Radiological Environmental Operating Report.

Bases

12.5.3.C The requirement for participation in the Interlaboratory Comparison (crosscheck) Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive materials in environmental sample matrices are performed as part of the Quality Assurance Program for environmental monitoring in order to demonstrate that the results are reasonably valid.

12.6 REPORTING REQUIREMENTS

12.6.1 Annual Radiological Environmental Operating Report

An Annual Radiological Environmental Operating Report containing the data taken in the Radiological Environmental Monitoring Program Table 12.5-1, shall be submitted by April 30 of the following year. The content of the report shall include:

1. Results of Radiological Environmental Sampling, summarized and tabulated, following the format of Regulatory Guide 4.8, Table 1 (December 1975); individual sample results will be retained at the station; in the event that some results are not available for inclusion with the report, the report shall be submitted noting and explaining the reason for the missing results. The missing data shall be submitted as soon as possible in a supplementary report.

2. An assessment of the monitoring results and radiation dose via the principal pathways of exposure resulting from plant emissions of radioactivity; including maximum noble gas gamma and beta air doses in the UNRESTRICTED AREA (dose calculations shall be performed in accordance with the ODCM).

3. Results of the census to determine the locations of animals producing milk for human consumption.

4. A summary of the meteorological conditions concurrent with the release of gaseous effluents during each quarter as outlined in Regulatory Guide 1.21 (Revision 1) dated June, 1974, following the format of Appendix B thereof.

5. A summary description of the Radiological Environmental Monitoring Program.

6. A map of all sampling locations keyed to a table giving approximate distances and directions from one reactor.

7. The results of the Interlaboratory Comparison Program required by Section 12.5.3.A.

12.6 **REPORTING REQUIREMENTS** (Continued)

8. This report shall also include an annual summary of hourly meteorological data collected over the previous year. This annual summary may be either in the form of an hour-by-hour listing of wind speed, wind direction, atmospheric stability, and precipitation (if measured) on magnetic tape, or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability. This same report shall include an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the station during the previous calendar year. This same report shall also include an assessment of the radiation doses from the radioactive liquid and gaseous effluents to individuals due to their activities inside the SITE BOUNDARY (see Zion Station ODCM Annex, Appendix F, Figure F-1) during the report period. All assumption used in making these assessments (i.e., specific activity, exposure time and location) shall be included in these reports. The meteorological conditions concurrent with the time of release of radioactive materials in gaseous effluents (as determined by sampling frequency and measurement) shall be used for determinating the gaseous pathways doses. The assessment of radiation doses shall be performed in accordance with the ODCM.

   This report shall also include an assessment of radiation doses to the most likely exposed real individual from reactor releases and other nearby uranium fuel cycle sources (including doses from primary effluents pathways and direct radiation) for the previous 12 consecutive months to show conformance with 40 CFR 190, Environmental Radiation Protection Standards for Nuclear Power Operation. Acceptable methods for calculating the dose contribution from liquid and gaseous effluents are given in Regulatory Guide 1.109, Rev. 1.

9. This report shall also include a special report pursuant to the requirements of the Technical Specification 3.3.6, whenever the reactor coolant specific activity limits have been exceeded.

12.6.2 Annual Radioactive Effluent Release Report

Prior to April 1 of the following year, a report shall be submitted covering the radioactive content of effluents released to UNRESTRICTED AREAS during the previous six months operation. The data shall be in the format of Regulatory Guide 1.21, Rev. 1 (June 1974) and shall be summarized on a quarterly basis and shall include as a minimum:

1. Gaseous Effluents:

   a. Gross Radioactivity Releases:

      1) Total gross radioactivity (in curies) primarily noble and activation gases released.

      2) Maximum gross radioactivity release rate during any one-hour period.

      3) Total gross radioactivity (in curies) by nuclide releases, based on representative isotopic analyses performed.

      4) Percent of ODCM limits.

   b. Iodine Releases:

      1) Total iodine radioactivity (in curies) by nuclide released, based on representative isotopic analyses performed.

      2) Percent of ODCM limits for I-131 released.

   c. Particulate Releases:

      1) Total gross radioactivity (Beta-Gamma) released (in curies) excluding background radioactivity.

      2) Total gross Alpha radioactivity released (in curies) excluding background radioactivity.

      3) Total gross radioactivity released (in curies) of nuclides with half-lives greater than 8 days.

      4) Percent of ODCM limits for particulate radioactivity with half-lives greater than 8 days.

2. Liquid Effluents:

   a. Total gross radioactivity (Beta-Gamma) released (in curies) excluding tritium and average concentration released to the UNRESTRICTED AREA.

   b. Total tritium and total Alpha radioactivity released (in curies) and average concentration released to the UNRESTRICTED AREA.

   c. Total dissolved noble gas radioactivity released (in curies) and average concentration released to the UNRESTRICTED AREA.

   d. Total volume (in liters) of liquid waste released.

   e. Total volume (in liters) of dilution water used prior to release from the restricted area.

   f. The maximum concentration of gross radioactivity (Beta-Gamma) released to the UNRESTRICTED AREA (average over the period of released).

   g. Total gross radioactivity (in curies) by nuclide released, based on representative isotopic analyses performed.

   h. Percent of ODCM limit.

3. Solid Radioactive Waste:

   Refer to the Annual Reporting Requirements provided in the Process Control Program (PCP).

4. The radioactive effluent release reports shall include unplanned releases from the site to UNRESTRICTED AREAS of radioactive materials in gaseous and liquid effluents on a quarterly basis.

12.6.3 Unique Reporting Requirements

Non-Routine Reports:

1. Radiological Environmental Monitoring Program:

   If a confirmed measured radionuclide concentration in an environmental sampling medium averaged over any calendar quarter sampling period exceeds the reporting level given in Table 12.5-2 and if the radioactivity is attributable to plant operation, a written report shall be submitted to the Director of the NRC Regional Office of Inspection and Enforcement with a copy to the Director, Office of Nuclear Reactor Regulation within 30 days from the end of the quarter. When more than one of the radionuclides in Table 12.5-2 are detected in the medium, the reporting level shall have been exceeded if:

   $$\frac{C_i}{RL_i} \geq 1$$

   where C is the concentration of the ith radionuclides in the medium and RL is the reporting level of radionuclide i.

2. If radionuclides other than those in Table 12.5-2 are detected and are due to plant effluents, a reporting level is exceeded if the potential annual dose of an individual is equal to or greater than the design objective doses of 10 CFR 50, Appendix I.

3. This report shall include an evaluation of any release conditions, environmental factors, or other aspects necessary to explain the anomalous effect.

12.6.4 Offsite Dose Calculation Manual (ODCM)

Changes to the ODCM:

a. Shall be documented and records of reviews performed shall be retained as required by Specification 6.5.2. This documentation shall contain:

1. Sufficient Information to support the change together with the appropriate analyses or evaluations justifying the change(s); and

2. A determination that the change will maintain the level of radioactive effluent control required by 10 CFR 20, 106, 40 CFR Part 190, 10 CFR 50.36a, and Appendix I to 10 CFR Part 50 and not adversely impact the accuracy or reliability of effluent, dose, or setpoint calculations.

3. Documentation of the fact that the change has been reviewed and found acceptable by both the Onsite and Offsite Review Functions.

b. Shall become effective after review and acceptance by the Onsite Review and Investigative Function, the Offsite Review and Ivestigative Function, and the approval of the Plant Manager on the date specified by the Onsite Review and Investigative Function.

c. Shall be submitted to the Commission in the form of a complete, legible copy of the entire ODCM as a part of or concurrent with the Annual Radioactive Effluent Release Report for the period of the report in which any change to the ODCM was made effective. Each change shall be identified by markings in the margin of the affected pages, clearly indicating the area of the page that was changed, and shall indicate the date (e.g., month/year) the change was implemented.

ZION ANNEX INDEX

APPENDIX F

STATION-SPECIFIC DATA FOR ZION

UNITS 1 AND 2

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STATION-SPECIFIC DATA FOR ZION UNITS 1 AND 2

F.1 INTRODUCTION

This appendix contains data relevant to the Zion site. Included is a figure showing the unrestricted area boundary and values of parameters used in offsite dose assessment.

F.2 REFERENCES

1. Sargent & Lundy, Analysis nd Technology Division, Calculations Nos. ATD-0129, Revision 0, and ATD-0090, Revision 0.

2. "Verification of Environmental Parameters used for Commonwealth Edison Company's Offsite Dose Calculations", NUS Corporation, 1988.

3. "Verification of Environmental Parameters used for Commonwealth Edison Company's Offsite Dose Calculations", NUTECH Engineering Group, 1992.

Table F-1

Aquatic Environment Dose Parameters

General Information[a]

The existence of irrigation is not mentioned in Zion Environmental Report.

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

Water and Fish Ingestion Parameters

Parameter[b]	Value
U^w, water usage, L/hr	0.083
U^f, fish consumption, kg/hr	2.4E-3
M^w, M^f	1/60[b], 1.0[b]
F^w, cfs[b,c]	F^c(gpm)/448.86
F^f, cfs	4.0E5
t^f, hr[d]	24.0
t^w, hr[e]	5.5

Limits on Radioactivity in Unprotected Outdoor Tanks[f]

Outside Temporary Radioactive Liquid Storage Tank	≤ 10 Ci[g]

(per Technical Specification 3.11.1)

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[a] This is based on information in the Zion Environmental Report Section 2.3.2.2.

[b] The parameters are defined in Section A.2.1 of Appendix A. Based on the Lake Michigan Model discussed in Section C.1.3.1.2 of Appendix C.

[c] F^c is the average flow of condenser cooling water (gpm) during the period of discharge (either Unit 1 or 2). The constant 448.86 is the number of gpm per cfs.

[d] t^f (hr) = 24 hr (all stations) for the fish ingestion pathway.

Table F-1

Aquatic Environment Dose Parameters - Continued

[e] t^{*} (hr) = 5.5 hr (distance to the nearest public potable water intake, Lake County, is 1.1 mile north of the station and 3000 ft out in Lake Michigan; flow rate of 0.2 mph).

[f] See Section A.2.4 of Appendix A.

[g] Tritium and dissolved or entrained gases are excluded from this limit.

Table F-2
Station Characteristics

STATION: Zion Nuclear Power Station

LOCATION: Zion, Illinois

CHARACTERISTICS OF ELEVATED RELEASE POINT: Not Applicable (NA)

1) Release Height = _____m 2) Diameter = _____m

3) Exit Speed = _____ms^{-1} 4) Heat Content = _____KCal s^{-1}

CHARACTERISTICS OF VENT STACK RELEASE POINT

1) Release Height = 55.32 m* 2) Diameter = 2.32 m

3) Exit Speed = 11.2 ms^{-1}*

CHARACTERISTICS OF GROUND LEVEL RELEASE

1) Release Height = 0 m

2) Building Factor (D) = 57.6 m*

METEOROLOGICAL DATA

A 250 ft Tower is Located 700 m NNW of elevated release point

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Tower Data Used in Calculations

Release Point	Wind Speed and Direction	Differential Temperature
Elevated	(NA)	(NA)
Vent	125	250-35
Ground	35	250-35

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*Used in calculating the meteorological and dose factors in Tables F-5, F-6, F-7. See Sections B.3 through B.6 of Appendix B.

Table F-3
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	469	375	4000	None
NNE	475	400	d	None
NE	400	325	d	None
ENE	400	200	d	None
E	400	175	d	None
ESE	400	175	d	None
SE	400	175	d	None
SSE	400	200	d	None
S	433	350	d	None
SSW	439	375	3700	None
SW	518	475	2000	None
WSW	671	671	2000	None
W	658	658	1100	None
WNW	893	893	2000	None
NW	847	847	2000	None
NNW	725	250	2400	None

[a]Used in calculating the meteorological and dose factors in Tables F-5 and F-7. See Sections B.3 through B.6 of Appendix B.

[b]1992 annual survey by Teledyne Isotopes Midwest Laboratories. The distances are rounded to the nearest conservative 100 meters.

[c]1992 annual milch animal census by Teledyne Isotopes Midwest Laboratories. Used in calculating the D/Q values in Table F-6. The distances are rounded to the nearest conservative 100 meters.

[d]Lake Michigan.

Table F-4

Average Wind Speeds

Downwind Direction	Average Wind Speed (m/sec)[a] Mixed Mode	Ground Level
N	5.0	3.2
NNE	5.3	3.3
NE	5.8	4.1
ENE	5.6	3.9
E	5.7	3.9
ESE	5.1	3.3
SE	4.9	3.0
SSE	5.1	3.4
S	5.9	4.6
SSW	5.8	4.4
SW	5.1	4.0
WSW	5.2	4.6
W	5.1	4.4
WNW	4.8	3.7
NW	4.7	3.1
NNW	5.1	3.9

[a]Calculated in Reference 1 of Section F.2 using formulas in Section B.1.3 of Appendix B. Based on Zion site meteorological data. January 1979 through December 1987.

Table F-5

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

Downwind Direction	Mixed Mode(Vent) Release				Ground Level Release			
	Radius (meters)	X/Q (sec/m**3)	Radius (meters)	D/Q (1/m**2)	Radius (meters)	X/Q (sec/m**3)	D/Q (1/m**2)	
N	469.	2.032E-06	469.	1.168E-08	469.	9.548E-06	3.680E-08	
NNE	475.	1.792E-06	475.	9.983E-09	475.	1.004E-05	3.256E-08	
NE	400.	2.710E-06	400.	1.997E-08	400.	1.386E-05	5.708E-08	
ENE	400.	2.180E-06	400.	1.734E-08	400.	1.160E-05	4.855E-08	
E	400.	1.949E-06	400.	1.889E-08	400.	1.169E-05	5.211E-08	
ESE	400.	1.650E-06	400.	1.319E-08	400.	1.280E-05	4.730E-08	
SE	400.	1.646E-06	400.	1.237E-08	400.	1.312E-05	4.985E-08	
SSE	400.	1.001E-06	400.	9.230E-09	400.	7.852E-06	3.238E-08	
S	433.	1.272E-06	433.	1.524E-08	433.	7.058E-06	3.562E-08	
SSW	439.	9.650E-07	439.	1.357E-08	439.	5.768E-06	3.290E-08	
SW	518.	4.590E-07	518.	6.031E-09	518.	3.125E-06	1.625E-08	
WSW	671.	2.311E-07	671.	3.509E-09	671.	1.393E-06	8.964E-09	
W	658.	2.394E-07	658.	3.381E-09	658.	1.445E-06	8.440E-09	
WNW	893.	1.427E-07	893.	1.869E-09	893.	8.817E-07	4.789E-09	
NW	847.	2.110E-07	847.	2.671E-09	847.	1.310E-06	6.607E-09	
NNW	725.	3.740E-07	725.	4.535E-09	725.	2.038E-06	1.148E-08	

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Note: Based on the formulas in Sections B.3 and B.4 of Appendix B.

X/Q is used for beta skin, and inhalation dose pathways. See Sections A.1.2, A.1.3, and A.1.4.2 of Apprendix A.

D/Q is used for produce and leafy vegetable pathways. Section A.1.4 of Appendix A.

The mixed mode level release data are provided for reference purposes only. Routine dose calculations are performed using ground level data.

Radius is the approximate distance from the midpoint between gaseous effluent release points to the location of highest X/Q or D/Q at or beyond the unrestricted area boundary (UAB).

Table F-5a

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

Downwind Direction	Mixed Mode(Vent) Release				Ground Level Release			
	Radius (meters)	X/Q (sec/m**3)	Radius (meters)	D/Q (1/m**2)	Radius (meters)	X/Q (sec/m**3)	D/Q (1/m**2)	
N	375.	3.015E-06	375.	1.605E-08	375.	1.420E-05	5.165E-08	
NNE	400.	2.426E-06	400.	1.278E-08	400.	1.363E-05	4.230E-08	
NE	325.	3.917E-06	325.	2.653E-08	325.	2.009E-05	7.781E-08	
ENE	200.	7.441E-06	200.	4.345E-08	200.	4.027E-05	1.330E-07	
E	175.	8.400E-06	175.	5.512E-08	175.	5.177E-05	1.719E-07	
ESE	175.	7.025E-06	175.	3.590E-08	175.	5.670E-05	1.559E-07	
SE	175.	7.002E-06	175.	3.298E-08	175	5.811E-05	1.644E-07	
SSE	200.	3.362E-06	200.	2.113E-08	200.	2.730E-05	8.871E-08	
S	350.	1.851E-06	350.	2.054E-08	350.	1.031E-05	4.906E-08	
SSW	375.	1.270E-06	375.	1.676E-08	375.	7.631E-06	4.174E-08	
SW	475.	5.307E-07	475.	6.818E-09	475.	3.626E-06	1.858E-08	
WSW	671.	2.311E-07	671.	3.509E-09	671.	1.393E-06	8.964E-09	
W	658.	2.394E-07	658.	3.381E-09	658.	1.445E-06	8.440E-09	
WNW	893.	1.427E-07	893.	1.869E-09	893.	8.817E-07	4.789E-09	
NW	847.	2.110E-07	847.	2.571E-09	847.	1.310E-06	6.607E-09	
NNW	250.	2.279E-06	250.	1.778E-08	250.	1.316E-05	5.779E-08	

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Note: Based on the formulas in Sections B.3 and B.4 of Appendix B.

The mixed mode release data are provided for reference purposes only. Routine dose calculations are performed using ground level data.

Radius is the approximate distance from the midpoint between gaseous effluent release points to the location of highest X/Q or D/Q at or beyond the restricted area boundary (RAB).

Table F-6

D/Q at the Nearest Milk Cow and Meat Animal Locations within 5 miles

Downwind Direction	Nearest Milk Cow Radius (meters)	D/Q(1/m**2) Mixed Release	D/Q(1/m**2) Ground Release	Nearest Meat Animal Radius (meters)	D/Q(1/m**2) Mixed Release	D/Q(1/m**2) Ground Release
N	8000.	1.154E-10	2.975E-10	8000.	1.154E-10	2.975E-10
NNE	8000.	1.041E-10	2.684E-10	8000.	1.041E-10	2.684E-10
NE	8000.	1.639E-10	3.623E-10	8000.	1.639E-10	3.623E-10
ENE	8000.	1.478E-10	3.081E-10	8000.	1.478E-10	3.081E-10
E	8000.	1.666E-10	3.308E-10	8000.	1.666E-10	3.308E-10
ESE	8000.	1.325E-10	3.002E-10	8000.	1.325E-10	3.002E-10
SE	8000.	1.343E-10	3.164E-10	8000.	1.343E-10	3.164E-10
SSE	8000.	9.873E-11	2.055E-10	8000.	9.873E-11	2.055E-10
S	8000.	1.372E-10	2.550E-10	8000.	1.372E-10	2.550E-10
SSW	8000.	1.389E-10	2.404E-10	8000.	1.389E-10	2.404E-10
SW	8000.	8.296E-11	1.531E-10	8000.	8.296E-11	1.531E-10
WSW	8000.	6.592E-11	1.268E-10	7200.	7.920E-11	1.533E-10
W	8000.	6.472E-11	1.157E-10	5600.	1.195E-10	2.194E-10
WNW	8000.	5.744E-11	1.074E-10	8000.	5.744E-11	1.074E-10
NW	8000.	7.706E-11	1.359E-10	8000.	7.706E-11	1.359E-10
NNW	8000.	9.972E-11	1.836E-10	8000.	9.972E-11	1.836E-10

Note: Based on the formulas in Section B.4 of Appendix B.

Approximate distance from the station as determined by annual census.

The mixed mode release data are provided for reference purposes only.

Routine dose calculations are performed using ground level release data.

Table F-7

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Kr-83m

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	2.083E-04	1.571E-04	469.	9.339E-04	7.042E-04
NNE	475.	475.	1.807E-04	1.362E-04	475.	9.509E-04	7.170E-04
NE	400.	400.	2.720E-04	2.051E-04	400.	1.286E-03	9.693E-04
ENE	400.	400.	2.248E-04	1.695E-04	400.	1.092E-03	8.237E-04
E	400.	400.	2.097E-04	1.581E-04	400.	1.109E-03	8.363E-04
ESE	400.	400.	1.722E-04	1.298E-04	400.	1.193E-03	8.995E-04
SE	400.	400.	1.769E-04	1.334E-04	400.	1.277E-03	9.630E-04
SSE	400.	400.	1.100E-04	8.298E-05	400.	7.648E-04	5.767E-04
S	433.	433.	1.458E-04	1.099E-04	433.	7.104E-04	5.356E-04
SSW	439.	439.	1.151E-04	8.679E-05	439.	6.071E-04	4.578E-04
SW	518.	518.	5.574E-05	4.203E-05	518.	3.385E-04	2.553E-04
WSW	671.	671.	3.032E-05	2.286E-05	671.	1.629E-04	1.228E-04
W	658.	658.	3.056E-05	2.304E-05	658.	1.657E-04	1.249E-04
WNW	893.	893.	1.812E-05	1.366E-05	893.	1.004E-04	7.567E-05
NW	847.	847.	2.674E-05	2.016E-05	847.	1.483E-04	1.118E-04
NNW	725.	725.	4.752E-05	3.583E-05	725.	2.306E-04	1.739E-04

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Note: Based on the formulas in Sections B.5 and B.6 of Appendix B.

Approximate distance from midpoint between gaseous effluent release points.

Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Kr-85m

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	1.249E-03	1.198E-03	469.	3.995E-03	3.816E-03
NNE	475.	475.	1.110E-03	1.064E-03	475.	3.989E-03	3.809E-03
NE	400.	400.	1.611E-03	1.545E-03	400.	5.315E-03	5.074E-03
ENE	400.	400.	1.363E-03	1.307E-03	400.	4.613E-03	4.406E-03
E	400.	400.	1.323E-03	1.269E-03	400.	4.732E-03	4.519E-03
ESE	400.	400.	1.189E-03	1.142E-03	400.	5.043E-03	4.817E-03
SE	400.	400.	1.263E-03	1.213E-03	400.	5.581E-03	5.332E-03
SSE	400.	400.	8.562E-04	8.228E-04	400.	3.369E-03	3.219E-03
S	433.	433.	9.628E-04	9.241E-04	433.	3.136E-03	2.997E-03
SSW	439.	439.	8.568E-04	8.231E-04	439.	2.804E-03	2.681E-03
SW	518.	518.	5.038E-04	4.847E-04	518.	1.645E-03	1.573E-03
WSW	671.	671.	3.185E-04	3.067E-04	671.	8.367E-04	8.009E-04
W	658.	658.	3.128E-04	3.011E-04	658.	8.482E-04	8.118E-04
WNW	893.	893.	2.051E-04	1.976E-04	893.	5.554E-04	5.320E-04
NW	847.	847.	2.935E-04	2.827E-04	847.	8.008E-04	7.668E-04
NNW	725.	725.	4.801E-04	4.621E-04	725.	1.185E-03	1.134E-03

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Kr-85

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	1.403E-05	1.356E-05	469.	4.313E-05	4.171E-05
NNE	475.	475.	1.249E-05	1.207E-05	475.	4.315E-05	4.173E-05
NE	400.	400.	1.803E-05	1.743E-05	400.	5.723E-05	5.534E-05
ENE	400.	400.	1.526E-05	1.476E-05	400.	4.984E-05	4.819E-05
E	400.	400.	1.482E-05	1.433E-05	400.	5.110E-05	4.941E-05
ESE	400.	400.	1.349E-05	1.304E-05	400.	5.450E-05	5.270E-05
SE	400.	400.	1.436E-05	1.388E-05	400.	6.049E-05	5.849E-05
SSE	400.	400.	9.798E-06	9.474E-06	400.	3.657E-05	3.536E-05
S	433.	433.	1.082E-05	1.046E-05	433.	3.398E-05	3.286E-05
SSW	439.	439.	9.715E-06	9.394E-06	439.	3.053E-05	2.952E-05
SW	518.	518.	5.829E-06	5.636E-06	518.	1.805E-05	1.746E-05
WSW	671.	671.	3.737E-06	3.614E-06	671.	9.147E-06	8.845E-06
W	658.	658.	3.664E-06	3.543E-06	658.	9.329E-06	9.021E-06
WNW	893.	893.	2.425E-06	2.345E-06	893.	6.158E-06	5.955E-06
NW	847.	847.	3.444E-06	3.330E-06	847.	8.861E-06	8.569E-06
NNW	725.	725.	5.601E-06	5.416E-06	725.	1.305E-05	1.262E-05

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Kr-87

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	4.083E-03	3.965E-03	469.	1.194E-02	1.159E-02
NNE	475.	475.	3.638E-03	3.533E-03	475.	1.182E-02	1.148E-02
NE	400.	400.	5.285E-03	5.132E-03	400.	1.594E-02	1.548E-02
ENE	400.	400.	4.477E-03	4.347E-03	400.	1.378E-02	1.338E-02
E	400.	400.	4.372E-03	4.245E-03	400.	1.418E-02	1.377E-02
ESE	400.	400.	3.997E-03	3.882E-03	400.	1.509E-02	1.465E-02
SE	400.	400.	4.251E-03	4.128E-03	400.	1.660E-02	1.612E-02
SSE	400.	400.	2.913E-03	2.829E-03	400.	1.000E-02	9.709E-03
S	433.	433.	3.188E-03	3.096E-03	433.	9.319E-03	9.048E-03
SSW	439.	439.	2.882E-03	2.799E-03	439.	8.294E-03	8.053E-03
SW	518.	518.	1.737E-03	1.687E-03	518.	4.802E-03	4.663E-03
WSW	671.	671.	1.105E-03	1.073E-03	671.	2.485E-03	2.413E-03
W	658.	658.	1.086E-03	1.055E-03	658.	2.484E-03	2.412E-03
WNW	893.	893.	7.089E-04	6.884E-04	893.	1.620E-03	1.573E-03
NW	847.	847.	1.016E-03	9.866E-04	847.	2.339E-03	2.271E-03
NNW	725.	725.	1.646E-03	1.599E-03	725.	3.466E-03	3.365E-03

Zion Site Meteorological Data 1/79 - 12/87

Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Kr-88

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	9.857E-03	9.577E-03	469.	2.869E-02	2.785E-02
NNE	475.	475.	8.789E-03	8.540E-03	475.	2.857E-02	2.773E-02
NE	400.	400.	1.269E-02	1.233E-02	400.	3.819E-02	3.707E-02
ENE	400.	400.	1.076E-02	1.045E-02	400.	3.315E-02	3.217E-02
E	400.	400.	1.049E-02	1.019E-02	400.	3.406E-02	3.306E-02
ESE	400.	400.	9.643E-03	9.372E-03	400.	3.629E-02	3.523E-02
SE	400.	400.	1.027E-02	9.982E-03	400.	4.011E-02	3.893E-02
SSE	400.	400.	7.051E-03	6.854E-03	400.	2.420E-02	2.350E-02
S	433.	433.	7.661E-03	7.445E-03	433.	2.251E-02	2.185E-02
SSW	439.	439.	6.944E-03	6.750E-03	439.	2.014E-02	1.955E-02
SW	518.	518.	4.228E-03	4.111E-03	518.	1.180E-02	1.146E-02
WSW	671.	671.	2.722E-03	2.647E-03	671.	6.046E-03	5.872E-03
W	658.	658.	2.671E-03	2.597E-03	658.	6.105E-03	5.930E-03
WNW	893.	893.	1.763E-03	1.715E-03	893.	4.018E-03	3.902E-03
NW	847.	847.	2.507E-03	2.438E-03	847.	5.787E-03	5.620E-03
NNW	725.	725.	4.046E-03	3.934E-03	725.	8.527E-03	8.281E-03

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Kr-89

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	5.171E-03	5.022E-03	469.	1.200E-02	1.165E-02
NNE	475.	475.	4.511E-03	4.381E-03	475.	1.066E-02	1.036E-02
NE	400.	400.	7.533E-03	7.317E-03	400.	1.769E-02	1.718E-02
ENE	400.	400.	6.385E-03	6.202E-03	400.	1.487E-02	1.444E-02
E	400.	400.	6.418E-03	6.235E-03	400.	1.553E-02	1.509E-02
ESE	400.	400.	5.519E-03	5.361E-03	400.	1.536E-02	1.492E-02
SE	400.	400.	5.718E-03	5.554E-03	400.	1.603E-02	1.557E-02
SSE	400.	400.	4.006E-03	3.891E-03	400.	9.747E-03	9.467E-03
S	433.	433.	4.618E-03	4.486E-03	433.	9.634E-03	9.357E-03
SSW	439.	439.	4.165E-03	4.045E-03	439.	8.417E-03	8.175E-03
SW	518.	518.	2.197E-03	2.134E-03	518.	4.032E-03	3.916E-03
WSW	671.	671.	1.160E-03	1.127E-03	671.	1.945E-03	1.889E-03
W	658.	658.	1.147E-03	1.115E-03	658.	1.835E-03	1.782E-03
WNW	893.	893.	5.673E-04	5.511E-04	893.	8.457E-04	8.215E-04
NW	847.	847.	8.765E-04	8.515E-04	847.	1.278E-03	1.241E-03
NNW	725.	725.	1.729E-03	1.679E-03	725.	2.580E-03	2.506E-03

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Kr-90

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release			Ground Level Release		
		Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	9.956E-04	9.656E-04	469.	1.150E-03	1.115E-03
NNE	475.	475.	9.477E-04	9.192E-04	475.	9.696E-04	9.400E-04
NE	400.	400.	2.318E-03	2.248E-03	400.	3.045E-03	2.952E-03
ENE	400.	400.	1.891E-03	1.834E-03	400.	2.413E-03	2.339E-03
E	400.	400.	1.967E-03	1.908E-03	400.	2.548E-03	2.470E-03
ESE	400.	400.	1.417E-03	1.375E-03	400.	1.823E-03	1.767E-03
SE	400.	400.	1.347E-03	1.306E-03	400.	1.778E-03	1.723E-03
SSE	400.	400.	1.054E-03	1.022E-03	400.	1.311E-03	1.271E-03
S	433.	433.	1.426E-03	1.382E-03	433.	1.738E-03	1.685E-03
SSW	439.	439.	1.208E-03	1.171E-03	439.	1.463E-03	1.419E-03
SW	518.	518.	4.444E-04	4.310E-04	518.	4.833E-04	4.686E-04
WSW	671.	671.	1.729E-04	1.677E-04	671.	1.891E-04	1.833E-04
W	658.	658.	1.667E-04	1.617E-04	658.	1.789E-04	1.735E-04
WNW	893.	893.	4.046E-05	3.924E-05	893.	3.380E-05	3.277E-05
NW	847.	847.	5.538E-05	5.372E-05	847.	2.908E-05	2.820E-05
NNW	725.	725.	1.911E-04	1.854E-04	725.	1.565E-04	1.518E-04

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Xe-131m

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	1.905E-04	1.491E-04	469.	8.286E-04	6.420E-04
NNE	475.	475.	1.665E-04	1.304E-04	475.	8.472E-04	6.560E-04
NE	400.	400.	2.477E-04	1.938E-04	400.	1.132E-03	8.762E-04
ENE	400.	400.	2.053E-04	1.607E-04	400.	9.692E-04	7.507E-04
E	400.	400.	1.919E-04	1.505E-04	400.	9.833E-04	7.618E-04
ESE	400.	400.	1.605E-04	1.263E-04	400.	1.058E-03	8.194E-04
SE	400.	400.	1.662E-04	1.309E-04	400.	1.144E-03	8.865E-04
SSE	400.	400.	1.049E-04	8.286E-05	400.	6.876E-04	5.330E-04
S	433.	433.	1.345E-04	1.056E-04	433.	6.368E-04	4.937E-04
SSW	439.	439.	1.084E-04	8.552E-05	439.	5.513E-04	4.279E-04
SW	518.	518.	5.468E-05	4.347E-05	518.	3.136E-04	2.437E-04
WSW	671.	671.	3.075E-05	2.461E-05	671.	1.499E-04	1.167E-04
W	658.	658.	3.092E-05	2.471E-05	658.	1.546E-04	1.203E-04
WNW	893.	893.	1.899E-05	1.525E-05	893.	9.547E-05	7.446E-05
NW	847.	847.	2.776E-05	2.225E-05	847.	1.405E-04	1.095E-04
NNW	725.	725.	4.826E-05	3.854E-05	725.	2.156E-04	1.678E-04

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Xe-133m

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	3.416E-04	2.939E-04	469.	1.313E-03	1.105E-03
NNE	475.	475.	3.007E-04	2.590E-04	475.	1.332E-03	1.119E-03
NE	400.	400.	4.421E-04	3.801E-04	400.	1.776E-03	1.491E-03
ENE	400.	400.	3.697E-04	3.184E-04	400.	1.529E-03	1.285E-03
E	400.	400.	3.514E-04	3.034E-04	400.	1.557E-03	1.310E-03
ESE	400.	400.	3.040E-04	2.640E-04	400.	1.670E-03	1.404E-03
SE	400.	400.	3.187E-04	2.773E-04	400.	1.822E-03	1.535E-03
SSE	400.	400.	2.082E-04	1.822E-04	400.	1.098E-03	9.249E-04
S	433	433.	2.506E-04	2.170E-04	433.	1.018E-03	8.582E-04
SSW	439.	439.	2.117E-04	1.848E-04	439.	8.932E-04	7.547E-04
SW	518.	518.	1.156E-04	1.020E-04	518.	5.152E-04	4.366E-04
WSW	671.	671.	6.940E-05	6.183E-05	671.	2.520E-04	2.144E-04
W	658.	658.	6.885E-05	6.122E-05	658.	2.586E-04	2.199E-04
WNW	893.	893.	4.398E-05	3.931E-05	893.	1.638E-04	1.399E-04
NW	847.	847.	6.341E-05	5.658E-05	847.	2.390E-04	2.038E-04
NNW	725.	725.	1.065E-04	9.463E-05	725.	3.610E-04	3.070E-04

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Xe-133

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	3.709E-04	3.304E-04	469.	1.412E-03	1.236E-03
NNE	475.	475.	3.266E-04	2.912E-04	475.	1.427E-03	1.247E-03
NE	400.	400.	4.796E-04	4.271E-04	400.	1.899E-03	1.658E-03
ENE	400.	400.	4.020E-04	3.584E-04	400.	1.639E-03	1.433E-03
E	400.	400.	3.836E-04	3.428E-04	400.	1.672E-03	1.463E-03
ESE	400.	400.	3.316E-04	2.976E-04	400.	1.790E-03	1.565E-03
SE	400.	400.	3.485E-04	3.133E-04	400.	1.963E-03	1.720E-03
SSE	400.	400.	2.285E-04	2.063E-04	400.	1.183E-03	1.037E-03
S	433.	433.	2.749E-04	2.464E-04	433.	1.099E-03	9.639E-04
SSW	439.	439.	2.337E-04	2.106E-04	439.	9.702E-04	8.527E-04
SW	518.	518.	1.278E-04	1.163E-04	518.	5.633E-04	4.965E-04
WSW	671.	671.	7.715E-05	7.065E-05	671.	2.779E-04	2.459E-04
W	658.	658.	7.644E-05	6.990E-05	658.	2.848E-04	2.518E-04
WNW	893.	893.	4.907E-05	4.506E-05	893.	1.820E-04	1.616E-04
NW	847.	847.	7.083E-05	6.495E-05	847.	2.647E-04	2.347E-04
NNW	725.	725.	1.188E-04	1.086E-04	725.	3.978E-04	3.518E-04

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Xe-135m

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	2.366E-03	2.281E-03	469.	6.852E-03	6.594E-03
NNE	475.	475.	2.093E-03	2.017E-03	475.	6.600E-03	6.351E-03
NE	400.	400.	3.146E-03	3.032E-03	400.	9.348E-03	8.994E-03
ENE	400.	400.	2.661E-03	2.565E-03	400.	7.926E-03	7.627E-03
E	400.	400.	2.620E-03	2.525E-03	400.	8.209E-03	7.900E-03
ESE	400.	400.	2.337E-03	2.253E-03	400.	8.641E-03	8.315E-03
SE	400.	400.	2.463E-03	2.376E-03	400.	9.291E-03	8.942E-03
SSE	400.	400.	1.680E-03	1.620E-03	400.	5.550E-03	5.342E-03
S	433.	433.	1.896E-03	1.828E-03	433.	5.246E-03	5.049E-03
SSW	439.	439.	1.697E-03	1.637E-03	439.	4.559E-03	4.389E-03
SW	518.	518.	9.762E-04	9.419E-04	518.	2.487E-03	2.394E-03
WSW	671.	671.	5.877E-04	5.672E-04	671.	1.323E-03	1.274E-03
W	658.	658.	5.810E-04	5.608E-04	658.	1.274E-03	1.227E-03
WNW	893.	893.	3.547E-04	3.424E-04	893.	7.789E-04	7.504E-04
NW	847.	847.	5.237E-04	5.055E-04	847.	1.144E-03	1.102E-03
NNW	725.	725.	8.818E-04	8.511E-04	725.	1.784E-03	1.718E-03

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Xe-135

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	1.686E-03	1.628E-03	469.	5.315E-03	5.130E-03
NNE	475.	475.	1.498E-03	1.447E-03	475.	5.309E-03	5.124E-03
NE	400.	400.	2.171E-03	2.097E-03	400.	7.053E-03	6.807E-03
ENE	400.	400.	1.837E-03	1.775E-03	400.	6.136E-03	5.922E-03
E	400.	400.	1.785E-03	1.724E-03	400.	6.293E-03	6.074E-03
ESE	400.	400.	1.611E-03	1.556E-03	400.	6.707E-03	6.474E-03
SE	400.	400.	1.713E-03	1.655E-03	400.	7.442E-03	7.183E-03
SSE	400.	400.	1.164E-03	1.125E-03	400.	4.497E-03	4.340E-03
S	433.	433.	1.301E-03	1.257E-03	433.	4.184E-03	4.039E-03
SSW	439.	439.	1.163E-03	1.124E-03	439.	3.754E-03	3.624E-03
SW	518.	518.	6.885E-04	6.656E-04	518.	2.214E-03	2.137E-03
WSW	671.	671.	4.379E-04	4.234E-04	671.	1.126E-03	1.087E-03
W	658.	658.	4.296E-04	4.153E-04	658.	1.144E-03	1.105E-03
WNW	893.	893.	2.830E-04	2.737E-04	893.	7.530E-04	7.273E-04
NW	847.	847.	4.040E-04	3.906E-04	847.	1.084E-03	1.047E-03
NNW	725.	725.	6.593E-04	6.374E-04	725.	1.600E-03	1.545E-03

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Xe-137

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release			Ground Level Release		
		Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	7.660E-04	7.413E-04	469.	1.897E-03	1.835E-03
NNE	475.	475.	6.673E-04	6.458E-04	475.	1.711E-03	1.656E-03
NE	400.	400.	1.095E-03	1.059E-03	400.	2.748E-03	2.659E-03
ENE	400.	400.	9.276E-04	8.977E-04	400.	2.310E-03	2.235E-03
E	400.	400.	9.288E-04	8.988E-04	400.	2.409E-03	2.330E-03
ESE	400.	400.	7.993E-04	7.735E-04	400.	2.416E-03	2.337E-03
SE	400.	400.	8.297E-04	8.029E-04	400.	2.529E-03	2.447E-03
SSE	400.	400.	5.768E-04	5.582E-04	400.	1.528E-03	1.478E-03
S	433.	433.	6.693E-04	6.476E-04	433.	1.497E-03	1.449E-03
SSW	439.	439.	5.999E-04	5.806E-04	439.	1.302E-03	1.260E-03
SW	518.	518.	3.198E-04	3.094E-04	518.	6.382E-04	6.175E-04
WSW	671.	671.	1.729E-04	1.673E-04	671.	3.149E-04	3.047E-04
W	658.	658.	1.710E-04	1.655E-04	658.	2.974E-04	2.878E-04
WNW	893.	893.	8.763E-05	8.480E-05	893.	1.447E-04	1.400E-04
NW	847.	847.	1.343E-04	1.300E-04	847.	2.191E-04	2.120E-04
NNW	725.	725.	2.582E-04	2.499E-04	725.	4.200E-04	4.064E-04

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Xe-138

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	469.	469.	5.120E-03	4.970E-03	469.	1.421E-02	1.379E-02
NNE	475.	475.	4.542E-03	4.409E-03	475.	1.365E-02	1.324E-02
NE	400.	400.	6.821E-03	6.622E-03	400.	1.940E-02	1.883E-02
ENE	400.	400.	5.776E-03	5.607E-03	400.	1.645E-02	1.596E-02
E	400.	400.	5.700E-03	5.534E-03	400.	1.706E-02	1.655E-02
ESE	400.	400.	5.130E-03	4.981E-03	400.	1.793E-02	1.740E-02
SE	400.	400.	5.415E-03	5.258E-03	400.	1.926E-02	1.869E-02
SSE	400.	400.	3.711E-03	3.603E-03	400.	1.151E-02	1.117E-02
S	433.	433.	4.129E-03	4.008E-03	433.	1.088E-02	1.056E-02
SSW	439.	439.	3.727E-03	3.619E-03	439.	9.468E-03	9.188E-03
SW	518.	518.	2.169E-03	2.106E-03	518.	5.153E-03	5.001E-03
WSW	671.	671.	1.308E-03	1.271E-03	671.	2.749E-03	2.668E-03
W	658.	658.	1.295E-03	1.258E-03	658.	2.641E-03	2.564E-03
WNW	893.	893.	7.908E-04	7.680E-04	893.	1.612E-03	1.565E-03
NW	847.	847.	1.169E-03	1.135E-03	847.	2.370E-03	2.300E-03
NNW	725.	725.	1.959E-03	1.903E-03	725.	3.702E-03	3.593E-03

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Table F-7 (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Unrestricted Area Boundary for Ar-41

Downwind Direction	Unrestricted Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR (mrad/yr)/(uCi/sec)	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR (mrad/yr)/(uCi/sec)
N	469.	469.	6.355E-03	6.152E-03	469.	1.886E-02	1.826E-02
NNE	475.	475.	5.659E-03	5.478E-03	475.	1.875E-02	1.815E-02
NE	400.	400.	8.206E-03	7.944E-03	400.	2.516E-02	2.435E-02
ENE	400.	400.	6.950E-03	6.727E-03	400.	2.179E-02	2.109E-02
E	400.	400.	6.775E-03	6.558E-03	400.	2.239E-02	2.168E-02
ESE	400.	400.	6.188E-03	5.990E-03	400.	2.385E-02	2.309E-02
SE	400.	400.	6.582E-03	6.371E-03	400.	2.630E-02	2.546E-02
SSE	400.	400.	4.506E-03	4.362E-03	400.	1.585E-02	1.535E-02
S	433.	433.	4.941E-03	4.783E-03	433.	1.476E-02	1.429E-02
SSW	439.	439.	4 458E-03	4.315E-03	439.	1.316E-02	1.274E-02
SW	518.	518.	2.685E-03	2.599E-03	518.	7.664E-03	7.419E-03
WSW	671.	671.	1.713E-03	1.658E-03	671.	3.940E-03	3.814E-03
W	658.	658.	1.682E-03	1.628E-03	658.	3.961E-03	3.834E-03
WNW	893.	893.	1.103E-03	1.068E-03	893.	2.591E-03	2.508E-03
NW	847.	847.	1.576E-03	1.525E-03	847.	3.736E-03	3.617E-03
NNW	725.	725.	2.554E-03	2.472E-03	725.	5.528E-03	5.351E-03

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Table F-7a

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-83m

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release			Ground Level Release		
		Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	2.860E-04	2.156E-04	375.	1.289E-03	9.716E-04
NNE	400.	400.	2.305E-04	1.738E-04	400.	1.217E-03	9.175E-04
NE	325.	325.	3.644E-04	2.747E-04	325.	1.728E-03	1.303E-03
ENE	200.	200.	5.895E-04	4.445E-04	200.	2.915E-03	2.198E-03
E	175.	175.	6.653E-04	5.016E-04	175.	3.579E-03	2.698E-03
ESE	175.	175.	5.378E-04	4.055E-04	175.	3.838E-03	2.894E-03
SE	175.	175.	5.556E-04	4.189E-04	175.	4.177E-03	3.149E-03
SSE	200.	200.	2.908E-04	2.193E-04	200.	2.084E-03	1.572E-03
S	350.	350.	1.986E-04	1.498E-04	350.	9.700E-04	7.314E-04
SSW	375.	375.	1.452E-04	1.095E-04	375.	7.691E-04	5.799E-04
SW	475.	475.	6.325E-05	4.769E-05	475.	3.867E-04	2.916E-04
WSW	671.	671.	3.032E-05	2.286E-05	671.	1.629E-04	1.228E-04
W	658.	658.	3.056E-05	2.304E-05	658.	1.657E-04	1.249E-04
WNW	893.	893.	1.812E-05	1.366E-05	893.	1.004E-04	7.567E-05
NW	847.	847.	2.674E-05	2.016E-05	847.	1.483E-04	1.118E-04
NNW	250.	250.	2.155E-04	1.625E-04	250.	1.132E-03	8.533E-04

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Note: Based on the formulas in Sections B.5 and B.6 of Appendix B.

Approximate distance from midpoint between gaseous effluent release points.

Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-85m

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release			Ground Level Release		
		Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	1.618E-03	1.551E-03	375.	5.252E-03	5.013E-03
NNE	400.	400.	1.352E-03	1.296E-03	400.	4.916E-03	4.692E-03
NE	325.	325.	2.046E-03	1.961E-03	325.	6.839E-03	6.526E-03
ENE	200.	200.	3.013E-03	2.885E-03	200.	1.070E-02	1.020E-02
E	175.	175.	3.419E-03	3.274E-03	175.	1.294E-02	1.233E-02
ESE	175.	175.	3.026E-03	2.900E-03	175.	1.379E-02	1.314E-02
SE	175.	175.	3.205E-03	3.072E-03	175.	1.535E-02	1.464E-02
SSE	200.	200.	1.871E-03	1.795E-03	200.	7.910E-03	7.543E-03
S	350.	350.	1.236E-03	1.186E-03	350.	4.081E-03	3.897E-03
SSW	375.	375.	1.033E-03	9.921E-04	375.	3.421E-03	3.269E-03
SW	475.	475.	5.572E-04	5.359E-04	475.	1.838E-03	1.758E-03
WSW	671.	671.	3.185E-04	3.067E-04	671.	8.367E-04	8.009E-04
W	658.	658.	3.128E-04	3.011E-04	658.	8.482E-04	8.118E-04
WNW	893.	893.	2.051E-04	1.976E-04	893.	5.554E-04	5.320E-04
NW	847.	847.	2.935E-04	2.827E-04	847.	8.008E-04	7.668E-04
NNW	250.	250.	1.600E-03	1.537E-03	250.	4.539E-03	4.332E-03

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Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-85

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	1.810E-05	1.750E-05	375.	5.650E-05	5.463E-05
NNE	400.	400.	1.517E-05	1.467E-05	400.	5.302E-05	5.127E-05
NE	325.	325.	2.282E-05	2.207E-05	325.	7.343E-05	7.101E-05
ENE	200.	200.	3.346E-05	3.236E-05	200.	1.145E-04	1.107E-04
E	175.	175.	3.796E-05	3.671E-05	175.	1.383E-04	1.338E-04
ESE	175.	175.	3.398E-05	3.286E-05	175.	1.475E-04	1.426E-04
SE	175.	175.	3.607E-05	3.488E-05	175.	1.644E-04	1.590E-04
SSE	200.	200.	2.120E-05	2.050E-05	200.	8.484E-05	8.204E-05
S	350.	350.	1.384E-05	1.339E-05	350.	4.403E-05	4.258E-05
SSW	375.	375.	1.168E-05	1.129E-05	375.	3.710E-05	3.588E-05
SW	475.	475.	6.434E-06	6.222E-06	475.	2.012E-05	1.945E-05
WSW	671.	671.	3.737E-06	3.614E-06	671.	9.147E-06	8.845E-06
W	658.	658.	3.664E-06	3.543E-06	658.	9.329E-06	9.021E-06
WNW	893.	893.	2.425E-06	2.345E-06	893.	6.158E-06	5.955E-06
NW	847.	847.	3.444E-06	3.330E-06	847.	8.861E-06	8.569E-06
NNW	250.	250.	1.832E-05	1.771E-05	250.	4.876E-05	4.715E-05

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Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-87

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR (mrad/yr)/(uCi/sec)	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR (mrad/yr)/(uCi/sec)
N	375.	375.	5.296E-03	5.143E-03	375.	1.578E-02	1.532E-02
NNE	400.	400.	4.438E-03	4.309E-03	400.	1.466E-02	1.423E-02
NE	325.	325.	6.714E-03	6.519E-03	325.	2.061E-02	2.001E-02
ENE	200.	200.	9.905E-03	9.618E-03	200.	3.243E-02	3.148E-02
E	175.	175.	1.128E-02	1.095E-02	175.	3.936E-02	3.822E-02
ESE	175.	175.	1.017E-02	9.876E-03	175.	4.192E-02	4.070E-02
SE	175.	175.	1.080E-02	1.048E-02	175.	4.654E-02	4.518E-02
SSE	200.	200.	6.361E-03	6.177E-03	200.	2.388E-02	2.319E-02
S	350.	350.	4.089E-03	3.971E-03	350.	1.220E-02	1.184E-02
SSW	375.	375.	3.469E-03	3.369E-03	375.	1.017E-02	9.875E-03
SW	475.	475.	1.921E-03	1.865E-03	475.	5.388E-03	5.231E-03
WSW	671.	671.	1.105E-03	1.073E-03	671.	2.485E-03	2.413E-03
W	658.	658.	1.086E-03	1.055E-03	658.	2.484E-03	2.412E-03
WNW	893.	893.	7.089E-04	6.884E-04	893.	1.620E-03	1.573E-03
NW	847.	847.	1.016E-03	9.866E-04	847.	2.339E-03	2.271E-03
NNW	250.	250.	5.515E-03	5.356E-03	250.	1.369E-02	1.329E-02

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Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-88

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	1.274E-02	1.238E-02	375.	3.775E-02	3.664E-02
NNE	400.	400.	1.069E-02	1.039E-02	400.	3.525E-02	3.422E-02
NE	325.	325.	1.609E-02	1.563E-02	325.	4.918E-02	4.773E-02
ENE	200.	200.	2.365E-02	2.297E-02	200.	7.712E-02	7.483E-02
E	175.	175.	2.689E-02	2.612E-02	175.	9.340E-02	9.062E-02
ESE	175.	175.	2.435E-02	2.366E-02	175.	9.953E-02	9.657E-02
SE	175.	175.	2.587E-02	2.514E-02	175.	1.107E-01	1.074E-01
SSE	200.	200.	1.528E-02	1.485E-02	200.	5.695E-02	5.526E-02
S	350.	350.	9.800E-03	9.523E-03	350.	2.930E-02	2.844E-02
SSW	375.	375.	8.341E-03	8.107E-03	375.	2.457E-02	2.386E-02
SW	475.	475.	4.669E-03	4.539E-03	475.	1.319E-02	1.280E-02
WSW	671.	671.	2.722E-03	2.647E-03	671.	6.046E-03	5.872E-03
W	658.	658.	2.671E-03	2.597E-03	658.	6.106E-03	5.930E-03
WNW	893.	893.	1.763E-03	1.715E-03	893.	4.018E-03	3.902E-03
NW	847.	847.	2.507E-03	2.438E-03	847.	5.787E-03	5.620E-03
NNW	250.	250.	1.330E-02	1.293E-02	250.	3.267E-02	3.170E-02

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Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-89

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release			Ground Level Release		
		Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	7.380E-03	7.168E-03	375.	1.814E-02	1.762E-02
NNE	400.	400.	5.941E-03	5.771E-03	400.	1.486E-02	1.444E-02
NE	325.	325.	1.027E-02	9.973E-03	325.	2.548E-02	2.475E-02
ENE	200.	200.	1.716E-02	1.667E-02	200.	4.719E-02	4.583E-02
E	175.	175.	2.046E-02	1.987E-02	175.	6.053E-02	5.879E-02
ESE	175.	175.	1.785E-02	1.734E-02	175.	6.259E-02	6.079E-02
SE	175.	175.	1.865E-02	1.812E-02	175.	6.664E-02	6.472E-02
SSE	200.	200.	1.076E-02	1.046E-02	200.	3.241E-02	3.148E-02
S	350.	350.	6.363E-03	6.181E-03	350.	1.407E-02	1.367E-02
SSW	375.	375.	5.297E-03	5.145E-03	375.	1.119E-02	1.087E-02
SW	475.	475.	2.528E-03	2.456E-03	475.	4.779E-03	4.642E-03
WSW	671.	671.	1.160E-03	1.127E-03	671.	1.945E-03	1.889E-03
W	658.	658.	1.147E-03	1.115E-03	658.	1.835E-03	1.782E-03
WNW	893.	893.	5.673E-04	5.511E-04	893.	8.457E-04	8.215E-04
NW	847.	847.	8.765E-04	8.515E-04	847.	1.278E-03	1.241E-03
NNW	250.	250.	8.944E-03	8.688E-03	250.	1.846E-02	1.793E-02

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Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-90

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	1.931E-03	1.873E-03	375.	2.639E-03	2.558E-03
NNE	400.	400.	1.546E-03	1.500E-03	400.	1.800E-03	1.745E-03
NE	325.	325.	3.920E-03	3.802E-03	325.	5.743E-03	5.567E-03
ENE	200.	200.	9.603E-03	9.312E-03	200.	1.770E-02	1.715E-02
E	175.	175.	1.293E-02	1.254E-02	175.	2.606E-02	2.526E-02
ESE	175.	175.	1.009E-02	9.782E-03	175.	2.292E-02	2.222E-02
SE	175.	175.	1.001E-02	9.712E-03	175.	2.348E-02	2.276E-02
SSE	200.	200.	5.619E-03	5.450E-03	200.	1.091E-02	1.058E-02
S	350.	350.	2.477E-03	2.402E-03	350.	3.313E-03	3.212E-03
SSW	375.	375.	1.852E-03	1.796E-03	375.	2.423E-03	2.349E-03
SW	475.	475.	5.779E-04	5.605E-04	475.	6.556E-04	6.356E-04
WSW	671.	671.	1.729E-04	1.677E-04	671.	1.891E-04	1.833E-04
W	658.	658.	1.667E-04	1.617E-04	658.	1.789E-04	1.735E-04
WNW	893.	893.	4.046E-05	3.924E-05	893.	3.380E-05	3.277E-05
NW	847.	847.	5.538E-05	5.372E-05	847.	2.908E-05	2.820E-05
NNW	250.	250.	4.099E-03	3.975E-03	250.	5.977E-03	5.793E-03

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Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-131m

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release			Ground Level Release		
		Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	2.585E-04	2.019E-04	375.	1.131E-03	8.751E-04
NNE	400.	400.	2.102E-04	1.644E-04	400.	1.074E-03	8.308E-04
NE	325.	325.	3.283E-04	2.564E-04	325.	1.507E-03	1.165E-03
ENE	200.	200.	5.219E-04	4.065E-04	200.	2.510E-03	1.938E-03
E	175.	175.	5.878E-04	4.580E-04	175.	3.068E-03	2.368E-03
ESE	175.	175.	4.817E-04	3.763E-04	175.	3.291E-03	2.539E-03
SE	175.	175.	5.000E-04	3.909E-04	175.	3.598E-03	2.778E-03
SSE	200.	200.	2.661E-04	2.088E-04	200.	1.808E-03	1.397E-03
S	350.	350.	1.811E-04	1.419E-04	350.	8.589E-04	6.652E-04
SSW	375.	375.	1.354E-04	1.066E-04	375.	6.908E-04	5.357E-04
SW	475.	475.	6.163E-05	4.894E-05	475.	3.555E-04	2.761E-04
WSW	671.	671.	3.075E-05	2.461E-05	671.	1.499E-04	1.167E-04
W	658.	658.	3.092E-05	2.471E-05	658.	1.546E-04	1.203E-04
WNW	893.	893.	1.899E-05	1.525E-05	893.	9.547E-05	7.446E-05
NW	847.	847.	2.776E-05	2.225E-05	847.	1.405E-04	1.095E-04
NNW	250.	250.	2.021E-04	1.594E-04	250.	9.883E-04	7.646E-04

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Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-133m

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	4.538E-04	3.891E-04	375.	1.767E-03	1.482E-03
NNE	400.	400.	3.735E-04	3.209E-04	400.	1.671E-03	1.400E-03
NE	325.	325.	5.749E-04	4.927E-04	325.	2.334E-03	1.955E-03
ENE	200.	200.	8.845E-04	7.536E-04	200.	3.802E-03	3.169E-03
E	175.	175.	9.991E-04	8.516E-04	175.	4.629E-03	3.855E-03
ESE	175.	175.	8.457E-04	7.250E-04	175.	4.954E-03	4.124E-03
SE	175.	175.	8.856E-04	7.605E-04	175.	5.453E-03	4.545E-03
SSE	200.	200.	4.912E-04	4.248E-04	200.	2.764E-03	2.309E-03
S	350.	350.	3.300E-04	2.848E-04	350.	1.354E-03	1.138E-03
SSW	375.	375.	2.599E-04	2.262E-04	375.	1.107E-03	9.334E-04
SW	475.	475.	1.289E-04	1.137E-04	475.	5.805E-04	4.913E-04
WSW	671.	671.	6.940E-05	6.183E-05	671.	2.520E-04	2.144E-04
W	658.	658.	6.885E-05	6.122E-05	658.	2.586E-04	2.199E-04
WNW	893.	893.	4.398E-05	3.931E-05	893.	1.638E-04	1.399E-04
NW	847.	847.	6.341E-05	5.658E-05	847.	2.390E-04	2.038E-04
NNW	250.	250.	3.948E-04	3.445E-04	250.	1.537E-03	1.289E-03

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Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-133

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	4.891E-04	4.343E-04	375.	1.884E-03	1.644E-03
NNE	400.	400.	4.034E-04	3.588E-04	400.	1.779E-03	1.551E-03
NE	325.	325.	6.195E-04	5.499E-04	325.	2.478E-03	2.158E-03
ENE	200.	200.	9.409E-04	8.304E-04	200.	3.981E-03	3.449E-03
E	175.	175.	1.063E-03	9.388E-04	175.	4.634E-03	4.184E-03
ESE	175.	175.	9.007E-04	7.989E-04	175.	5.166E-03	4.469E-03
SE	175.	175.	9.451E-04	8.394E-04	175.	5.711E-03	4.948E-03
SSE	200.	200.	5.285E-04	4.722E-04	200.	2.917E-03	2.527E-03
S	350.	350.	3.597E-04	3.213E-04	350.	1.451E-03	1.269E-03
SSW	375.	375.	2.854E-04	2.567E-04	375.	1.196E-03	1.049E-03
SW	475.	475.	1.423E-04	1.292E-04	475.	6.328E-04	5.571E-04
WSW	671.	671.	7.715E-05	7.065E-05	671.	2.779E-04	2.459E-04
W	658.	658.	7.644E-05	6.990E-05	658.	2.848E-04	2.518E-04
WNW	893.	893.	4.907E-05	4.506E-05	893.	1.820E-04	1.616E-04
NW	847.	847.	7.083E-05	6.495E-05	847.	2.647E-04	2.347E-04
NNW	250.	250.	4.276E-04	3.849E-04	250.	1.635E-03	1.425E-03

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Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-135m

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	3.138E-03	3.024E-03	375.	9.338E-03	8.985E-03
NNE	400.	400.	2.600E-03	2.506E-03	400.	8.407E-03	8.088E-03
NE	325.	325.	4.063E-03	3.916E-03	325.	1.239E-02	1.192E-02
ENE	200.	200.	6.164E-03	5.938E-03	200.	2.012E-02	1.935E-02
E	175.	175.	7.093E-03	6.833E-03	175.	2.479E-02	2.384E-02
ESE	175.	175.	6.280E-03	6.052E-03	175.	2.629E-02	2.527E-02
SE	175.	175.	6.628E-03	6.388E-03	175.	2.881E-02	2.771E-02
SSE	200.	200.	3.860E-03	3.721E-03	200.	1.453E-02	1.398E-02
S	350.	350.	2.475E-03	2.385E-03	350.	7.077E-03	6.810E-03
SSW	375.	375.	2.071E-03	1.997E-03	375.	5.731E-03	5.516E-03
SW	475.	475.	1.090E-03	1.052E-03	475.	2.837E-03	2.732E-03
WSW	671.	671.	5.877E-04	5.672E-04	671.	1.323E-03	1.274E-03
W	658.	658.	5.810E-04	5.608E-04	658.	1.274E-03	1.227E-03
WNW	893.	893.	3.547E-04	3.424E-04	893.	7.789E-04	7.504E-04
NW	847	847.	5.237E-04	5.055E-04	847.	1.144E-03	1.102E-03
NNW	250.	250.	3.278E-03	3.162E-03	250.	8.275E-03	7.961E-03

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Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-135

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/	GBAR uCi/sec)
N	375.	375.	2.177E-03	2.103E-03	375.	6.962E-03	6.719E-03
NNE	400.	400.	1.821E-03	1.759E-03	400.	6.524E-03	6.295E-03
NE	325.	325.	[illegible]0E-03	2.656E-03	325.	9.048E-03	8.731E-03
ENE	200.	200.	[illegible]1E-03	3.893E-03	[illegible]0.	1.408E-02	1.359E-02
E	175.	175.	[illegible]73E-03	4.417E-03	[illegible]	1.701E-02	1.641E-02
ESE	175.	175.	4.064E-03	3.925E-03	[illegible]5.	1.812E-02	1.748E-02
SE	175.	175.	4.309E-03	4.163E-03	[illegible]5.	2.022E-02	1.950E-02
SSE	200.	200.	2.526E-03	2.440E-03	200.	1.044E-02	1.007E-02
S	350.	350.	1.667E-03	1.611E-03	350.	5.424E-03	5.235E-03
SSW	375.	375.	1.399E-03	1.352E-03	375.	4.567E-03	4.408E-03
SW	475.	475.	7.607E-04	7.353E-04	475.	2.469E-03	2.384E-03
WSW	671.	671.	4.379E-04	4.234E-04	671.	1.126E-03	1.087E-03
W	658.	658.	4.296E-04	4.153E-04	658.	1.144E-03	1.105E-03
WNW	893.	893.	2.830E-04	2.737E-04	893.	7.530E-04	7.273E-04
NW	847.	847.	4.040E-04	3.906E-04	847.	1.084E-03	1.047E-03
NNW	250.	250.	2.171E-03	2.098E-03	250.	6.009E-03	5.799E-03

Zion Site Meteorological Data 1/79 - 12/87

Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-137

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Ground Level Release Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	1.078E-03	1.043E-03	375.	2.808E-03	2.717E-03
NNE	400.	400.	8.696E-04	8.415E-04	400.	2.342E-03	2.266E-03
NE	325.	325.	1.477E-03	1.429E-03	325.	3.895E-03	3.768E-03
ENE	200.	200.	2.423E-03	2.344E-03	200.	7.006E-03	6.778E-03
E	175.	175.	2.870E-03	2.777E-03	175.	8.924E-03	8.634E-03
ESE	175.	175.	2.496E-03	2.416E-03	175.	9.281E-03	8.979E-03
SE	175.	175.	2.609E-03	2.525E-03	175.	9.922E-03	9.600E-03
SSE	200.	200.	1.505E-03	1.456E-03	200.	4.851E-03	4.693E-03
S	350.	350.	9.127E-04	8.832E-04	350.	2.154E-03	2.084E-03
SSW	375.	375.	7.572E-04	7.328E-04	375.	1.712E-03	1.657E-03
SW	475.	475.	3.659E-04	3.541E-04	475.	7.510E-04	7.266E-04
WSW	671.	671.	1.729E-04	1.673E-04	671.	3.149E-04	3.047E-04
W	658.	658.	1.710E-04	1.655E-04	658.	2.974E-04	2.878E-04
WNW	893.	893.	8.763E-05	8.480E-05	893.	1.447E-04	1.400E-04
NW	847.	847.	1.343E-04	1.300E-04	847.	2.191E-04	2.120E-04
NNW	250.	250.	1.252E-03	1.211E-03	250.	2.763E-03	2.673E-03

Zion Site Meteorological Data 1/79 - 12/87

Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-138

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release			Ground Level Release		
		Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	6.790E-03	6.591E-03	375.	1.939E-02	1.882E-02
NNE	400.	400.	5.641E-03	5.476E-03	400.	1.741E-02	1.689E-02
NE	325.	325.	8.807E-03	8.549E-03	325.	2.575E-02	2.499E-02
ENE	200.	200.	1.336E-02	1.296E-02	200.	4.188E-02	4.063E-02
E	175.	175.	1.539E-02	1.494E-02	175.	5.166E-02	5.012E-02
ESE	175.	175.	1.376E-02	1.336E-02	175.	5.476E-02	5.312E-02
SE	175.	175.	1.454E-02	1.411E-02	175.	5.996E-02	5.817E-02
SSE	200.	200.	8.507E-03	8.259E-03	200.	3.022E-02	2.931E-02
S	350.	350.	5.383E-03	5.225E-03	350.	1.469E-02	1.426E-02
SSW	375.	375.	4.543E-03	4.411E-03	375.	1.190E-02	1.155E-02
SW	475.	475.	2.421E-03	2.351E-03	475.	5.881E-03	707E-03
WSW	671.	671.	1.308E-03	1.271E-03	671.	2.749E-03	668E-03
W	658.	658.	1.295E-03	1.258E-03	658.	2.641E-03	2.564E-03
WNW	893.	893.	7.908E-04	7.680E-04	893.	1.612E-03	1.565E-03
NW	847.	847.	1.169E-03	1.135E-03	847.	2.370E-03	2.300E-03
NNW	250.	250.	7.276E-03	7.064E-03	250.	1.722E-02	1.671E-02

Zion Site Meteorological Data 1/79 - 12/87

Table F-7a (Continued)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Ar-41

Downwind Direction	Controlled Area Bound (meters)	Mixed Mode(Vent) Release			Ground Level Release		
		Radius (meters)	V (mrad/yr)/(uCi/sec)	VBAR	Radius (meters)	G (mrad/yr)/(uCi/sec)	GBAR
N	375.	375.	8.235E-03	7.972E-03	375.	2.489E-02	2.409E-02
NNE	400.	400.	6.898E-03	6.677E-03	400.	2.319E-02	2.245E-02
NE	325.	325.	1.042E-02	1.009E-02	325.	3.247E-02	3.143E-02
ENE	200.	200.	1.536E-02	1.487E-02	200.	5.103E-02	4.940E-02
E	175.	175.	1.747E-02	1.691E-02	175.	6.188E-02	5.990E-02
ESE	175.	175.	1.573E-02	1.522E-02	175.	6.592E-02	6.381E-02
SE	175.	175.	1.669E-02	1.616E-02	175.	7.324E-02	7.090E-02
SSE	200.	200.	9.826E-03	9.511E-03	200.	3.763E-02	3.643E-02
S	350.	350.	6.335E-03	6.133E-03	350.	1.927E-02	1.866E-02
SSW	375.	375.	5.365E-03	5.193E-03	375.	1.611E-02	1.559E-02
SW	475.	475.	2.968E-03	2.873E-03	475.	8.584E-03	8.309E-03
WSW	671.	671.	1.713E-03	1.658E-03	671.	3.940E-03	3.814E-03
W	658.	658.	1.682E-03	1.628E-03	658.	3.961E-03	3.834E-03
WNW	893.	893.	1.103E-03	1.068E-03	893.	2.591E-03	2.508E-03
NW	847.	847.	1.576E-03	1.525E-03	847.	3.736E-03	3.617E-03
NNW	250.	250.	8.510E-03	8.238E-03	250.	2.156E-02	2.087E-02

Zion Site Meteorological Data 1/79 - 12/87

Supplemental Table A

Mixed Mode Joint Frequency Distribution Table Summaries

250 Foot Elevation Data

Summary Table of Percent by Direction and Class

Class	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
A	.267	.504	.349	.248	.243	.315	.542	.409	.247	.214	.335	.440	.648	.737	.705	.400	6.604
B	.068	.110	.085	.055	.079	.069	.118	.117	.067	.050	.090	.105	.143	.138	.143	.152	1.590
C	.104	.162	.121	.059	.098	.087	.142	.139	.071	.065	.104	.132	.139	.141	.183	.146	1.892
D	.745	.992	.685	.498	.544	.536	.741	.887	.552	.603	.978	.933	1.115	1.136	1.361	1.003	13.309
E	1.512	1.507	1.234	1.161	1.021	.924	1.376	1.887	1.597	1.672	2.358	2.073	2.051	2.097	2.238	1.620	26.327
F	.729	.603	.521	.386	.409	.410	.568	.923	1.196	1.133	1.354	.977	.897	.875	.858	.644	12.483
G	.499	.412	.352	.283	.246	.247	.362	.700	1.366	1.480	1.008	.612	.421	.428	.463	.388	9.265
Total	3.924	4.292	3.346	2.689	2.640	2.588	3.848	5.062	5.097	5.217	6.227	5.272	5.414	5.552	5.950	4.353	71.471

Summary Table of Percent by Direction and Speed

Speed	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
.45	.003	.000	.005	.013	.009	.006	.000	.010	.014	.002	.000	.003	.000	.001	.001	.005	.074
1.05	.023	.022	.026	.043	.027	.036	.030	.035	.026	.023	.027	.027	.027	.030	.026	.031	.459
2.05	.194	.172	.200	.239	.270	.267	.262	.260	.224	.187	.189	.158	.159	.217	.213	.180	3.391
3.05	.320	.372	.529	.560	.576	.515	.586	.601	.414	.362	.393	.318	.343	.433	.572	.344	7.238
4.05	.478	.599	.629	.522	.514	.473	.722	.842	.562	.590	.595	.548	.546	.716	.831	.595	9.764
5.05	.619	.720	.650	.456	.374	.392	.753	.898	.886	.895	.937	.813	.809	1.029	1.145	.851	12.256
6.05	.656	.713	.484	.296	.247	.262	.528	.807	.976	.968	1.115	.993	.872	1.215	1.362	.971	12.467
8.05	1.106	1.257	.615	.372	.422	.478	.722	1.237	1.609	1.749	2.243	1.856	1.990	1.651	1.628	1.180	20.116
10.05	.458	.407	.191	.171	.182	.146	.229	.348	.365	.412	.677	.522	.630	.249	.164	.187	5.338
13.05	.037	.029	.016	.017	.020	.012	.017	.023	.022	.029	.048	.034	.037	.011	.007	.010	.369
18.00	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
99.00	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Total	3.924	4.292	3.346	2.689	2.640	2.588	3.848	5.062	5.097	5.217	6.227	5.272	5.414	5.552	5.950	4.353	71.471

NOTE: Wind directions in tables are presented in "wind from" and not "wind to" direction.

In order to determine the final mixed mode values, 71.471% of the elevated value (presented in the 250 FT Mixed Mode table) and 28.529% of the ground level value (presented in the 30 FT Mixed Mode table) are used to calculate the final values.

Supplemental Table A - Continued

Mixed Mode Joint Frequency Distribution Table Summaries

250 Foot Elevation Data

Summary Table of Percent by Speed and Class

Class Speed	A	B	C	D	E	F	G
.45	.001	.000	.003	.006	.025	.016	.023
1.05	.006	.004	.005	.034	.147	.070	.193
2.05	.119	.048	.074	.456	1.047	.616	1.031
3.05	.564	.166	.196	1.332	2.330	1.167	1.485
4.05	.940	.221	.275	1.932	3.494	1.459	1.443
5.05	1.250	.267	.320	2.204	4.388	2.178	1.647
6.05	1.204	.321	.306	2.176	4.544	2.456	1.460
8.05	1.923	.401	.539	3.884	7.909	3.699	1.760
10.05	.560	.151	.161	1.188	2.279	.784	.215
13.05	.037	.011	.013	.096	.165	.039	.007
18.00	.000	.000	.000	.000	.000	.000	.000
99.00	.000	.000	.000	.000	.000	.000	.000

Supplemental Table A - Continued

Mixed Mode Joint Frequency Distribution Table Summaries

35 Foot Elevation Data

Summary Table of Percent by Direction and Class

Class	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
A	.325	.401	.141	.095	.077	.100	.120	.122	.108	.127	.198	.209	.332	.278	.210	.186	3.029
B	.093	.099	.037	.028	.020	.014	.021	.048	.041	.020	.056	.061	.080	.049	.050	.058	.775
C	.103	.122	.047	.027	.030	.028	.028	.047	.029	.031	.065	.077	.090	.056	.054	.052	.885
D	.708	.607	.317	.291	.266	.182	.186	.283	.281	.283	.607	.505	.664	.413	.442	.396	6.431
E	1.140	.850	.531	.507	.431	.288	.289	.656	.894	.818	1.403	1.177	1.133	.621	.600	.384	11.722
F	.273	.144	.099	.098	.090	.066	.109	.165	.557	.449	.569	.436	.349	.232	.175	.109	3.919
G	.059	.029	.027	.018	.031	.038	.039	.063	.412	.289	.247	.159	.119	.114	.081	.042	1.768
Total	2.700	2.252	1.199	1.065	.946	.717	.792	1.384	2.322	2.017	3.144	2.623	2.766	1.764	1.611	1.227	28.529

Summary Table of Percent by Direction and Speed

Speed	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
.45	.001	.002	.001	.000	.001	.001	.001	.003	.002	.003	.002	.002	.000	.002	.003	.002	.025
1.05	.007	.006	.007	.008	.005	.008	.008	.009	.019	.020	.021	.012	.011	.011	.015	.011	.178
2.05	.082	.053	.034	.027	.033	.042	.058	.047	.162	.250	.218	.167	.120	.167	.218	.098	1.775
3.05	.170	.146	.103	.076	.075	.093	.180	.148	.483	.360	.315	.312	.327	.349	.356	.205	3.699
4.05	.214	.250	.157	.090	.086	.095	.183	.255	.614	.250	.350	.379	.389	.291	.350	.230	4.182
5.05	.273	.311	.149	.084	.090	.066	.127	.245	.469	.225	.369	.382	.391	.255	.251	.192	3.878
6.05	.438	.386	.181	.091	.107	.080	.083	.214	.278	.292	.470	.403	.450	.224	.211	.173	4.080
8.05	.892	.607	.268	.225	.208	.161	.118	.323	.219	.473	1.001	.677	.762	.388	.190	.262	6.775
10.05	.413	.313	.208	.333	.213	.118	.032	.114	.061	.128	.317	.209	.219	.061	.019	.046	2.804
13.05	.178	.155	.088	.117	.102	.050	.003	.025	.015	.014	.075	.079	.085	.014	.000	.009	1.009
18.00	.032	.023	.004	.013	.025	.003	.000	.000	.000	.001	.005	.003	.012	.003	.000	.000	.123
99.00	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Total	2.700	2.252	1.199	1.065	.946	.717	.792	1.384	2.322	2.017	3.144	2.623	2.766	1.764	1.611	1.227	28.529

NOTE: Wind directions in tables are presented in "wind from" and not "wind to" direction.

Supplemental Table A - Continued

Mixed Mode Joint Frequency Distribution Table Summaries

35 Foot Elevation Data

Summary Table of Percent by Speed and Class

Class Speed	A	B	C	D	E	F	G
.45	.000	.000	.000	.001	.003	.007	.015
1.05	.001	.000	.002	.004	.032	.048	.091
2.05	.028	.010	.010	.104	.421	.544	.658
3.05	.198	.055	.062	.486	1.333	1.014	.551
4.05	.445	.098	.104	.786	1.701	.818	.230
5.05	.424	.093	.118	.830	1.701	.582	.129
6.05	.429	.120	.146	.999	1.918	.404	.063
8.05	.937	.259	.275	1.985	2.893	.403	.023
10.05	.405	.098	.103	.845	1.270	.078	.007
13.05	.147	.039	.054	.348	.401	.019	.001
18.00	.014	.004	.012	.043	.049	.001	.000
99.00	.000	.000	.000	.000	.000	.000	.000

Supplemental Table B

Ground Level Joint Frequency Distribution Table Summaries

Summary Table of Percent by Direction and Class

Class	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
A	.573	.881	.500	.366	.343	.440	.582	.503	.397	.324	.509	.640	.941	.989	.950	.666	9.605
B	.175	.211	.131	.089	.087	.086	.113	.157	.131	.058	.139	.176	.219	.171	.215	.206	2.363
C	.213	.281	.165	.113	.103	.120	.152	.171	.115	.089	.168	.207	.235	.184	.250	.209	2.771
D	1.488	1.629	1.012	.801	.756	.681	.797	.971	1.036	.783	1.610	1.454	1.820	1.478	1.967	1.433	19.716
E	2.801	2.521	1.683	1.537	1.317	1.065	1.255	2.107	2.835	2.531	3.911	3.300	3.293	2.756	3.239	1.907	38.058
F	1.155	.710	.463	.384	.389	.313	.509	.692	1.908	1.815	1.987	1.547	1.385	1.331	1.143	.707	16.439
G	.472	.253	.176	.132	.127	.192	.258	.353	1.603	1.642	1.448	.987	1.028	1.192	.770	.416	11.049
Total	6.877	6.486	4.130	3.421	3.122	2.898	3.667	4.954	8.025	7.241	9.772	8.311	8.921	8.097	8.534	5.543	100.000

Summary Table of Percent by Direction and Speed

Speed	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
.45	.048	.065	.058	.009	.022	.012	.018	.037	.027	.042	.027	.052	.042	.043	.075	.054	.631
1.05	.206	.168	.156	.118	.121	.118	.135	.134	.216	.238	.271	.197	.233	.264	.350	.234	3.158
2.05	.903	.674	.518	.467	.458	.558	.636	.534	1.254	1.834	1.675	1.396	1.326	1.837	2.043	.990	17.102
3.05	1.089	1.031	.861	.743	.683	.806	1.309	1.075	2.628	1.993	1.781	1.670	1.944	2.223	2.304	1.333	23.474
4.05	1.054	1.309	.883	.554	.456	.478	.846	1.269	2.134	1.088	1.655	1.639	1.715	1.534	1.873	1.234	19.724
5.05	.931	1.129	.586	.345	.338	.230	.369	.797	1.005	.755	1.450	1.328	1.404	1.079	1.079	.836	13.661
6.05	.906	.841	.409	.273	.279	.231	.161	.477	.418	.573	1.176	.894	1.007	.550	.537	.468	9.201
8.05	1.119	.779	.354	.415	.393	.283	.158	.482	.265	.575	1.338	.845	.936	.489	.253	.338	9.022
10.05	.411	.312	.213	.366	.246	.127	.032	.123	.063	.129	.318	.208	.219	.062	.019	.046	2.896
13.05	.177	.154	.087	.118	.102	.050	.003	.026	.015	.014	.075	.078	.085	.014	.000	.009	1.008
18.00	.032	.023	.004	.013	.024	.003	.000	.000	.000	.001	.005	.003	.012	.003	.000	.000	.122
99.00	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Total	6.877	6.486	4.130	3.421	3.122	2.898	3.667	4.954	8.025	7.241	9.772	8.311	8.921	8.097	8.534	5.543	100.000

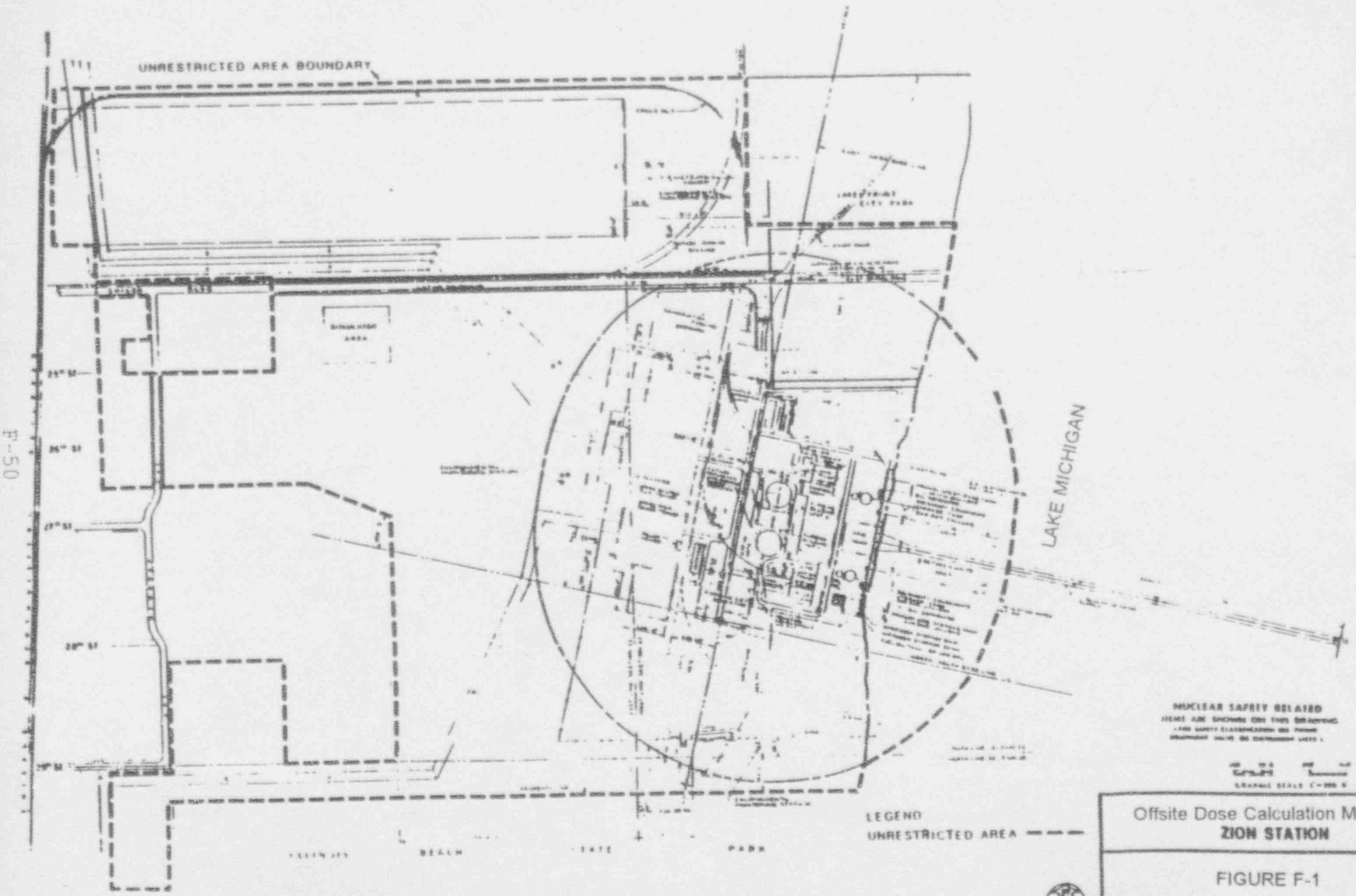
NOTE: Wind directions in tables are presented in "wind from" and not "wind to" direction.

Supplemental Table B -Continued

Ground Level Joint Frequency Distribution Table Summaries

Summary Table of Percent by Speed and Class

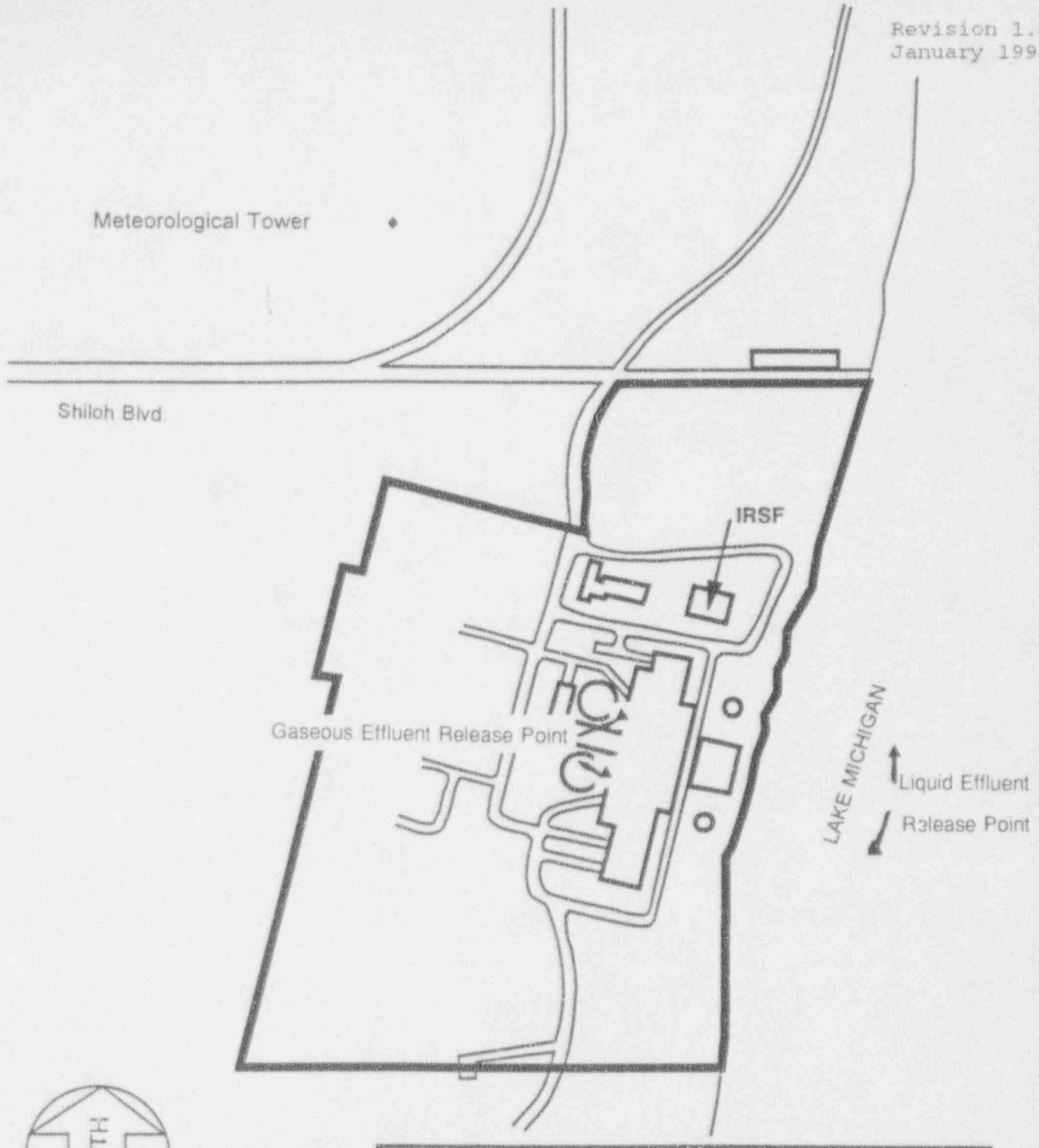
Class Speed	A	B	C	D	E	F	G
.45	.006	.004	.005	.040	.172	.154	.249
1.05	.036	.013	.024	.121	.797	.823	1.344
2.05	.464	.141	.194	1.591	4.805	4.405	5.502
3.05	1.606	.433	.507	3.810	8.847	5.409	2.862
4.05	2.520	.563	.613	4.211	8.107	2.995	.715
5.05	1.909	.419	.505	3.384	5.795	1.394	.251
6.05	1.211	.306	.368	2.527	4.023	.681	.085
8.05	1.281	.342	.381	2.766	3.745	.478	.030
10.05	.410	.099	.104	.877	1.317	.078	.010
13.05	.147	.039	.054	.348	.400	.019	.001
18.00	.014	.004	.012	.042	.049	.001	.000
99.00	.000	.000	.000	.000	.000	.000	.000



Offsite Dose Calculation Manual
ZION STATION

FIGURE F-1

UNRESTRICTED AREA BOUNDARY



OFFSITE DOSE CALCULATION MANUAL

ZION STATION

FIGURE F-2

RESTRICTED AREA BOUNDARY