ARKANSAS NUCLEAR ONE

UNIT 1 AND UNIT 2

OPERATING LICENSE NOS. DPR-51 AND NPF-6

ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT

JANUARY 1 THROUGH DECEMBER 31, 2002

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1. INTRODUCTION

Arkansas Nuclear One (ANO) is a two unit site consisting of a Babcock & Wilcox (Unit 1) and a Combustion Engineering (Unit 2) nuclear steam supply system. Both liquid and gaseous effluents are released in accordance with the Offsite Dose Calculation Manual (ODCM). This report is a summary of the effluent data in accordance with Unit 1 TS 5.6.3 and Unit 2 TS 6.9.3. This report provides the following information:

A. Routine radioactive effluent release reports covering the operation of the units and the independent spent fuel storage installation (ISFSI) during the reporting period.

B. Description of unplanned releases to unrestricted areas.

C. Description of changes to the Offsite Dose Calculation Manual (ODCM).

D. Description of changes to the Process Control Program (PCP).

E. Summary of radiation doses due to radiological effluents during the previous calendar year.

F. Radiation dose to members of the public due to activities inside the site boundary.

G. Description of licensee initiated major changes to the radioactive waste systems during the previous calendar year.

H. Items to be reported in the annual Radioactive Effluent Release Report per other miscellaneous ODCM requirements.

This report covers the period from January 1 through December 31, 2002.

2. REGULATORY LIMITS

The ODCM contains the limits to which ANO must adhere. Because of the "as low as reasonably achievable" (ALARA) philosophy at ANO, an attempt is made to reduce the amount of radiation released to the environment. Liquid and gaseous release data show that the dose from both Unit 1 and Unit 2 is considerably below the ODCM limits. This data reveals that the radioactive effluents have an overall minimal dose contribution to the surrounding environment. The following are the limits required by the ODCM:

A Gaseous Effluents

1. Dose rate due to radioactive materials released in gaseous effluent to unrestricted areas shall be limited to the following:

   a Noble gases

      Less than or equal to 500 mrem/year to the total body
      Less than or equal to 3000 mrem/year to the skin

   b. Iodine-131, tritium, and for all radionuclides in particulate form with half lives greater than 8 days

      Less than or equal to 1500 mrem/yr to any organ

2. Dose - Noble Gases

   Quarterly

   Less than or equal to 5 mrads gamma
   Less than or equal to 10 mrads beta

   Yearly

   Less than or equal to 10 mrads gamma
   Less than or equal to 20 mrads beta

3. Dose - Iodine-131, Tritium, and Radionuclides in Particulate Form

   Quarterly

   Less than or equal to 7.5 mrems to any organ

   Yearly

   Less than or equal to 15 mrems to any organ

B. Liquid Effluents

1. Concentration

The concentration of radioactive material released to the discharge canal shall be limited to the concentration specified in 10CFR20, Appendix B, Table II, Column 2, for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the total concentration released shall be limited to 2E-4 microcuries/ml.

2. Dose

Quarterly

Less than or equal to 1.5 mrem total body
Less than or equal to 5 mrem critical organ

Yearly

Less than or equal to 3 mrem total body
Less than or equal to 10 mrem critical organ

3. SUMMARY OF LIQUID EFFLUENT DATA

As required by Regulatory Guide 1.21, Rev. 1, *Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants,* a summary of data for liquid releases is provided in the annual Radioactive Effluent Release Report. This summary covers releases from January 1 through December 31, 2002. The summary of liquid effluents for both Unit 1 and Unit 2 is as follows:

	Unit 1	Unit 2
Number of releases:	210	107
Total time for all releases (minutes):	472062	550795
Maximum time for a release (minutes):	10525	12616
Average time for a release (minutes):	2232	5618
Minimum time for a release (minutes):	12	133

The Unit 1 liquid releases consisted of.

210 Planned Releases

0 Unplanned Releases

The Unit 2 liquid releases consisted of:

107 Planned Releases

0 Unplanned Releases

ANNUAL SUMMATION FOR ALL RELEASES BY QUARTER
(ALL LIQUID EFFLUENTS)
January 1 through June 30, 2002

Unit 1

Type of Effluent	Units	Quarter 1	Quarter 2	Est. Total Error %
A Fission and Activation Products				
1. Total Release (Not Including Tritium, Gases, Alpha)	Curies	6.746E-03	9.662E-03	25
2. Average Diluted Concentration During Period	µCi/ml	2.207E-11	2.637E-11	
3. Percent of Applicable Limit	%	7.356E-03	8.791E-03	
B. Tritium				
1. Total Release	Curies	5.546E+01	1.379E+02	25
2. Average Diluted Concentration During Period	µCi/ml	1.814E-07	3.765E-07	
3. Percent of Applicable Limit	%	6.047E-03	1.255E-02	
C Dissolved and Entrained Gases				
1. Total Release	Curies	0 000E+00	1.349E-04	25
2. Average Diluted Concentration During Period	µCi/ml	0.000E+00	3.684E-13	
3. Percent of Applicable Limit	%	0.000E+00	1.842E-07	
D Gross Alpha Radioactivity				
1. Total Release	Curies	0.000E+00	0.000E+00	25
E. Waste Vol Released (Pre-Dilution)	Liters	2.073E+07	2.033E+07	25
F. Volume of Dilution Water Used	Liters	3.057E+11	3.663E+11	25

ANNUAL SUMMATION FOR ALL RELEASES BY QUARTER
(ALL LIQUID EFFLUENTS)
July 1 through December 31, 2002

Unit 1

Type of Effluent	Units	Quarter 3	Quarter 4	Est. Total Error %
A. Fission and Activation Products				
1. Total Release (Not Including Tritium, Gases, Alpha)	Curies	6.594E-03	9.421E-03	25
2. Average Diluted Concentration During Period	µCi/ml	1.764E-11	3.328E-11	
3. Percent of Applicable Limit	%	5.879E-03	1.109E-02	
B. Tritium				
1. Total Release	Curies	3.491E+02	7.512E+01	25
2. Average Diluted Concentration During Period	µCi/ml	9.337E-07	2.653E-07	
3. Percent of Applicable Limit	%	3.112E-02	8.845E-03	
C. Dissolved and Entrained Gases				
1. Total Release	Curies	2.423E-01	8.400E-03	25
2. Average Diluted Concentration During Period	µCi/ml	6.480E-10	2.967E-11	
3. Percent of Applicable Limit	%	3.240E-04	1.484E-05	
D. Gross Alpha Radioactivity				
1. Total Release	Curies	0.000E+00	0.000E+00	25
E Waste Vol Released (Pre-Dilution)	Liters	1.744E+07	1.051E+07	25
F. Volume of Dilution Water Used	Liters	3.738E+11	2.830E+11	25

UNIT 1

REPORT CATEGORY : **ANNUAL LIQUID CONTINUOUS AND BATCH RELEASES**
: **TOTALS FOR EACH NUCLIDE RELEASED**
TYPE OF ACTIVITY : **ALL RADIONUCLIDES**
REPORTING PERIOD : **QUARTER # 1 AND QUARTER # 2 YEAR 2002**

NUCLIDE	UNIT	CONTINUOUS RELEASES QUARTER 1	CONTINUOUS RELEASES QUARTER 2	BATCH RELEASES QUARTER 1	BATCH RELEASES QUARTER 2
CO-57	CURIES	0.00E+00	0.00E+00	0.00E+00	7.15E-06
I-133	CURIES	0.00E+00	0.00E+00	0.00E+00	7.34E-06
MN-54	CURIES	0.00E+00	0.00E+00	0.00E+00	2.78E-05
AG-110M	CURIES	0.00E+00	0.00E+00	0.00E+00	4.08E-05
CS-134	CURIES	0.00E+00	0.00E+00	9.75E-06	4.37E-05
XE-133	CURIES	0.00E+00	0.00E+00	0.00E+00	1.35E-04
CO-60	CURIES	0.00E+00	0.00E+00	1.28E-04	3.88E-04
CO-58	CURIES	0.00E+00	0.00E+00	2.45E-04	6.65E-04
SB-125	CURIES	0.00E+00	0.00E+00	6.13E-03	7.37E-04
CS-137	CURIES	0.00E+00	0.00E+00	2.38E-04	1.67E-03
NA-24	CURIES	0.00E+00	6.08E-03	0.00E+00	0.00E+00
H-3	CURIES	2.66E-01	2.29E-01	5.48E+01	1.38E+02
Total for Period	CURIES	2.66E-01	2 35E-01	5.48E+01	1.38E+02

UNIT 1

REPORT CATEGORY : ANNUAL LIQUID CONTINUOUS AND BATCH RELEASES
: TOTALS FOR EACH NUCLIDE RELEASED

TYPE OF ACTIVITY : ALL RADIONUCLIDES

REPORTING PERIOD : QUARTER # 3 AND QUARTER # 4 YEAR 2002

		CONTINUOUS RELEASES		BATCH RELEASES	
NUCLIDE	UNIT	QUARTER 3	QUARTER 4	QUARTER 3	QUARTER 4
NB-97	CURIES	0.00E+00	0.00E+00	4.61E-06	0.00E+00
KR-85M	CURIES	0.00E+00	0.00E+00	1.16E-05	0.00E+00
XE-135	CURIES	0.00E+00	0 00E+00	4.64E-04	0.00E+00
XE-133M	CURIES	0.00E+00	0.00E+00	2.09E-03	0.00E+00
CS-134	CURIES	0.00E+00	0.00E+00	1.40E-05	3.28E-07
MN-54	CURIES	0.00E+00	0.00E+00	4.14E-06	2.23E-06
ZR-95	CURIES	0.00E+00	0.00E+00	3.42E-05	8.54E-06
AG-110M	CURIES	0.00E+00	0.00E+00	1.46E-05	1.02E-05
I-133	CURIES	0.00E+00	0.00E+00	1.11E-05	4.61E-05
NB-95	CURIES	0.00E+00	0.00E+00	8.67E-05	6.68E-05
I-131	CURIES	0.00E+00	0.00E+00	9.59E-05	4.15E-04
KR-85	CURIES	0.00E+00	0.00E+00	2.46E-02	4.28E-04
CS-137	CURIES	0.00E+00	0.00E+00	4.66E-04	4.69E-04
CO-60	CURIES	0.00E+00	0.00E+00	9.22E-04	6.00E-04
NA-24	CURIES	1.12E-03	8.46E-04	4.00E-05	0.00E+00
SB-125	CURIES	0.00E+00	0.00E+00	2.12E-03	1.02E-03
CO-58	CURIES	0.00E+00	0.00E+00	1.66E-03	5.94E-03
XE-133	CURIES	0.00E+00	0.00E+00	2.15E-01	7.97E-03
H-3	CURIES	7.58E-02	3.80E-02	3.49E+02	7.51E+01
Total for Period	CURIES	7.69E-02	3.88E-02	3.49E+02	7.51E+01

ANNUAL SUMMATION FOR ALL RELEASES BY QUARTER
(ALL LIQUID EFFLUENTS)
January 1 through June 30, 2002

Unit 2

Type of Effluent	Units	Quarter 1	Quarter 2	Est. Total Error %
A. Fission and Activation Products				
1. Total Release (Not Including Tritium, Gases, Alpha)	Curies	6.118E-03	8.229E-03	25
2. Average Diluted Concentration During Period	μCi/ml	2.001E-11	2.246E-11	
3. Percent of Applicable Limit	%	6.670E-03	7.488E-03	
B Tritium				
1. Total Release	Curies	2.704E+02	1.188E+02	25
2. Average Diluted Concentration During Period	μCi/ml	8.845E-07	3.243E-07	
3. Percent of Applicable Limit	%	2.948E-02	1.081E-02	
C. Dissolved and Entrained Gases				
1. Total Release	Curies	4.596E-03	4.791E-02	25
2. Average Diluted Concentration During Period	μCi/ml	1.503E-11	1.308E-10	
3. Percent of Applicable Limit	%	7.516E-06	6.540E-05	
D Gross Alpha Radioactivity				
1. Total Release	Curies	0.000E+00	0.000E+00	25
E. Waste Vol Released (Pre-Dilution)	Liters	1.831E+07	1.196E+07	25
F. Volume of Dilution Water Used	Liters	3.057E+11	3.663E+11	25

ANNUAL SUMMATION FOR ALL RELEASES BY QUARTER
(ALL LIQUID EFFLUENTS)
July 1 through December 31, 2002

Unit 2

Type of Effluent	Units	Quarter 3	Quarter 4	Est. Total Error %
A Fission and Activation Products				
1. Total Release (Not Including Tritium, Gases, Alpha)	Curies	2.647E-03	2.544E-03	25
2. Average Diluted Concentration During Period	μCi/ml	7.081E-12	8.988E-12	
3. Percent of Applicable Limit	%	2.360E-03	2.996E-03	
B Tritium				
1. Total Release	Curies	7.631E+01	9.217E+01	25
2. Average Diluted Concentration During Period	μCi/ml	2.041E-07	3.256E-07	
3. Percent of Applicable Limit	%	6.803E-03	1.085E-02	
C. Dissolved and Entrained Gases				
1. Total Release	Curies	0.000E+00	2.306E-04	25
2. Average Diluted Concentration During Period	μCi/ml	0.000E+00	8.145E-13	
3. Percent of Applicable Limit	%	0.000E+00	4.072E-07	
D. Gross Alpha Radioactivity				
1. Total Release	Curies	0.000E+00	0.000E+00	25
E. Waste Vol Released (Pre-Dilution)	Liters	6.983E+06	6.250E+06	25
F. Volume of Dilution Water Used	Liters	3.738E+11	2.830E+11	25

UNIT 2

REPORT CATEGORY	**: ANNUAL LIQUID CONTINUOUS AND BATCH RELEASES**
	: TOTALS FOR EACH NUCLIDE RELEASED
TYPE OF ACTIVITY	**: ALL RADIONUCLIDES**
REPORTING PERIOD	**: QUARTER # 1 AND QUARTER # 2 YEAR 2002**

		CONTINUOUS RELEASES		BATCH RELEASES	
NUCLIDE	UNIT	QUARTER 1	QUARTER 2	QUARTER 1	QUARTER 2
I-133	CURIES	0.00E+00	0.00E+00	2.18E-05	0.00E+00
I-131	CURIES	0.00E+00	0.00E+00	9.27E-05	0.00E+00
CS-134	CURIES	0.00E+00	0.00E+00	1.21E-05	1.18E-05
XE-135	CURIES	0.00E+00	0.00E+00	0.00E+00	3.63E-05
NB-97	CURIES	0.00E+00	0.00E+00	2.17E-05	4.57E-05
MN-54	CURIES	0.00E+00	0.00E+00	4.84E-05	5.58E-05
FE-55	CURIES	0.00E+00	5.76E-05	0.00E+00	0.00E+00
FE-59	CURIES	0.00E+00	0.00E+00	0.00E+00	1.11E-04
NB-95	CURIES	0.00E+00	0.00E+00	0.00E+00	1.39E-04
ZR-95	CURIES	0.00E+00	0.00E+00	0.00E+00	2.29E-04
XE-133M	CURIES	0.00E+00	0.00E+00	0.00E+00	2.95E-04
CO-60	CURIES	0.00E+00	0.00E+00	3.50E-04	3.71E-04
CS-137	CURIES	0.00E+00	0.00E+00	5.10E-04	7.14E-04
AG-110M	CURIES	0.00E+00	0.00E+00	8.20E-04	9.91E-04
SB-125	CURIES	0.00E+00	0.00E+00	4.13E-03	1.69E-03
CO-58	CURIES	0.00E+00	0.00E+00	1.13E-04	1.90E-03
CR-51	CURIES	0.00E+00	0.00E+00	0.00E+00	1.91E-03
KR-85	CURIES	0.00E+00	0.00E+00	0.00E+00	5.18E-03
XE-133	CURIES	0.00E+00	0.00E+00	4.60E-03	4.24E-02
H-3	CURIES	7.50E-02	3.58E-02	2.70E+02	1.19E+02
Total for Period	CURIES	7.50E-02	3.59E-02	2.70E+02	1.19E+02

UNIT 2

REPORT CATEGORY : **ANNUAL LIQUID CONTINUOUS AND BATCH RELEASES**
: **TOTALS FOR EACH NUCLIDE RELEASED**
TYPE OF ACTIVITY : **ALL RADIONUCLIDES**
REPORTING PERIOD : **QUARTER # 3 AND QUARTER # 4 YEAR 2002**

NUCLIDE	UNIT	CONTINUOUS RELEASES QUARTER 3	CONTINUOUS RELEASES QUARTER 4	BATCH RELEASES QUARTER 3	BATCH RELEASES QUARTER 4
NA-24	CURIES	3.10E-04	0.00E+00	0.00E+00	0.00E+00
FE-55	CURIES	1.64E-03	0.00E+00	1.40E-04	0.00E+00
MN-54	CURIES	0.00E+00	0.00E+00	0.00E+00	2.58E-05
I-131	CURIES	0.00E+00	0.00E+00	0.00E+00	3.13E-05
CS-137	CURIES	0.00E+00	0.00E+00	1.09E-04	5.74E-05
NB-95	CURIES	0.00E+00	0.00E+00	0.00E+00	7.34E-05
BE-7	CURIES	0.00E+00	0.00E+00	0.00E+00	1.47E-04
CO-60	CURIES	0.00E+00	0.00E+00	5.24E-05	1.54E-04
XE-133	CURIES	0.00E+00	0.00E+00	0.00E+00	2.31E-04
AG-110M	CURIES	0.00E+00	0.00E+00	2.00E-04	2.94E-04
CO-58	CURIES	0.00E+00	0.00E+00	1.68E-04	6.98E-04
SB-125	CURIES	0.00E+00	0.00E+00	2.35E-05	1.06E-03
H-3	CURIES	6.07E-02	1.32E-01	7.62E+01	9.21E+01
Total for Period	CURIES	6.27E-02	1.32E-01	7.62E+01	9.21E+01

4. SUMMARY OF GASEOUS EFFLUENT DATA

As required by Regulatory Guide 1.21, Rev. 1, a summary of data for gaseous releases is provided in the annual Radioactive Effluent Release Report. This summary covers releases from January 1 to December 31, 2002. The summary of gaseous effluents for both Unit 1 and Unit 2 is as follows:

	Unit 1	Unit 2
Number of releases:	127	150
Total time for all releases (minutes):	913681	1027741
Maximum time for a release (minutes):	10330	10530
Average time for a release (minutes).	7213	6889
Minimum time for a release (minutes):	1	1

The Unit 1 gaseous releases consisted of:

127 Planned vent & tank releases

0 Unplanned releases

The Unit 2 gaseous releases consisted of:

150 Planned vent & tank releases

0 Unplanned releases

ANNUAL SUMMATION FOR ALL RELEASES BY QUARTER
(ALL AIRBORNE EFFLUENTS)
January 1 through June 30, 2002

Unit 1

Type of Effluent	Units	Quarter 1	Quarter 2	Est. Total Error %
<u>A. Fission and Activation Products</u>				
1. Total Release	Curies	1.119E+01	0.000E+00	25
2. Average Release Rate for Period	µCi/Sec	1.440E+00	0.000E+00	
3. Percent of Applicable Limit	%	2.015E-02	0.000E+00	
<u>B. Radioiodines</u>				
1. Total Iodine-131	Curies	0.000E+00	0.000E+00	25
2. Average Release Rate for Period	µCi/Sec	0.000E+00	0.000E+00	
3. Percent of Applicable Limit	%	0.000E+00	0.000E+00	
<u>C Particulates</u>				
1. Particulates (Half-Lives > 8 Days)	Curies	0.000E+00	0.000E+00	25
2. Average Release Rate for Period	µCi/Sec	0.000E+00	0.000E+00	
3. Percent of Applicable Limit	%	0.000E+00	0.000E+00	
4. Gross Alpha Radioactivity	Curies	5.364E-07	0.000E+00	
<u>D. Tritium</u>				
1. Total Release	Curies	1.142E+01	6.928E+00	25
2. Average Release Rate for Period	µCi/Sec	1.468E+00	8.811E-01	
3. Percent of Applicable Limit	%	2.055E-03	1.234E-03	

ANNUAL SUMMATION FOR ALL RELEASES BY QUARTER
(ALL AIRBORNE EFFLUENTS)
July 1 through December 31, 2002

Unit 1

Type of Effluent	Units	Quarter 3	Quarter 4	Est. Total Error %
A. Fission and Activation Products				
1. Total Release	Curies	3.149E+00	3.890E+00	25
2. Average Release Rate for Period	µCi/Sec	3.962E-01	4.893E-01	
3. Percent of Applicable Limit	%	5.547E-03	6.851E-03	
B. Radioiodines				
1. Total Iodine-131	Curies	0.000E+00	1.818E-05	25
2. Average Release Rate for Period	µCi/Sec	0.000E+00	2.287E-06	
3. Percent of Applicable Limit	%	0.000E+00	6.403E-06	
C Particulates				
1. Particulates (Half-Lives > 8 Days)	Curies	0.000E+00	0.000E+00	25
2. Average Release Rate for Period	µCi/Sec	0.000E+00	0.000E+00	
3. Percent of Applicable Limit	%	0.000E+00	0.000E+00	
4. Gross Alpha Radioactivity	Curies	0.000E+00	0.000E+00	
D Tritium				
1. Total Release	Curies	3.441E+00	1.148E+01	25
2. Average Release Rate for Period	µCi/Sec	4.329E-01	1.444E+00	
3. Percent of Applicable Limit	%	6.060E-04	2.022E-03	

UNIT 1

REPORT CATEGORY : ANNUAL AIRBORNE GROUND LEVEL CONTINUOUS AND BATCH RELEASES
: TOTALS FOR EACH NUCLIDE RELEASED
TYPE OF ACTIVITY : FISSION GASES, IODINES, AND PARTICULATES
REPORTING PERIOD : QUARTER # 1 AND QUARTER # 2 YEAR 2002

NUCLIDE	UNIT	CONTINUOUS RELEASES QUARTER 1	CONTINUOUS RELEASES QUARTER 2	BATCH RELEASES QUARTER 1	BATCH RELEASES QUARTER 2

Fission Gases

KR-85	CURIES	0.00E+00	0.00E+00	2.28E-01	0.00E+00
XE-133	CURIES	0.00E+00	0.00E+00	1.10E+01	0.00E+00
Total for Period	CURIES	0.00E+00	0.00E+00	1.12E+01	0.00E+00

Iodines

NONE	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Particulates

NONE	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Other

Alpha	CURIES	0.00E+00	0.00E+00	5.36E-07	0.00E+00
H-3	CURIES	0.00E+00	0.00E+00	1.14E+01	6.93E+00
Total for Period	CURIES	0.00E+00	0.00E+00	1.14E+01	6.93E+00

UNIT 1

REPORT CATEGORY : **ANNUAL AIRBORNE GROUND LEVEL CONTINUOUS AND BATCH RELEASES**
: **TOTALS FOR EACH NUCLIDE RELEASED**
TYPE OF ACTIVITY : **FISSION GASES, IODINES, AND PARTICULATES**
REPORTING PERIOD : **QUARTER # 3 AND QUARTER # 4 YEAR 2002**

NUCLIDE	UNIT	CONTINUOUS RELEASES QUARTER 3	CONTINUOUS RELEASES QUARTER 4	BATCH RELEASES QUARTER 3	BATCH RELEASES QUARTER 4

Fission Gases

XE-133M	CURIES	0.00E+00	0.00E+00	0.00E+00	3.73E-04
XE-135	CURIES	0.00E+00	0.00E+00	0.00E+00	2.37E-03
XE-131M	CURIES	0.00E+00	0.00E+00	0.00E+00	1.21E-02
KR-85	CURIES	0.00E+00	0.00E+00	0.00E+00	3.26E-01
XE-133	CURIES	0.00E+00	0.00E+00	3.15E+00	3.55E+00
Total for Period	CURIES	0.00E+00	0.00E+00	3.15E+00	3.89E+00

Iodines

I-131	CURIES	0.00E+00	0.00E+00	0.00E+00	1.82E-05
Total for Period	CURIES	0.00E+00	0.00E+00	0.00E+00	1.82E-05

Particulates

NONE	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Other

H-3	CURIES	0.00E+00	0.00E+00	3.44E+00	1.15E+01
Total for Period	CURIES	0.00E+00	0.00E+00	3.44E+00	1.15E+01

ANNUAL SUMMATION FOR ALL RELEASES BY QUARTER
(ALL AIRBORNE EFFLUENTS)
January 1 through June 30, 2002

Unit 2

Type of Effluent	Units	Quarter 1	Quarter 2	Est. Total Error %
<u>A Fission and Activation Products</u>				
1. Total Release	Curies	0.000E+00	3.221E-01	25
2. Average Release Rate for Period	µCi/Sec	0.000E+00	4.096E-02	
3. Percent of Applicable Limit	%	0.000E+00	5.735E-04	
<u>B. Radioiodines</u>				
1. Total Iodine-131	Curies	0.000E+00	1.659E-05	25
2. Average Release Rate for Period	µCi/Sec	0.000E+00	2.110E-06	
3 Percent of Applicable Limit	%	0.000E+00	5.909E-06	
<u>C. Particulates</u>				
1. Particulates (Half-Lives > 8 Days)	Curies	0.000E+00	0.000E+00	25
2. Average Release Rate for Period	µCi/Sec	0.000E+00	0.000E+00	
3. Percent of Applicable Limit	%	0.000E+00	0.000E+00	
4. Gross Alpha Radioactivity	Curies	0.000E+00	0.000E+00	
<u>D. Tritium</u>				
1. Total Release	Curies	3.672E+00	7.769E+00	25
2. Average Release Rate for Period	µCi/Sec	4.722E-01	9.881E-01	
3. Percent of Applicable Limit	%	6.611E-04	1.383E-03	

ANNUAL SUMMATION FOR ALL RELEASES BY QUARTER
(ALL AIRBORNE EFFLUENTS)
July 1 through December 31, 2002

Unit 2

Type of Effluent	Units	Quarter 3	Quarter 4	Est. Total Error %
A Fission and Activation Products				
1. Total Release	Curies	0.000E+00	1.358E-01	25
2. Average Release Rate for Period	µCi/Sec	0.000E+00	1.709E-02	
3. Percent of Applicable Limit	%	0.000E+00	2.393E-04	
B Radioiodines				
1. Total Iodine-131	Curies	0.000E+00	0.000E+00	25
2. Average Release Rate for Period	µCi/Sec	0.000E+00	0.000E+00	
3. Percent of Applicable Limit	%	0.000E+00	0.000E+00	
C Particulates				
1. Particulates (Half-Lives > 8 Days)	Curies	0.000E+00	0.000E+00	25
2. Average Release Rate for Period	µCi/Sec	0.000E+00	0.000E+00	
3. Percent of Applicable Limit	%	0.000E+00	0.000E+00	
4. Gross Alpha Radioactivity	Curies	0.000E+00	0.000E+00	
D. Tritium				
1. Total Release	Curies	8.660E+00	7.495E+00	25
2. Average Release Rate for Period	µCi/Sec	1.089E+00	9.429E-01	
3. Percent of Applicable Limit	%	1.525E-03	1.320E-03	

UNIT 2

REPORT CATEGORY : ANNUAL AIRBORNE GROUND LEVEL CONTINUOUS AND BATCH RELEASES
: TOTALS FOR EACH NUCLIDE RELEASED
TYPE OF ACTIVITY : FISSION GASES, IODINES, AND PARTICULATES
REPORTING PERIOD : QUARTER # 1 AND QUARTER # 2 YEAR 2002

NUCLIDE	UNIT	CONTINUOUS RELEASES QUARTER 1	CONTINUOUS RELEASES QUARTER 2	BATCH RELEASES QUARTER 1	BATCH RELEASES QUARTER 2

Fission Gases

XE-135	CURIES	0.00E+00	0.00E+00	0.00E+00	3.54E-03
XE-133	CURIES	0.00E+00	0.00E+00	0.00E+00	3.19E-01
Total for Period	CURIES	0.00E+00	0.00E+00	0.00E+00	3.22E-01

Iodines

I-131	CURIES	0.00E+00	0.00E+00	0.00E+00	1.66E-05
Total for Period	CURIES	0.00E+00	0.00E+00	0.00E+00	1.66E-05

Particulates

NONE	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Other

H-3	CURIES	0.00E+00	0.00E+00	3.67E+00	7.77E+00
Total for Period	CURIES	0.00E+00	0.00E+00	3.67E+00	7.77E+00

UNIT 2

REPORT CATEGORY	**: ANNUAL AIRBORNE GROUND LEVEL CONTINUOUS AND BATCH RELEASES**
	: TOTALS FOR EACH NUCLIDE RELEASED
TYPE OF ACTIVITY	**: FISSION GASES, IODINES, AND PARTICULATES**
REPORTING PERIOD	**: QUARTER # 3 AND QUARTER # 4 YEAR 2002**

		CONTINUOUS RELEASES		BATCH RELEASES	
NUCLIDE	UNIT	QUARTER 3	QUARTER 4	QUARTER 3	QUARTER 4

Fission Gases

XE-133	CURIES	0.00E+00	0.00E+00	0.00E+00	2.48E-04
KR-85	CURIES	0.00E+00	0.00E+00	0.00E+00	1.36E-01
Total for Period	CURIES	0.00E+00	0.00E+00	0.00E+00	1.36E-01

Iodines

NONE	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Particulates

NONE	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	CURIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Other

H-3	CURIES	0.00E+00	0.00E+00	8.66E+00	7.50E+00
Total for Period	CURIES	0.00E+00	0.00E+00	8.66E+00	7.50E+00

5. SUMMARY OF RADIATION DOSES

The following is a summary of the annual radiation doses due to radiological effluents during 2002 calculated in accordance with the Offsite Dose Calculation Manual.

UNIT 1

Liquid Radwaste Effluents

Dose Limits (mRem): Total Body = 1.5/Qtr 3/Yr, Other Organs = 5/Qtr 10/Yr

Organ	Qtr 1	%	Qtr 2	%	Qtr 3	%	Qtr 4	%	Year	%
TBody	0.0002	0.01	0.0010	0.07	0.0008	0.05	0.0005	0 03	0 0025	0.08
Bone	0.0001	0.00	0.0008	0.02	0.0002	0.00	0.0004	0.01	0.0015	0.02
Liver	0.0003	0.01	0.0014	0.03	0.0009	0.02	0.0007	0.01	0.0032	0.03
Thyroid	0.0001	0.00	0.0002	0.00	0.0002	0.01	0.0005	0.01	0.0014	0.01
Kidney	0.0002	0.00	0.0006	0.01	0.0007	0.01	0.0003	0.01	0.0018	0.02
Lung	0.0001	0.00	0.0003	0.01	0.0006	0.01	0.0002	0 00	0.0013	0.01
GI-LLI	0.0001	0.00	0.0003	0.01	0.0006	0.01	0.0003	0.01	0.0013	0.01

Gaseous Radwaste Effluents

Iodine, H-3, and Particulate (ITP) - Dose Limits (mRem) = 7.5/Qtr 15/Yr

Organ	Qtr 1	%	Qtr 2	%	Qtr 3	%	Qtr 4	%	Year	%
TBody	0.0070	0.09	0.0043	0.06	0.0021	0.03	0.0071	0.09	0.0205	0.14
Bone	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
Liver	0.0070	0.09	0.0043	0.06	0.0021	0.03	0.0071	0.09	0.0205	0.14
Thyroid	0.0070	0.09	0.0043	0.06	0.0021	0.03	0.0110	0.15	0.0244	0.16
Kidney	0.0070	0.09	0.0043	0.06	0.0021	0.03	0.0071	0.09	0.0205	0.14
Lung	0.0070	0.09	0.0043	0.06	0.0021	0.03	0.0071	0.09	0.0205	0.14
GI-LLI	0.0070	0.09	0.0043	0.06	0.0021	0.03	0.0071	0.09	0.0205	0.14

Noble Gas Air Dose Limits (mRad) = Gamma 5/Qtr 10/Yr, Beta 10/Qtr 20/Yr

Type	Qtr 1	%	Qtr 2	%	Qtr 3	%	Qtr 4	%	Year	%
Gamma	0.0003	0.01	0.0000	0.00	0.0001	0.00	0.0001	0.00	0.0006	0.01
Beta	0.0011	0.01	0.0000	0.00	0.0003	0.00	0.0004	0.00	0.0017	0.01

UNIT 2

Liquid Radwaste Effluents

Dose Limits (mRem): Total Body = 1.5/Qtr 3/Yr, Other Organs = 5 /Qtr 10/Yr

Organ	Qtr 1	%	Qtr 2	%	Qtr 3	%	Qtr 4	%	Year	%
TBody	0.0007	0.05	0.0005	0.03	0.0001	0.01	0.0002	0.02	0.0016	0.05
Bone	0.0003	0.01	0.0004	0.01	0.0001	0.00	0.0000	0.00	0.0007	0.01
Liver	0.0008	0.02	0.0007	0.01	0.0002	0.00	0.0003	0.01	0.0019	0.02
Thyroid	0.0005	0.01	0.0002	0.00	0.0001	0.00	0.0002	0.00	0.0010	0.01
Kidney	0.0006	0.01	0.0004	0.01	0.0001	0.00	0.0002	0.00	0.0013	0.01
Lung	0.0005	0.01	0.0002	0.00	0.0001	0.00	0.0002	0.00	0.0010	0.01
GI-LLI	0.0005	0.01	0.0003	0.01	0.0001	0.00	0.0002	0.00	0.0010	0.01

Gaseous Radwaste Effluents

Iodine, H-3, and Particulate - Dose Limits (mRem) = 7.5/Qtr 15/Yr

Organ	Qtr 1	%	Qtr 2	%	Qtr 3	%	Qtr 4	%	Year	%
Tbody	0.0023	0.03	0.0048	0.06	0.0053	0.07	0.0046	0.06	0.0170	0.11
Bone	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
Liver	0.0023	0.03	0.0048	0.06	0.0053	0.07	0.0046	0.06	0.0170	0.11
Thyroid	0.0023	0.03	0.0084	0.11	0.0053	0.07	0.0046	0.06	0.0206	0.14
Kidney	0.0023	0.03	0.0048	0.06	0.0053	0.07	0.0046	0.06	0.0170	0.11
Lung	0.0023	0.03	0.0048	0.06	0.0053	0.07	0.0046	0.06	0.0170	0.11
GI-LLI	0.0023	0.03	0.0048	0.06	0.0053	0.07	0.0046	0.06	0.0170	0.11

Noble Gas Air Dose Limits (mRad) = Gamma 5/Qtr 10/Yr, Beta 10/Qtr 20/Yr

Type	Qtr 1	%	Qtr 2	%	Qtr 3	%	Qtr 4	%	Year	%
Gamma	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
Beta	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0001	0.00

6. SUMMARY OF DOSE TO MEMBERS OF THE PUBLIC

The following is a summary of the annual radiation dose to members of the public (in mrem) due to activities inside the site boundary.

UNIT 1

	BONE	LIVER	TBODY	THYROID	KIDNEY	GI-LLI	LUNG	SKIN
Gaseous Effluent								
Iodine/Tritium Particulate	7.79E-08	3.41E-03	3.41E-03	3.43E-03	3.41E-03	3.41E-03	3.41E-03	
Noble Gas			1.41E-04					3.54E-04
Liquid Effluent								
Fish	1.55E-03	3.16E-03	2.45E-03	1.37E-03	1.75E-03	1.27E-03	1.29E-03	
Sediment			4.99E-05					5.85E-05
Unit 1 Total	1.55E-03	6.57E-03	6.05E-03	4.80E-03	5.16E-03	4.68E-03	4.70E-03	4.13E-04

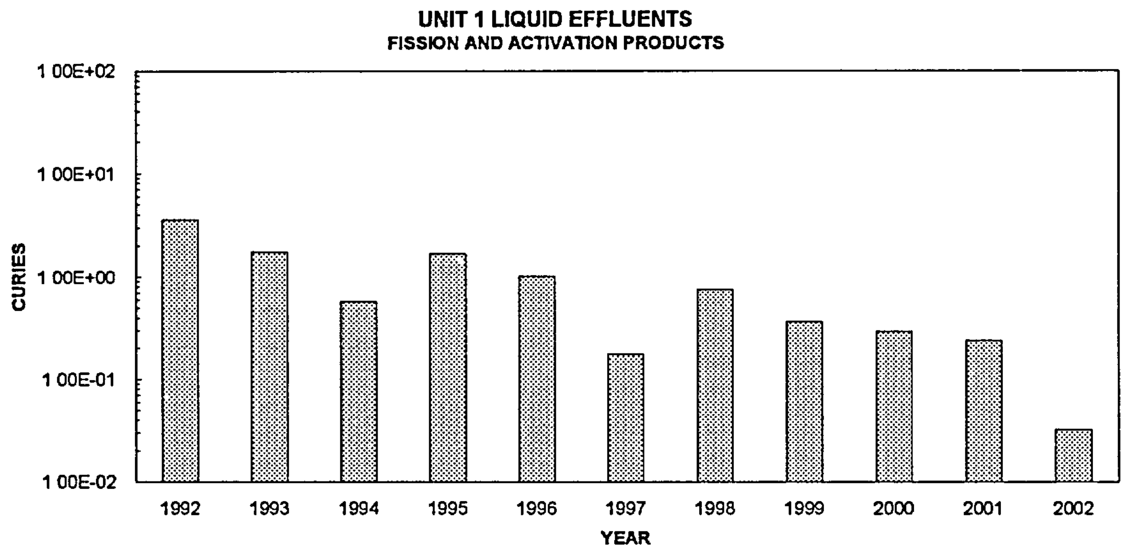
UNIT 2

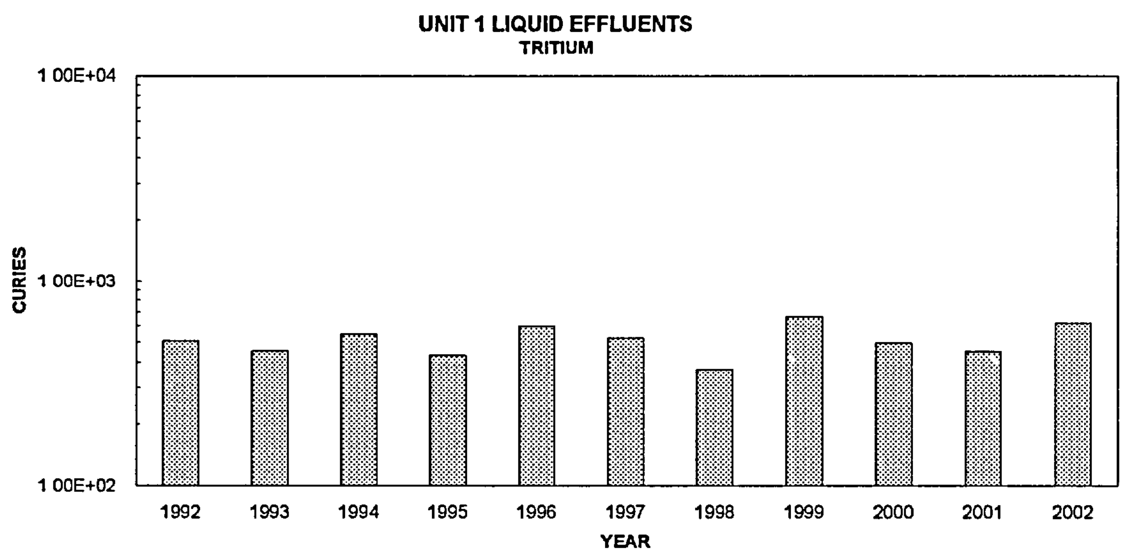
Gaseous Effluent								
Iodine/Tritium Particulate	7.10E-08	2.83E-03	2 83E-03	2.85E-03	2.83E-03	2.83E-03	2.83E-03	
Noble Gas			2.78E-06					1.14E-05
Liquid Effluent								
Fish	7.39E-04	1.93E-03	1.58E-03	9.75E-04	1.25E-03	1.03E-03	1.05E-03	
Sediment			2.83E-05					3.32E-05
Unit 2 Total	7.39E-04	4.76E-03	4.44E-03	3.83E-03	4.08E-03	3.86E-03	3.88E-03	4.46E-05

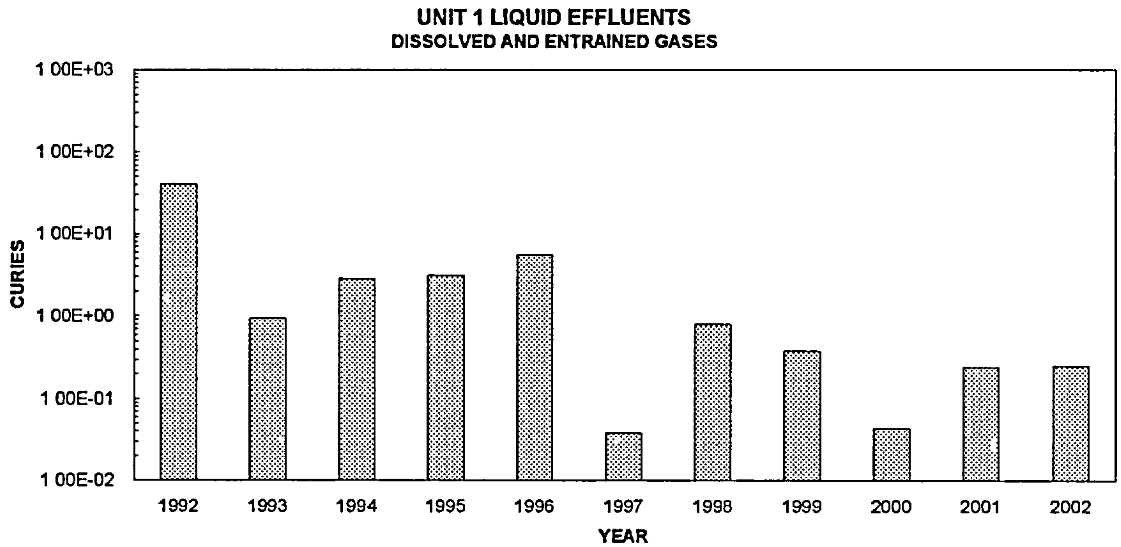
Site Total	2.29E-03	1.13E-02	1.05E-02	8.63E-03	9.24E-03	8.54E-03	8.58E-03	4.57E-04
Limit (40CFR190)	25	25	25	75	25	25	25	25
% Limit	9.16E-03	4.52E-02	4.20E-02	1.15E-02	3.70E-02	3.42E-02	3.43E-02	1.83E-03

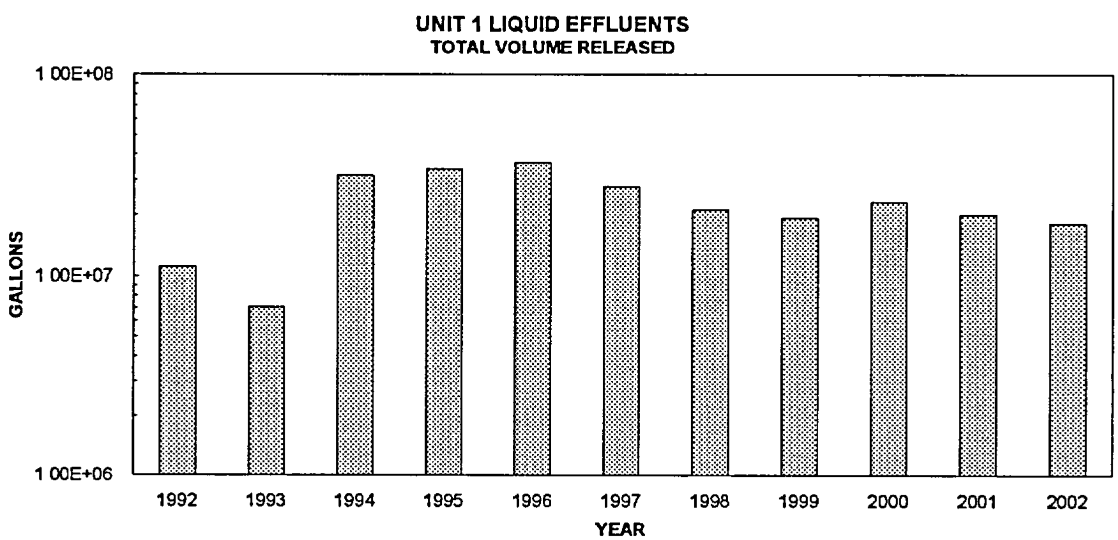
7. HISTORICAL EFFLUENT DATA

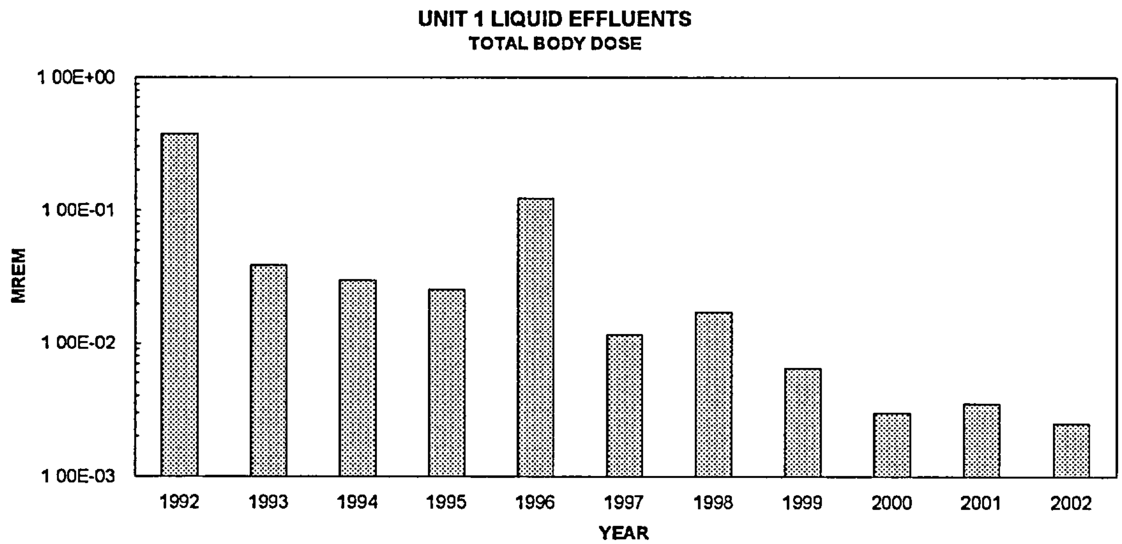
The following graphs show the historical release data for both units on a yearly basis. These graphs compare data from 1992 through 2002.

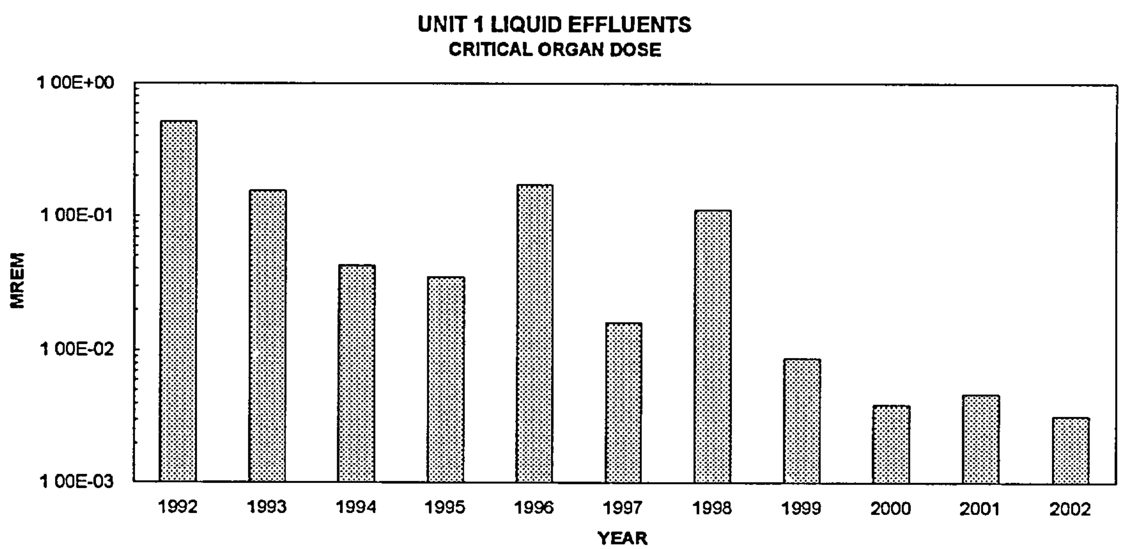


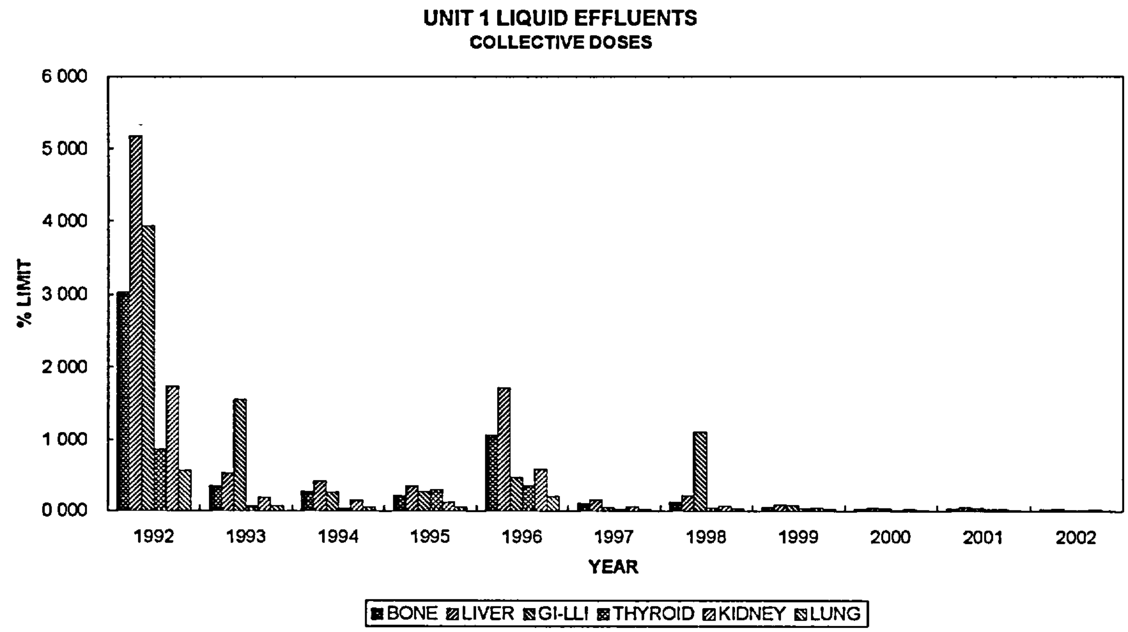


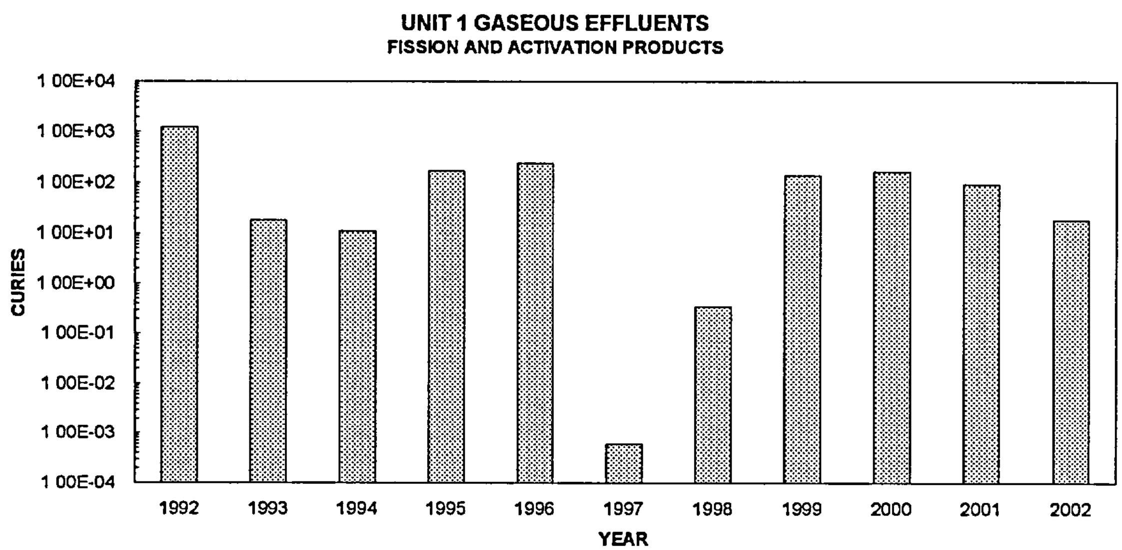

UNIT 1 LIQUID EFFLUENTS
DISSOLVED AND ENTRAINED GASES
CURIES
1 00E+03
1 00E+02
1 00E+01
1 00E+00
1 00E-01
1 00E-02
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR


UNIT 1 LIQUID EFFLUENTS
TOTAL VOLUME RELEASED
GALLONS
1 00E+08
1 00E+07
1 00E+06
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

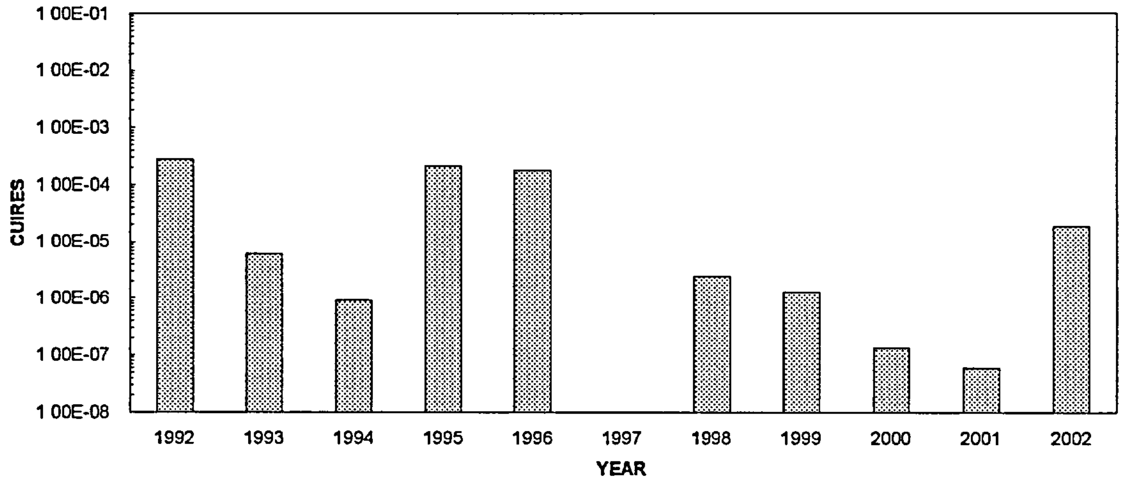

UNIT 1 LIQUID EFFLUENTS
TOTAL BODY DOSE
1 00E+00
1 00E-01
1 00E-02
1 00E-03
MREM
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR


UNIT 1 LIQUID EFFLUENTS
CRITICAL ORGAN DOSE
1 00E+00
1 00E-01
1 00E-02
1 00E-03
MREM
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

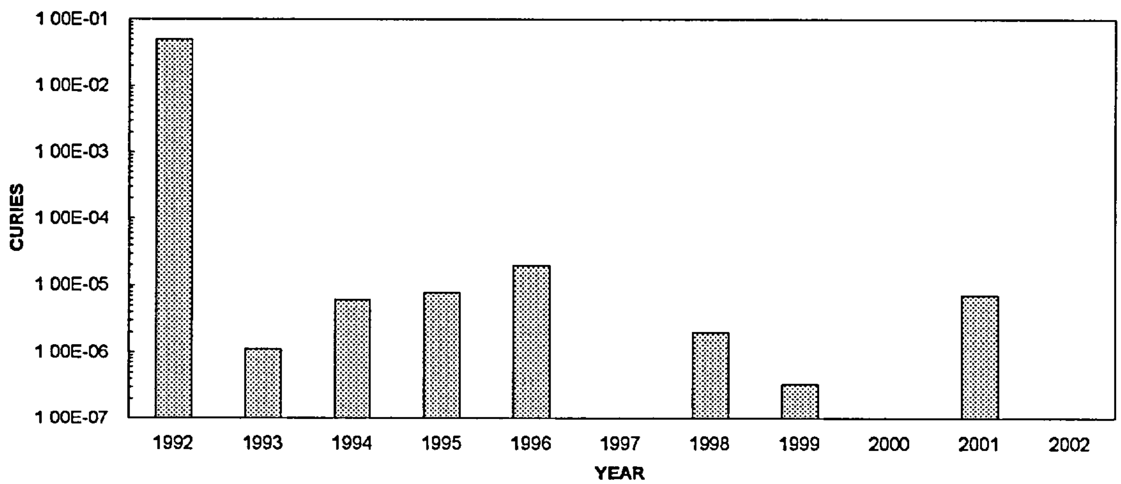

UNIT 1 LIQUID EFFLUENTS
COLLECTIVE DOSES
% LIMIT
6 000
5 000
4 000
3 000
2 000
1 000
0 000
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR
BONE LIVER GI-LLI THYROID KIDNEY LUNG

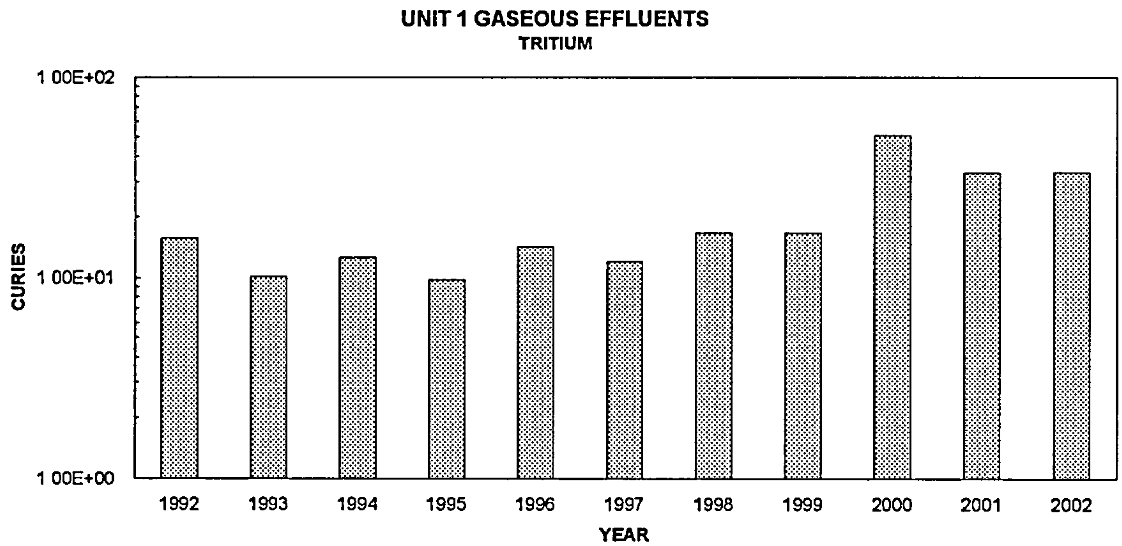

UNIT 1 GASEOUS EFFLUENTS
FISSION AND ACTIVATION PRODUCTS
CURIES
1 00E+04
1 00E+03
1 00E+02
1 00E+01
1 00E+00
1 00E-01
1 00E-02
1 00E-03
1 00E-04
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

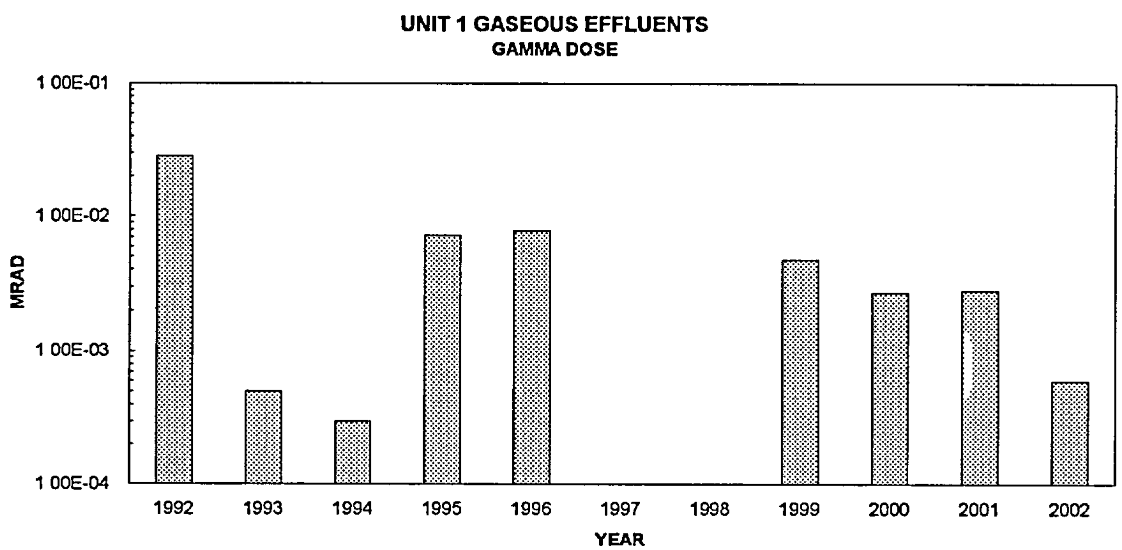
UNIT 1 GASEOUS EFFLUENTS
RADIOIODINES

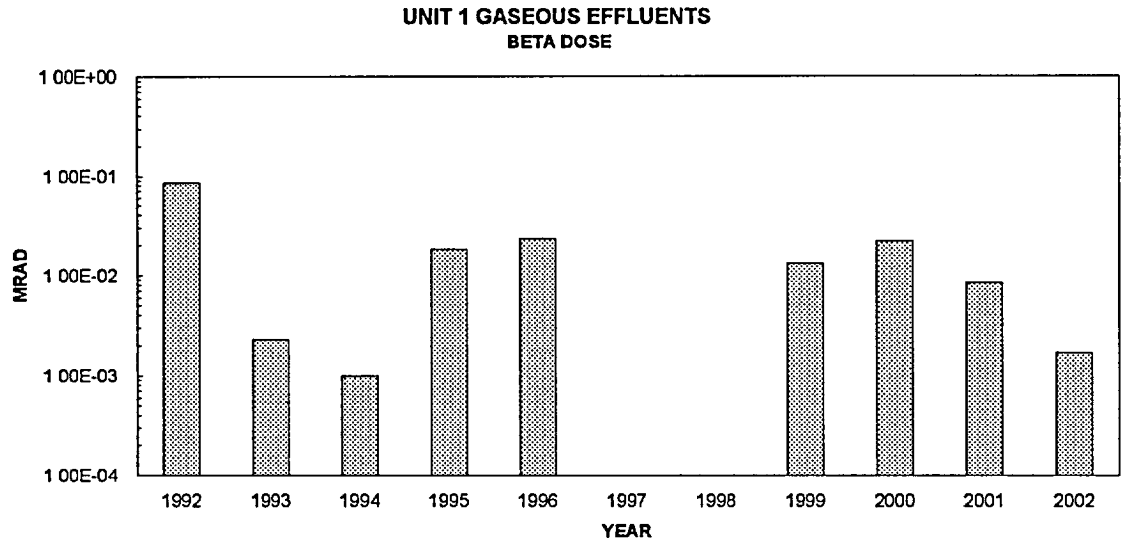


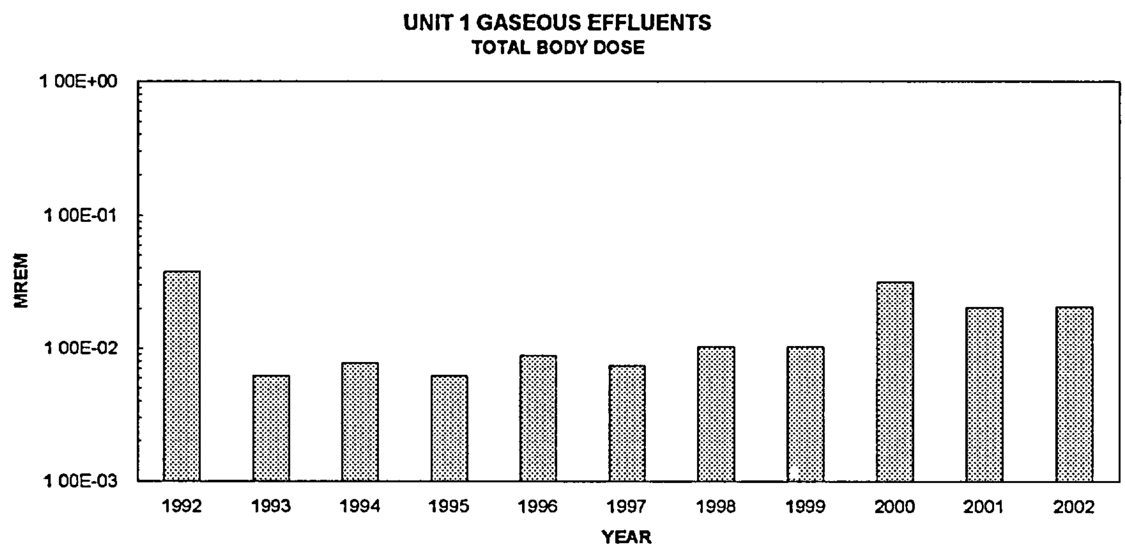
UNIT 1 GASEOUS EFFLUENTS
PARTICULATES

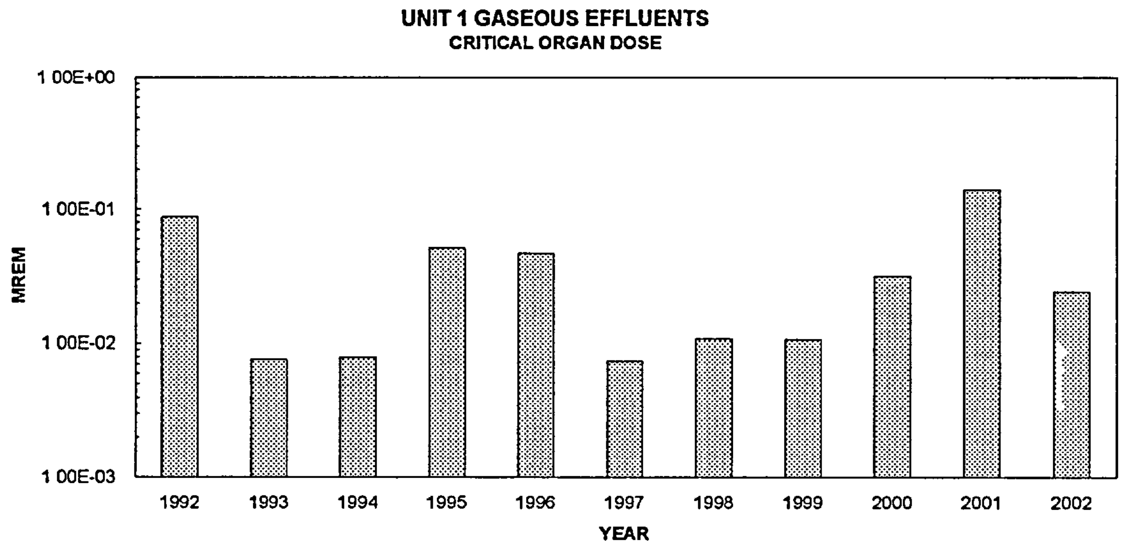


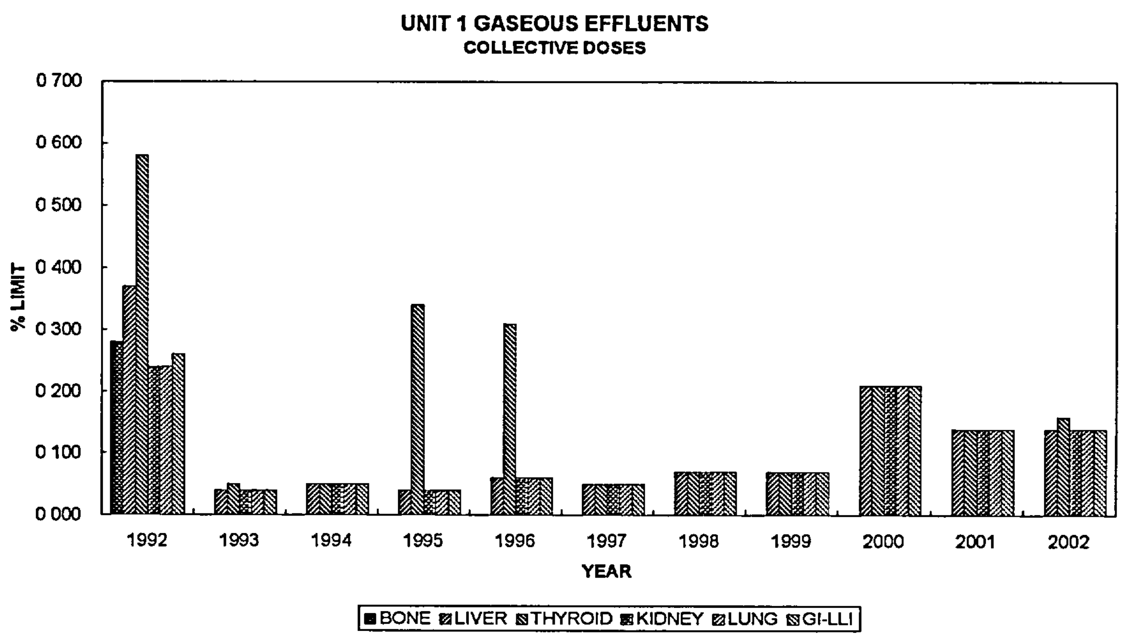

UNIT 1 GASEOUS EFFLUENTS
TRITIUM
1 00E+02
1 00E+01
1 00E+00
CURIES
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

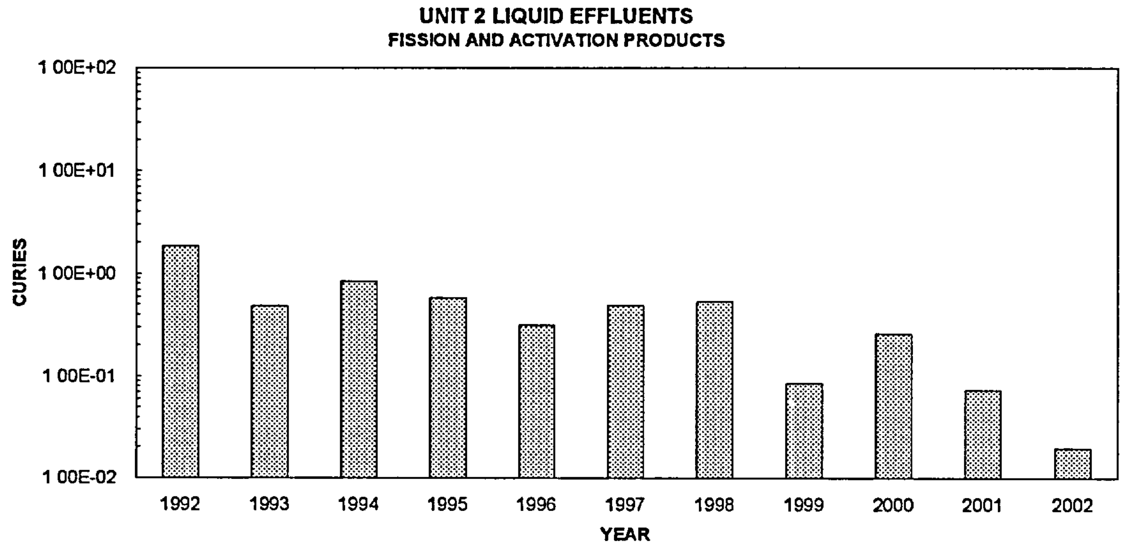

UNIT 1 GASEOUS EFFLUENTS
GAMMA DOSE
1 00E-01
1 00E-02
1 00E-03
1 00E-04
MRAD
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

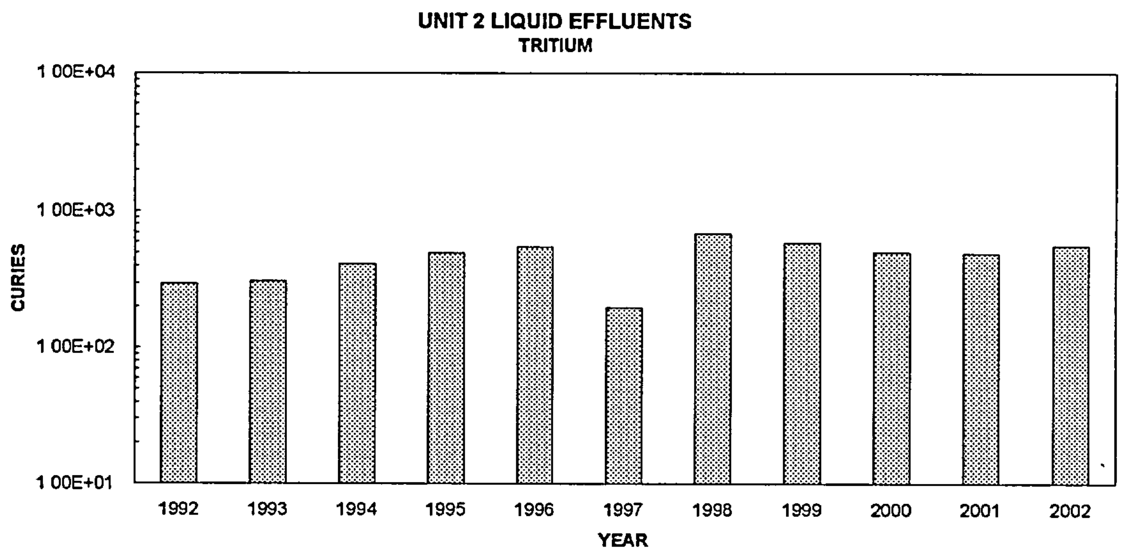

UNIT 1 GASEOUS EFFLUENTS
BETA DOSE
1 00E+00
1 00E-01
1 00E-02
1 00E-03
1 00E-04
MRAD
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

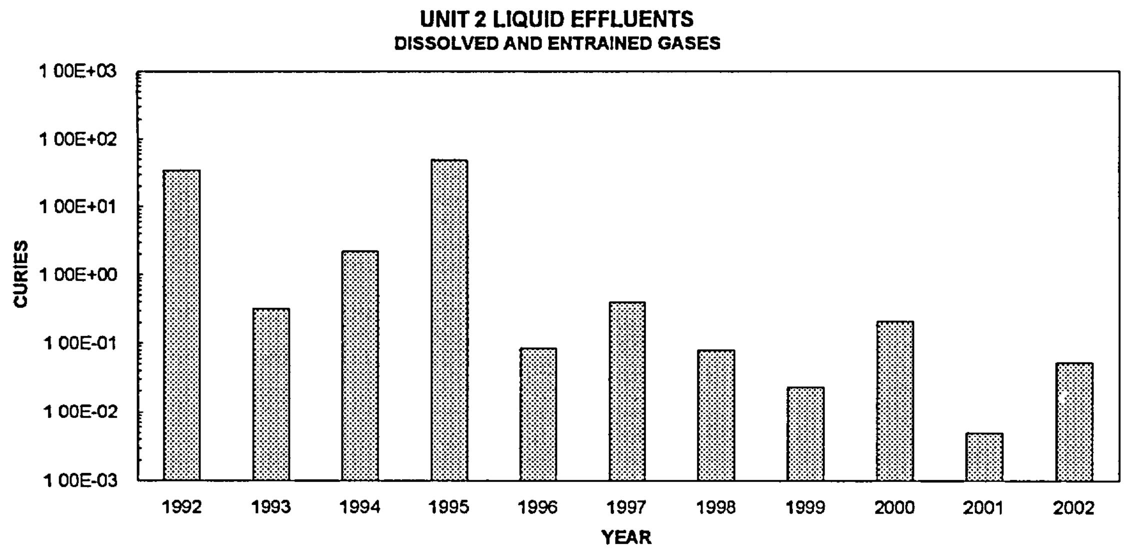

UNIT 1 GASEOUS EFFLUENTS
TOTAL BODY DOSE
1 00E+00
1 00E-01
1 00E-02
1 00E-03
MREM
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

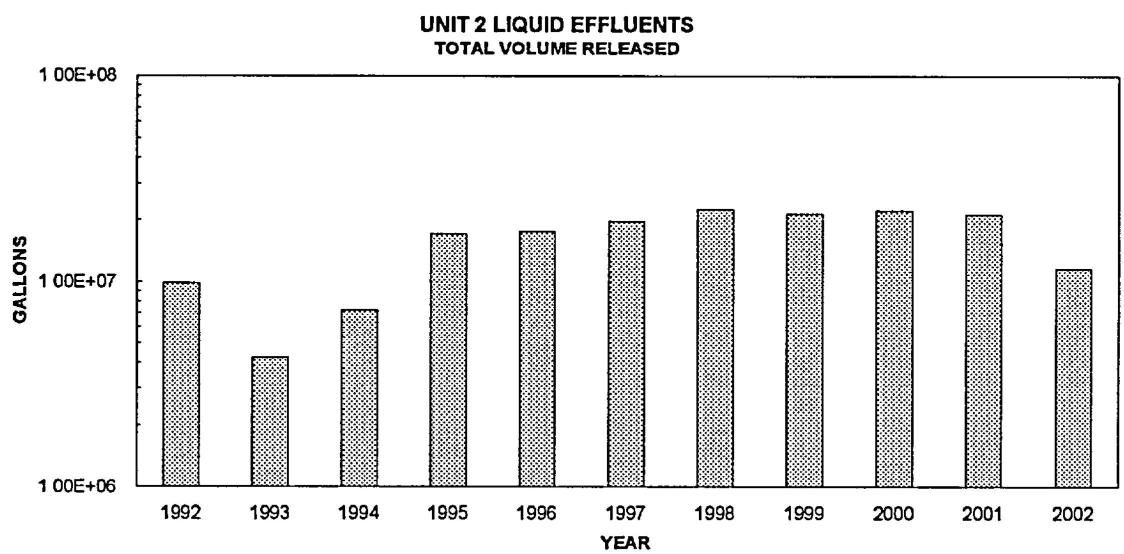

UNIT 1 GASEOUS EFFLUENTS
CRITICAL ORGAN DOSE
1 00E+00
1 00E-01
1 00E-02
1 00E-03
MREM
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

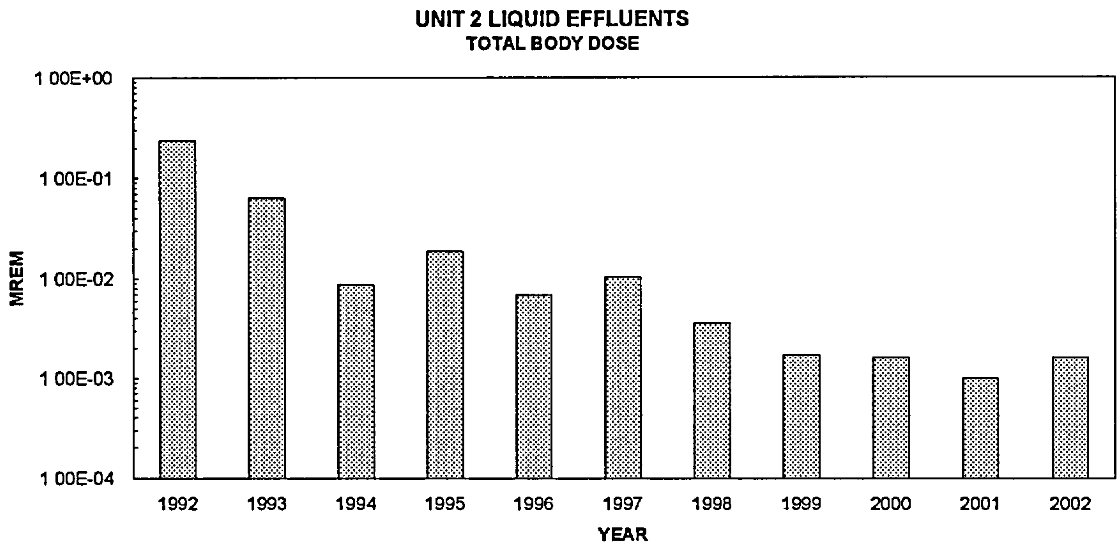

UNIT 1 GASEOUS EFFLUENTS
COLLECTIVE DOSES
0 700
0 600
0 500
0 400
0 300
0 200
0 100
0 000
% LIMIT
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR
BONE LIVER THYROID KIDNEY LUNG GI-LLI

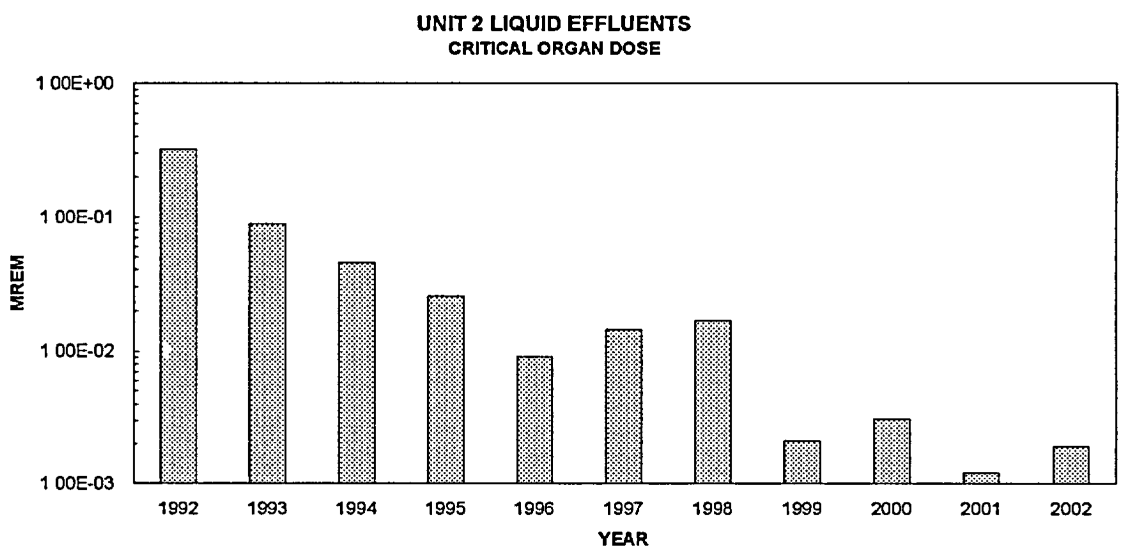

UNIT 2 LIQUID EFFLUENTS
FISSION AND ACTIVATION PRODUCTS
CURIES
1 00E+02
1 00E+01
1 00E+00
1 00E-01
1 00E-02
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

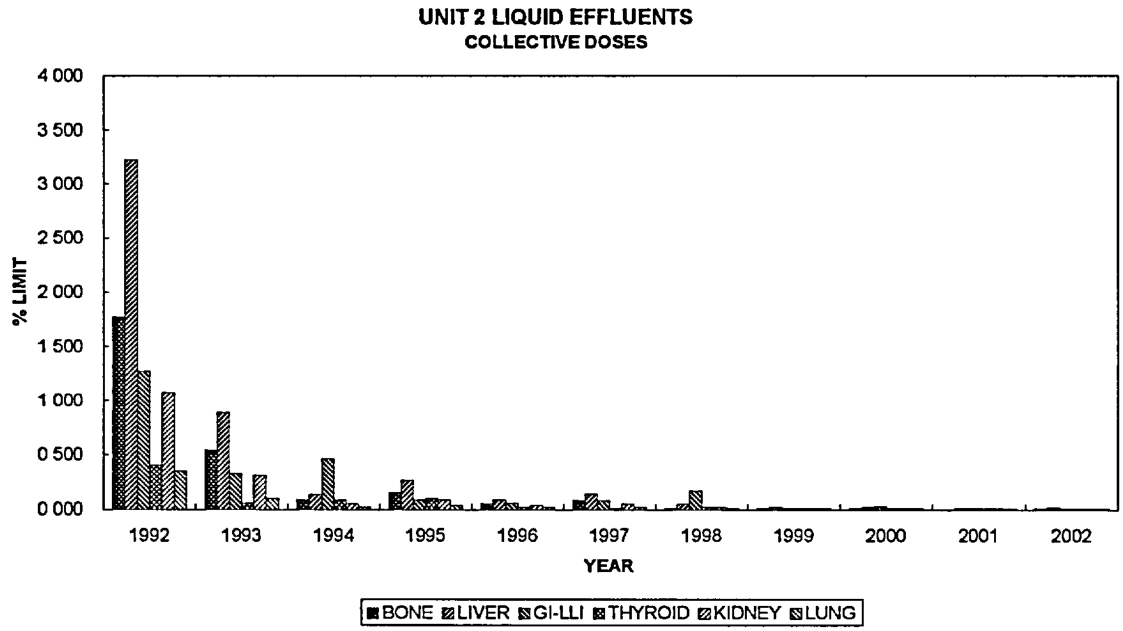

UNIT 2 LIQUID EFFLUENTS
TRITIUM
CURIES
1 00E+04
1 00E+03
1 00E+02
1 00E+01
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

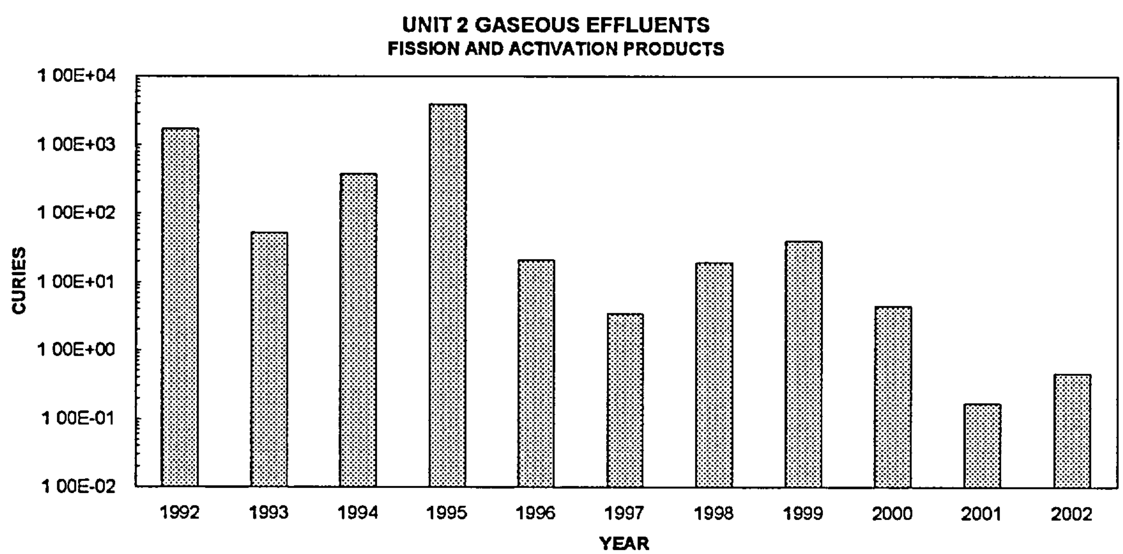

UNIT 2 LIQUID EFFLUENTS
DISSOLVED AND ENTRAINED GASES
CURIES
1 00E+03
1 00E+02
1 00E+01
1 00E+00
1 00E-01
1 00E-02
1 00E-03
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

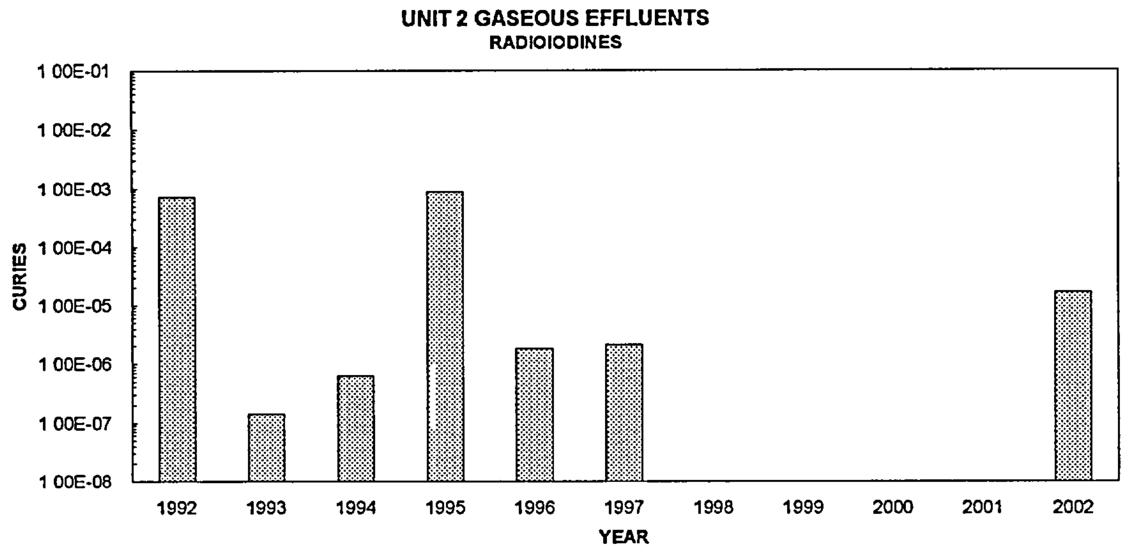

UNIT 2 LIQUID EFFLUENTS
TOTAL VOLUME RELEASED
GALLONS
1 00E+08
1 00E+07
1 00E+06
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

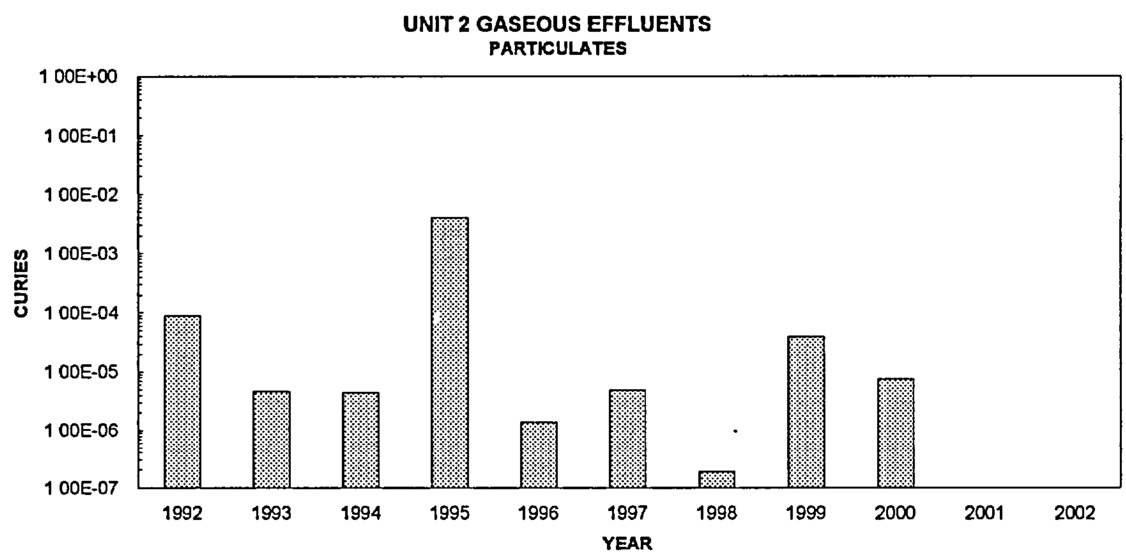

UNIT 2 LIQUID EFFLUENTS
TOTAL BODY DOSE
1 00E+00
1 00E-01
1 00E-02
1 00E-03
1 00E-04
MREM
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

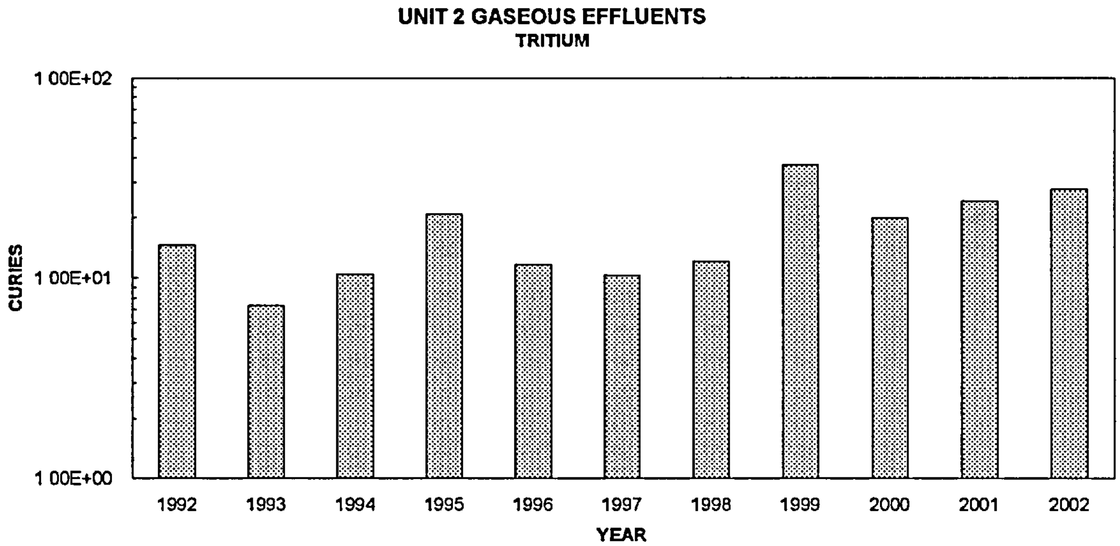

UNIT 2 LIQUID EFFLUENTS
CRITICAL ORGAN DOSE
1 00E+00
1 00E-01
1 00E-02
1 00E-03
MREM
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

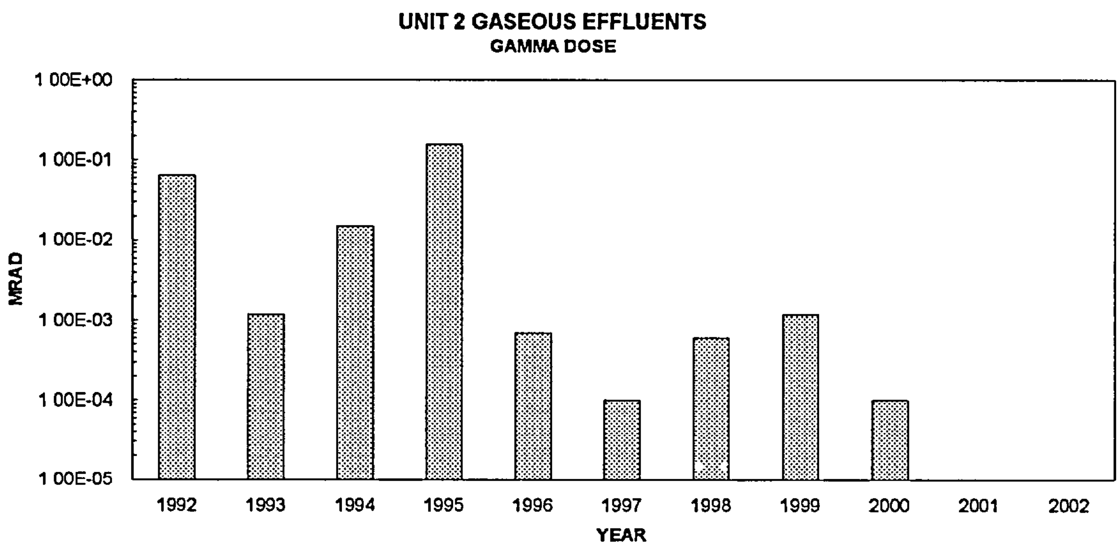

UNIT 2 LIQUID EFFLUENTS
COLLECTIVE DOSES
% LIMIT
4 000
3 500
3 000
2 500
2 000
1 500
1 000
0 500
0 000
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR
BONE
LIVER
GI-LLI
THYROID
KIDNEY
LUNG


UNIT 2 GASEOUS EFFLUENTS
FISSION AND ACTIVATION PRODUCTS
CURIES
1 00E+04
1 00E+03
1 00E+02
1 00E+01
1 00E+00
1 00E-01
1 00E-02
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

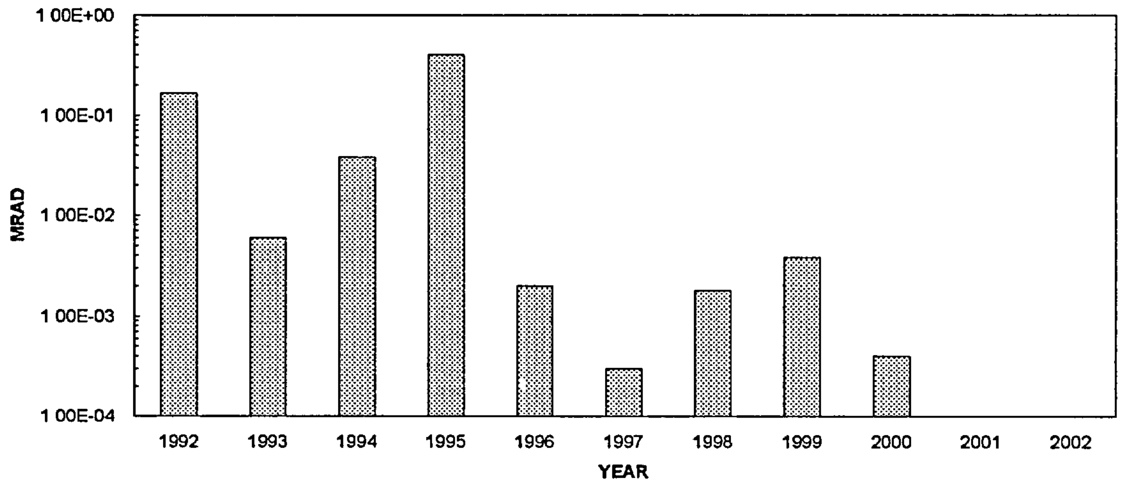

UNIT 2 GASEOUS EFFLUENTS
RADIOIODINES
CURIES
1 00E-01
1 00E-02
1 00E-03
1 00E-04
1 00E-05
1 00E-06
1 00E-07
1 00E-08
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR


UNIT 2 GASEOUS EFFLUENTS
PARTICULATES
CURIES
1 00E+00
1 00E-01
1 00E-02
1 00E-03
1 00E-04
1 00E-05
1 00E-06
1 00E-07
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

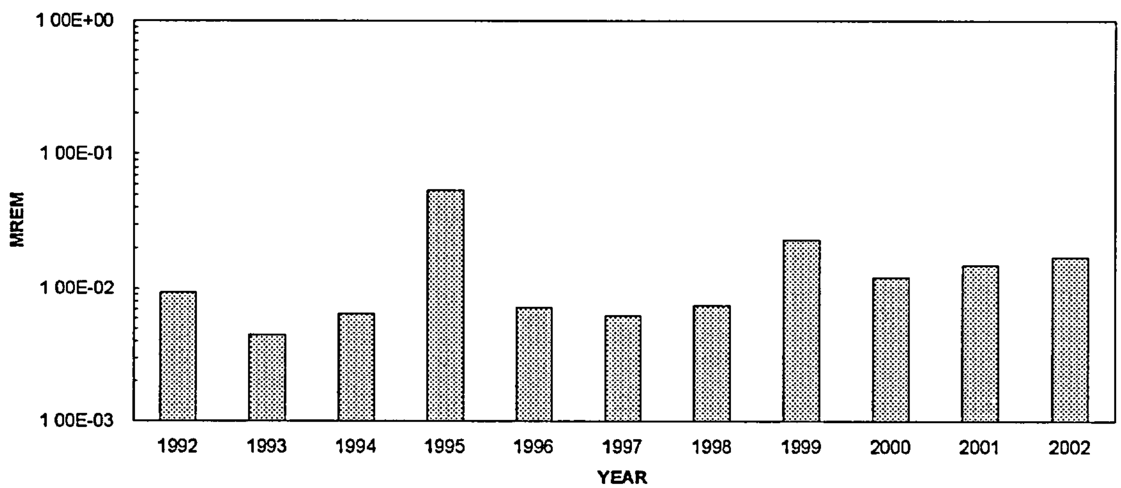

UNIT 2 GASEOUS EFFLUENTS
TRITIUM
1 00E+02
1 00E+01
1 00E+00
CURIES
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

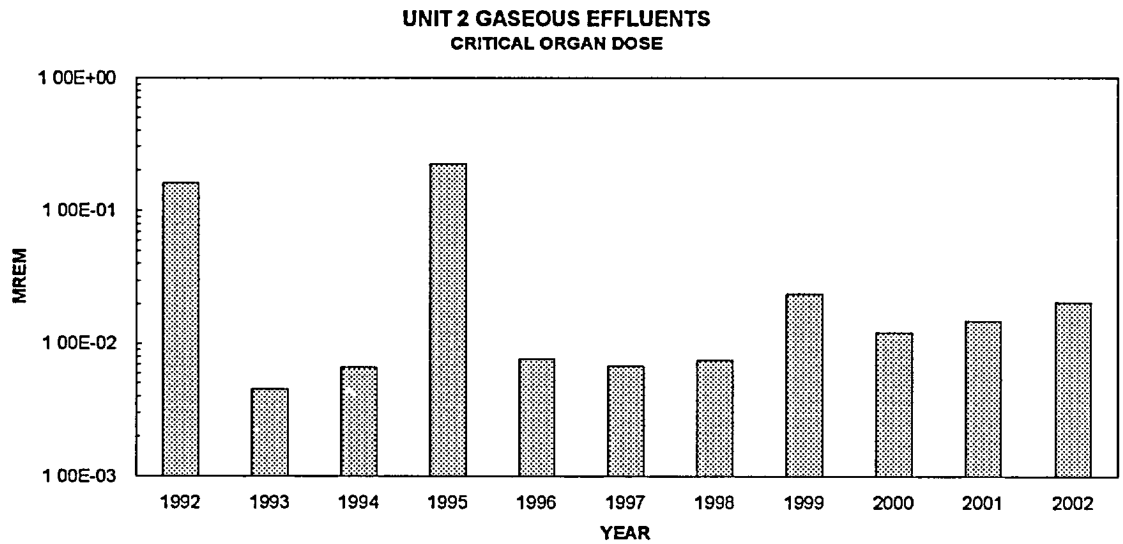

UNIT 2 GASEOUS EFFLUENTS
GAMMA DOSE
1 00E+00
1 00E-01
1 00E-02
1 00E-03
1 00E-04
1 00E-05
MRAD
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR

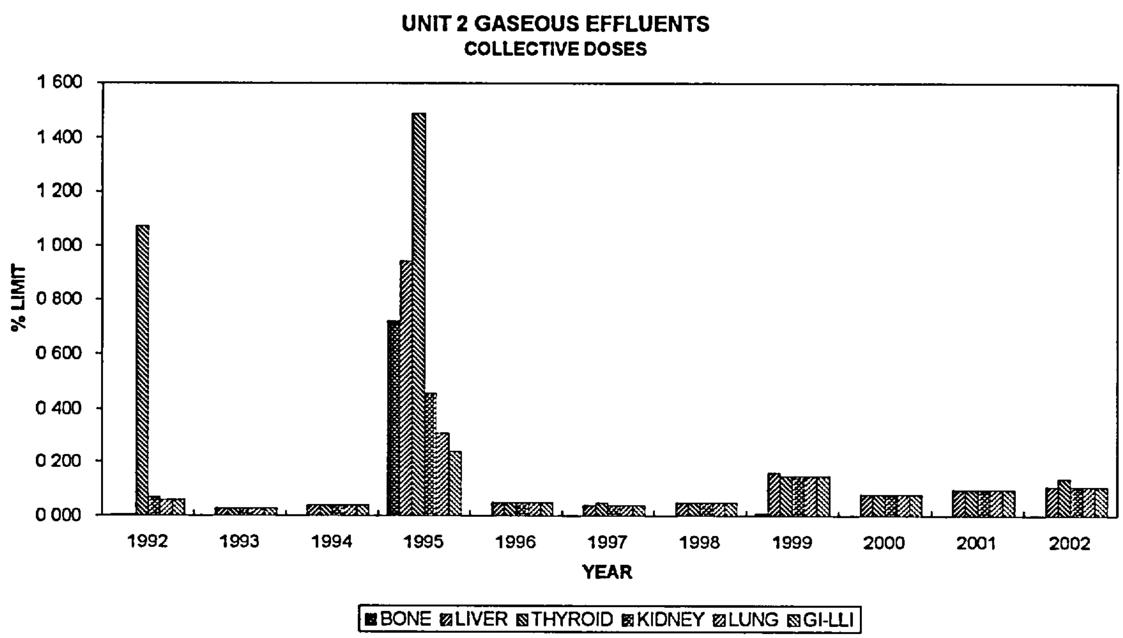
UNIT 2 GASEOUS EFFLUENTS
BETA DOSE



UNIT 2 GASEOUS EFFLUENTS
TOTAL BODY DOSE




UNIT 2 GASEOUS EFFLUENTS
CRITICAL ORGAN DOSE
1 00E+00
1 00E-01
1 00E-02
1 00E-03
MREM
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR


UNIT 2 GASEOUS EFFLUENTS
COLLECTIVE DOSES
1 600
1 400
1 200
1 000
0 800
0 600
0 400
0 200
0 000
% LIMIT
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
YEAR
BONE LIVER THYROID KIDNEY LUNG GI-LLI

8. SOLID WASTE SUMMARY

As required by Regulatory Guide 1.21, Rev. 1, a summary of data for solid wastes shipped offsite is provided in the annual Radioactive Effluent Release Report.

This summary covers shipments from January 1 through December 31, 2002. The summary for solid waste shipments is as follows:

REGULATORY GUIDE 1.21 REPORT
EFFLUENT AND WASTE DISPOSAL ANNUAL SUMMARY REPORT
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
JANUARY 1, 2002 THROUGH JUNE 30, 2002

A. Solid Waste Shipped Offsite for Burial or Disposal (Not Irradiated Fuel)

1. Type of Waste	Unit	6-Month Period	Est. Total Error, %
a. Spent resins, filter sludges, evaporator bottoms, etc.	m^3	0.00E+00	
	Ci	0.00E+00	±2.5E+01
b. Dry compressible waste, contaminated equip, etc.	m^3	7.25E+01	
	Ci	1.13E-01	±2.5E+01
c. Irradiated components, control rods, etc.	m^3	0.00E+00	
	Ci	0.00E+00	0 00E+00
d. Other (describe):	m^3	8.39E+01	
	Ci	1.13E-01	±2.5E+01

2. Estimate of Major Nuclide Composition (by Type of Waste)

a. Spent resins, filter sludges, evaporator bottoms, etc.

	%	Curies
None		

b. Dry compressible waste, contaminated equipment, etc.

	%	Curies
FE-55	7.66	8.63E-03
CO-58	44.73	5.04E-02
CO-60	5.09	5.74E-03
NI-63	11.98	1.35E-02
CS-137	30.54	3.44E-02

c. Irradiated components, control rods, etc.

	%	Curies
CO-60	0.91	1.06E-06
CS-134	1.76	2.06E-06
CS-137	97.33	1.14E-04

d. Other

	%	Curies
None		

3. Solid Waste Disposition

Number of Shipments	Mode of Transportation	Destination
6	Flatbed/Sea Van	Oak Ridge, TN

B. Irradiated Fuel Shipments (Disposition)

Number of Shipments	Mode of Transportation	Destination
None		

REGULATORY GUIDE 1.21 REPORT
EFFLUENT AND WASTE DISPOSAL ANNUAL SUMMARY REPORT
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
JULY 1, 2002 THROUGH DECEMBER 31, 2002

A. Solid Waste Shipped Offsite for Burial or Disposal (Not Irradiated Fuel)

1. Type of Waste	Unit	6-Month Period	Est. Total Error, %
a. Spent resins, filter sludges,	m^3	9.44E+01	
evaporator bottoms, etc.	Ci	1.24E+01	±2.5E+01
b Dry compressible waste,	m^3	1.81E+02	
contaminated equip, etc	Ci	1.69E+00	±2.5E+01
c. Irradiated components,	m^3	0.00E+00	
control rods, etc.	Ci	0.00E+00	±2.5E+01
d. Other (describe):	m^3	0.00E+00	
	Ci	0.00E+00	±2.5E+01

2. Estimate of Major Nuclide Composition (by Type of Waste)

a. Spent resins, filter sludges, evaporator bottoms, etc.

	%	Curies
H-3	2.22	2.75E-01
C-14	1.09	1.35E-01
FE-55	1.48	1.84E-01
CO-60	1.11	1.38E-01
NI-63	18.23	2.26E+00
SB-125	0.03	4.14E-03
CS-134	4.89	6.07E-01
CS-137	70.94	8.80E+00

b. Dry compressible waste, contaminated equipment, etc.

	%	Curies
CR-51	18.94	3.20E-01
MN-54	1.93	3.27E-02
FE-55	18.48	3.12E-01
FE-59	0.72	1.22E-02
CO-57	0.11	1.77E-03
CO-58	26.90	4.54E-01
CO-60	3.06	5.17E-02
NI-59	17.84	3.01E-01
NI-63	3.97	6.70E-02
SR-90	0.02	4.02E-04
ZR-95	3.06	5.16E-02
NB-95	4.33	7.32E-02
AG-110M	0.27	4.57E-03
SN-113	0.16	2.63E-03
CS-137	0.22	3.69E-03

c. Irradiated components, control rods, etc

	%	Curies
None		

d. Other

	%	Curies
None		

3. Solid Waste Disposition

Number of Shipments	Mode of Transportation	Destination
9	Flatbed/Sea Van	Memphis, TN
4	Cask (Strong Tight)	Erwin, TN

B. Irradiated Fuel Shipments (Disposition)

Number of Shipments	Mode of Transportation	Destination
None		

9. UNPLANNED RELEASES

An unplanned release is defined as any release of radioactive material to the environment that does not meet the following criteria:

A. Sample analysis prior to release, and
B. Release calculations performed prior to release.

During 2002, there were no unplanned releases to an unrestricted area.

10. RADIATION INSTRUMENTATION

As required by ODCM Appendices 1 and 2, any radioactive effluent instrumentation inoperable for more than 30 days shall be reported in the annual Radioactive Effluent Release Report.

No radioactive effluent instrumentation was inoperable for longer than 30 days during 2002.

11. CHANGES TO THE PROCESS CONTROL PROGRAM

As required by ODCM Appendices 1 and 2, a description of changes made to the Process Control Program (PCP) shall be included in the annual Radioactive Effluent Release Report for the period in which the change was made effective.

There were no changes made to the PCP during 2002.

12. CHANGES TO THE OFFSITE DOSE CALCULATION MANUAL

In accordance with Unit 1 and Unit 2 TS, changes to the ODCM shall be included in the annual Radioactive Effluent Release Report for the period in which the change(s) was made effective.

There was one change (014-01-0) to the ODCM in 2002. The ODCM was revised to transfer the Unit 1 Main Steam Line Radiation Monitor requirements found in the old Technical Specifications to Appendix 1, Section 4.0 of the ODCM. Specifically, the old Unit 1 Technical Specifications (3.5.1.14, Table 3.5.1-1, Item 17, with Note (Action) 30, and Table 4.1-1, item 28c) required the operability of main steam line radiation monitors and provided the corresponding actions and surveillance requirements for those monitors. As a part of the Improved Technical Specifications or ITS (Amendment 215), these specific requirements concerning the Unit 1 Main Steam Line Radiation Monitors have been deleted from the improved Technical Specifications and are no longer required. However, ANO will continue to maintain the Unit 1 Main Steam Line Radiation Monitor requirements originally found in the current Technical Specifications by placing discussion of these monitors in Appendix 1, Section 4.0 of the ODCM and by keeping the surveillance requirements for these monitors in Station Maintenance procedures. A copy of the ODCM (014-01-0) has been included behind Attachment 1.

13. LLD LEVELS

In accordance with ODCM Appendices 1 and 2, lower limits of detection (LLDs) higher than required shall be documented in the annual Radioactive Effluent Release Report.

During 2002, there were no LLDs higher than required However, upon review of the excel spreadsheet used by Chemistry to calculate Gross Alpha and Tritium LLD values, it was found that the calculation used by the spreadsheet was in error. The error was found in the numerator of the equation where the square root of the count rate was being taken instead of the square root of the number of counts. This error resulted in the Alpha and Tritium LLD values not being calculated correctly. The Alpha and Tritium LLD calculation spreadsheet was corrected and verified. Historical Alpha and Tritium LLDs in which the incorrect LLD calculation was used, were re-calculated using the corrected equation. All re-calculated LLD values were verified to be below the required ODCM levels Condition Report CR-ANO-C-2003-0064 was issued to document the error.

14. RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

In accordance with ODCM Appendices 1 and 2 Limitations L2.6.1.A and L2.6.2.A, unavailability of milk or fresh, leafy vegetable samples, or an increase in an environmental sample location's calculated dose commitment must be identified in the annual Radioactive Effluent Release Report.

A. Changes in Sample Locations

During 2002, there were no changes to milk or fresh leafy vegetable sample locations or instances where milk or fresh leafy vegetable samples were unavailable.

B. Increase in Calculated Dose Commitment

There were no environmental sampling locations identified during 2002 that would yield a calculated dose commitment greater than the values currently being calculated.

15. SUMMARY OF HOURLY METEOROLOGICAL DATA

In accordance with ODCM Appendices 1 and 2 Limitations L3.2.1.D.1, in lieu of including a summary of the meteorological data in this report, the 2002 data is retained at ANO. This data is available for NRC review.

16. DESCRIPTION OF MAJOR CHANGES TO RADIOACTIVE WASTE SYSTEMS

There were no major changes made to the Unit 1 liquid and gaseous or Unit 2 liquid and gaseous radwaste systems during 2002.

17. INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI) EFFLUENT RELEASES

No effluent releases occurred from the ISFSI during 2002.

Attachment 1

Offsite Dose Calculation Manual
(014-01-0)

Offsite Dose Calculation Manual

Arkansas Nuclear One

Revision 014-01-0

Record of Revision

Rev. No.	Pages Affected	Approved (Implemented) Date
014-00-0	1, 5, 10, 38, 46, 65, 70, 82, 103, 104, 106, 119, 124, 131, 142	11/30/01 (12/4/01)
014-01-0	3, 108, 109, 110	6/24/02 (6/24/02)

NOTE

This procedure contains Improved Technical Specifications (ITS) content in the following format:

[**ITS** Example Content **ITS**]

This content is not valid until after the implementation of Improved Technical Specifications.

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1.0 INTRODUCTION

The Offsite Dose Calculation Manual (ODCM) provides guidance for making release rate and dose calculations for radioactive liquid and gaseous effluents from Arkansas Nuclear One - Units 1 and 2. The methodology is drawn from NUREG-0133, Rev. 0. Parameters contained within this manual were taken from NUREG-0133 and Regulatory Guide 1.109 except as noted for site specific values. These numbers and the calculational method may be changed as provided for in the Technical Specifications.

The following references are utilized in conjunction with the limitations included in this manual concerning the indicated subjects:

Subject	ANO-1	ANO-2
Solid Radioactive Waste Management PCP	OP-1000.141	OP-1000.141
Radioactive Effluent Controls Program	TS 6.8.5 **[ITS** 5.5.4 **ITS]**	TS 6.8.4.a
Annual Radiological Environmental Monitoring Report	TS 6.12.2.5 **[ITS** 5.6.2 **ITS]**	TS 6.9.4
Radioactive Effluent Release Report	TS 6.12.2.6 **[ITS** 5.6.3 **ITS]**	TS 6.9.3
Offsite Dose Calculation Manual	TS 6.14 **[ITS** 5.5.1 **ITS]**	TS 6.14

2.0 LIQUID EFFLUENTS

2.1 Radioactive Liquid Effluent Monitor Setpoint

The Radioactive Liquid Effluent Instrumentation Limitation requires that the radioactive liquid effluents be monitored with the alarm/trip setpoints adjusted to ensure that the limits of the radioactive liquid effluent concentration limitations are not exceeded. These concentrations are for the site. The alarm/trip setpoint on the liquid effluent monitor is dependent upon the dilution water flowrate, radwaste tank flowrate, isotopic composition of the radioactive liquid to be discharged, a gross gamma count of the liquid to be discharged, background count rate of the monitor, and the efficiency of the monitor. Due to the fact that these are variables, an adjustable setpoint is used. The setpoint must be calculated and the monitor setpoint set prior to the release of each batch of radioactive liquid effluents. The following methodology is used for the setpoint determination for the following monitors.

ANO-1: RE-4642 Liquid Radwaste Monitor

ANO-2: 2RE-2330 Liquid Radwaste Monitor
2RE-4423 Liquid Radwaste Monitor

1) A sample from each tank (batch) to be discharged is obtained and counted for gross gamma (Cs-137 equivalent) and a gamma isotopic analysis is performed.

2) A dilution factor (DF) for the tank is calculated based upon the results of the gamma isotopic analysis and the Maximum Permissible Concentration (MPC) of each detected radionuclide.

   DF is calculated as follows:

$$DF = \Sigma_i \ (C_i/MPC_i) + C_{TNG}/MPC_{TNG}$$

   where:

   DF = dilution factor;

   C_i = concentration of isotope "i", (µCi/ml);

   MPC_i = maximum permissible concentration of isotope "i", (from 10 CFR 20, Appendix B, Table II, column 2 in µCi/ml);

   C_{TNG} = total concentration of noble gases (µCi/ml); and

   MPC_{TNG} = 2×10^{-4} (µCi/ml) per Appendix 1, Limitation L2.3.1.A and Appendix 2, Limitation L2.3.1.A.

3) The dilution water flowrate is normally the number of ANO-1 circulating water pumps in operation at the time of release. Each circulating water pump has an approximate flowrate of 191,500 gpm (this flowrate may be reduced due to throttling of circ water pump flow and/or circ water bay configuration). However, under specific conditions and under strict controls, lower dilution water flowrates utilizing service water and cooling tower blowdown flowrates may be used.

4) The theoretical release rate, F_m, of the tank (batch) to be released is expressed in terms of the dilution water flowrate, such that for each volume of dilution water released, a given volume of liquid radwaste may be combined. This may be expressed as follows:

$$F_m = DV/DF$$

where:

F_m = theoretical release rate (gpm);

DV = Dilution volume (gpm). When ANO-1 circulating water pumps are running, DV is the number of ANO-1 circulating water pumps in operation multiplied by the approximate flowrate of an ANO-1 circulating water pump (normally 191,500 gpm) or an indicated flow rate. The minimum total flow rate shall be greater than or equal to 100,000 gpm. Otherwise DV is dilution volume provided by service water and cooling tower blowdown flowrate; and

DF = dilution factor as calculated in Step 2 above.

> **NOTE**
>
> In the above equation, the theoretical release rate (F_M) approaches zero as the dilution factor increases. The actual flowrate (F_A) will normally be equal to the theoretical release rate for high activity releases. For low activity releases, the theoretical release rate becomes large and may exceed the capacity of the pump discharging the tank. In these cases, the actual release rate may be set to the maximum flowrate of the discharge pump.

5) The monitor setpoint is calculated by incorporating the monitor reading prior to starting the release (i.e., background countrate), and a factor which is the amount of increase in the release concentration that would be needed to exceed the radioactive liquid concentration limitation. The monitor setpoint is expressed as follows:

$$M_L = A*(K*F_M/F_A) + B$$

where:

M_L = monitor setpoint (CPM);

A = allocation fraction for the specific unit. (Typically, these values are set at 0.45, but may be adjusted up or down as needed. However, the total site allocation can not exceed 1.0.)

K = monitor countrate (CPM) expected based on the gross activity of the release. (This value is obtained from a graph of activity (μCi/ml) versus output countrate for the monitor (CPM));

F_M/F_A = number of times the activity would have to increase to exceed the radioactive liquid effluent-concentration limitation; and

B = background countrate (CPM) prior to the release.

To permit the computer to calculate the setpoint, an equation for the expected countrate (K) is expressed as follows:

$$K = Slope * 10^{S_A} + Offset$$

where:

$$Slope = \frac{\text{Log of the detector response in CPM}}{\text{Log of activity concentration in µCi/ml}}$$

S_A = Gross gamma (Cs-137 equivalent) activity for the tank (µCi/ml); and

Offset = detector response (CPM) for the minimum detectable sample activity calculated from the calibration data.

NOTE
I&C personnel use varying concentrations of Cs-137 to determine the response curve; therefore, a Cs-137 equivalent activity must be used to accurately predict the countrate.

Combining terms, the equation for determining the monitor setpoint may be expressed as follows:

$$M_L = A * [(Slope * 10^{S_A} + Offset) * F_M/F_A] + B$$

2.2 Liquid Dose Calculation

The "dose" or "dose commitment" to an individual in the unrestricted area shall be less than or equal to the limits specified in Radioactive Liquid Effluents-Dose Appendix 1 and Appendix 2 Limitations. The dose limits are on a per reactor basis. This value is calculated using the Adult as the maximum exposed individual via the aquatic foods (Sport Freshwater Fish) and the potable water pathways.

2.2.1 Dose Calculations for Aquatic Foods

The concentrations of radionuclides in aquatic foods are assumed to be directly related to the concentrations in water. The equilibrium ratios between the two concentrations are called "bioaccumulation factors".

Two different pathways are calculated for aquatic foods: sport and commercial freshwater fish.

The internal dose "d" from the consumption of aquatic foods in pathway "p" to organ "j" of individuals of age group "a" from all nuclides "i" is computed as follows: (See Chapter 4 of NUREG-0133 and Regulatory Guide 1.109-12, equation A-3).

$$d_p\ (r,\theta,a,j) = \Sigma_i\ \{1100*e^{-\lambda_i t_p}*B_i\}*M*U_a*F^{-1}*Q_i*D_{aij}$$

The total dose from both aquatic food pathways is then:

$$D(r,\theta,a,j) = \sum_p d_p\ (r,\theta,a,j)$$

where:

r = user-selected distance from the release point to the receptor location, in kilometers. It may be different from the controlling distance specified for the potable water pathway (0.4 km);

θ = user-selected sector (one of sixteen 22.5° sectors surrounding the reactor site, designated N, NNE, NE, ... etc). This sector may be different from the controlling sector specified for the potable water pathway (S);

a = user-selected age group: infant, child, teen, adult. It is the same controlling age group used in the potable water pathway (adult);

j = user-selected organ: bone, liver, total body, thyroid, kidney, lung, GI-LLI. It is the same controlling organ used in the potable water pathway (liver);

{ } = represents the concentration factor stored in the database;

> NOTE
>
> Only one concentration factor is needed to represent the two pathways since sport and commercial use the same bioaccumulation factor for a given pathway.

1100 = factor to convert from (Ci/yr)/(ft^3/sec) to ρCi/liter;

λ_i = decay constant of nuclide "i" in hr^{-1};

t_P = environmental transit time, release to receptor;

> **NOTE**
>
> This value should be set to 0 hours (i.e., no decay correction) for the above equation in order to be consistent with the equation presented in Chapter 4 of NUREG-0133. For maximum individual dose calculations, this value is set to 24 hours, which is the minimum transit time recommended by Regulatory Guide 1.109, Appendix A, 2.b.

B_i = bioaccumulation factor for nuclide "i", in ρCi/kg per ρCi/liter. Cesium has a site specific number based on carnivorous and bottom feeder sport fish of 400 ρCi/kg per ρCi/liter (0CAN048408, dated April 13, 1984); Niobium has a site specific number based upon freshwater fish of 300 ρCi/kg per ρCi/liter.

M = dimensionless mixing ratio (reciprocal of the dilution factor) at the point of exposure;

U_a = annual usage factor that specifies the intake rate for an individual of age group "a", in kilograms/year. The program selects this usage factor in accordance with the controlling age group "a" as specified previously by the user;

F = average flow rate in ft^3/sec. This value is based on total dilution volume for the quarter divided by time into the quarter;

Q_i = number of curies of nuclide "i" released; and

D_{aij} = ingestion dose factor for age group "a", nuclide "i", and organ "j", in mrem per ρCi ingested. The program selects the ingestion dose factor according to the user-specified controlling age group "a" and controlling organ "j".

2.2.2 Dose Calculations for Potable Water

The dose "D" from ingestion of water to organ "j" of individuals of age group "a" due to all nuclides "i" is calculated as follows (See Chapter 4 of NUREG-0133 and NRC Reg. Guide 1.109-12, equation A-2):

NOTE

The potable water pathway is used only during the time that the Russellville Water System is using the Arkansas River as a water source. The Russellville Water Works will notify ANO when they are using the Arkansas River as a water source.

$$D(r,\theta,a,j) = \Sigma_i \left[\{1100 * e^{-\lambda_i t_P}\} * M * U_a * F^{-1} * Q_i * D_{aij} \right]$$

where:

r = user-selected distance (0.4 km) from the release point to the receptor location, in kilometers. It may be different from the controlling distance selected for the aquatic food pathway;

θ = user-selected sector; (one of the sixteen 22.5° sectors surrounding the reactor site, designated N, NNE, NE, ... etc.). It may be different from the controlling sector for the aquatic food pathway;

a = user-selected age group (infant, child, teen, adult). The same controlling age group is used for all liquid pathways (adult);

j = user-selected organ (bone, liver, total body, thyroid, kidney, lung, GI-LLI). The same controlling organ is used for all liquid pathways (liver).

{} = the expression in brackets represents the concentration factor stored in the database;

1100 = factor to convert from (Ci/yr)/(ft^3/sec) to ρCi/liter;

M = dimensionless mixing ratio (reciprocal of the dilution factor) at the point of exposure;

λ_i = decay constant of nuclide "i" in hr^{-1}; and

t_P = environmental transit time, release to receptor.

NOTE

This value is set to 0 hours (i.e., no decay correction) for the above equation to be consistent with the equation presented in Chapter 4 of NUREG-0133.

U_a = annual usage factor that specifies the intake rate for an individual of age group "a", in liters/year. The program selects this usage factor according to the user-specified controlling age group "a";

F = average flow rate in ft³/sec; this value is based on total dilution volume for one quarter divided by time into the quarter;

Q_i = number of curies of nuclide "i" in the release; and

D_{aij} = ingestion dose factor, for age group "a", nuclide "i", and organ "j", in mrem per ρCi ingested. The program selects the ingestion dose factor according to the user-specified controlling age group "a" and controlling organ "j".

2.3 Liquid Projected Dose Calculation

The quarterly projected dose is based upon the methodology of Section 2.2 and is expressed as follows:

$$D_{QP} = 92*(D_{QC} + D_{RP})/T$$

where:

D_{QP} = quarterly projected dose (mrem);

92 = number of days per quarter;

D_{QC} = cumulative dose for the quarter (mrem);

D_{RP} = dose for current release (mrem); and

T = current days into quarter;

3.0 GASEOUS EFFLUENTS

3.1 Gaseous Monitor Setpoints

NOTE

Sections 3.1.1 and 3.1.2 below detail two methods of calculating setpoints at ANO. These methods cover two different sets of monitors of which only one will be in-service at any one time.

3.1.1 Batch Release Setpoint Calculations

3.1.1.a This section applies to the following gaseous radiation monitors (These releases are also monitored by the SPING monitors in Section 3.1.2):

ANO-1	
RE-4830*	Waste gas holdup system monitor
RX-9820	Unit 1 Containment Purge SPING

ANO-2	
2RE-8233	Containment purge
2RX-9820	Unit 2 Containment Purge SPING
2RE-2429*	Waste gas holdup system monitor

* These monitors provide automatic isolation for the waste gas holdup systems.

The setpoints to be used during a batch type of release (i.e., reactor building [containment] purge, release from the waste gas holdup system or any other non-routine release) will be calculated for each release before it occurs.

3.1.1.b The basic methodology for determining a monitor setpoint is based upon the expected concentration at the monitor (C_M). This is in turn based upon the fraction of an MPC assigned to this release point. Batch releases are maintained below the assigned MPC fraction by controlling the release rate. The calculated value of S may not exceed the equivalent of 1 MPC at site boundary. If value of S for RX(2RX)-9820 is less than SPING channel 5 high alarm setpoint, then high alarm setpoint may be used as a default value. If value of S for RE-4830 and 2RE-2429 is less than 50,000 counts/min, then 50,000 counts/min may be used as a minimum setpoint. If value of S for 2RE-8233 is less than 1,000 counts/min, then 1,000 counts/min may be used as a minimum setpoint.

$$S = 1.2 * (C_M * K) + (2.0 * B)$$

where:

S = monitor setpoint (counts/min);

C_M = Xe-133 equivalent concentration at the monitor (μCi/ml);

K = conversion factor determined from response curve of monitor (counts/min per μCi/ml). This value is 1.0 when calculating S for RX(2RX)-9820.

2.0 = factor to accommodate random count rate fluctuations;

B = background count rate at the monitor (counts/min).

1.2 = Safety Factor to correct for instrument uncertainties.

3.1.2 Eberline SPING (Final Effluent) Monitor Setpoint Calculations

3.1.2.a This section applies to the following gaseous radiation monitors:

ANO-1

RX-9820	Containment Purge
RX-9835	Hydrogen Purge/Emerg. Pen. Room Vent.
RX-9830	Fuel Handling Area
RX-9825	Radwaste Area

ANO-2

2RX-9820	Containment Purge
2RX-9840	PASS Bldg.
2RX-9845	Aux. Bldg. Ventilation
2RX-9835	Hydrogen Purge/Emerg. Pen. Room Vent.
2RX-9830	Fuel Handling Area
2RX-9825	Radwaste Area
2RX-9850	Low-Level Radwaste Storage Building

The determination of setpoints for the above monitors is based on an assigned fraction of the MPC of noble gas activity at the site boundary, (Xe-133 equivalent) released from the above release points. The total of these fractions is always less than 1.00. The assigned fractions are based on the vent flow rates, atmospheric dilution rate, and the ventilation system(s) in operation.

NOTE

The fact that an effluent monitor is in alarm does not necessarily mean that radioactive gases are being released at such a rate that the MPC limit is being exceeded. The alarm would indicate that radioactive gases are being released at a rate that is exceeding the fractional allocation of an MPC allotted to that particular release point. Consideration must be given to the release rate of radioactive gases via all of the release pathways.

The initial fractions of an MPC allocated to the release points are given below. The allocations may be changed as needed, to allow for operational transients, but may not exceed a site total of 1.00.

Monitor Number	Monitor Name	Fractional Allocation
RX-9820	Containment Purge	0.1000
RX-9835	Hydr. Purge/Emerg. Pen. Rm. Vent.	0.0001
RX-9830	Fuel Handling Area	0.1500
RX-9825	Radwaste Area	0.2000

Monitor Number	Monitor Name	Fractional Allocation
2RX-9820	Containment Purge	0.1000
2RX-9840	PASS Bldg.	0.0100
2RX-9845	Aux. Bldg. Ventilation	0.0100
2RX-9835	Hydr. Purge/Emerg. Pen. Rm. Vent.	0.0001
2RX-9830	Fuel Handling Area	0.1500
2RX-9825	Radwaste Area	0.2000
2RX-9850	Radwaste Storage Bldg.	0.0100

NOTE

The setpoints to be used during a batch release (i.e., reactor building [containment] purge, release from the waste gas holdup system) will be calculated for each release before it occurs.

3.1.2.b SPING monitor setpoints may be calculated as follows:

$$\text{Setpoint } (\mu Ci/cc) = A * \left[\frac{\text{Xe-133 eq } (\mu Ci/cc)}{F * 1.3215E\text{-}9 * TMPC} \right]$$

where:

A = allocation fraction (the fraction of an MPC at the site boundary (of noble gas Xe-133 eq activity) assigned to the particular release point);

Xe-133 eq = Xenon-133 equivalent concentration;

F = discharge flow of the particular release point in CFM;

$$1.3215E\text{-}9 = 2.8317E\text{-}2 (cm/cf) * \left[\frac{2.8E\text{-}6 (sec/m^3)}{60 (sec/min)} \right]$$

where:

2.8E-6 = the annual average gaseous dispersion factor (corrected for radioactive decay) as defined in Section 2.3 of the ANO-2 SAR; and

TMPC = total MPCs at site boundary.

3.2 Airborne Release Dose Rate Effects

3.2.1 Noble Gas Release Rate

3.2.1.a To calculate the noble gas release dose rate, the average ground-level concentration of radionuclide "i" at the receptor location must first be determined from the following equation. (See Regulatory Guide 1.109-20 equation B-4).

$$x_i\ (\theta) = 3.17 \times 10^4 * Q_i * D1X/Q(\theta)$$

where:

$x_i\ (\theta)$ = average ground level concentration in ρCi/m³ of nuclide "i" at the user-specified controlling distance in sector θ (1.05 km);

(θ) = one of the sixteen 22.5° sectors surrounding the reactor site, designated N, NNE, NE, ... etc. (WNW);

3.17×10^4 = number of ρCi per Ci divided by the number of seconds/year;

Q_i = release rate of nuclide "i" in curies/yr and

D1X/Q(θ) = annual average gaseous dispersion factor (corrected for radioactive decay) in the sector at angle "θ" at the receptor location in sec/m³. This value is 2.8E-6 sec/m³ for short term releases.

The annual dose to the total body and skin due to noble gas can be calculated according to Sections 3.1.2.b and 3.2.1.c.

3.2.1.b Annual Total Body Dose Rate

The annual average total body dose rate to the maximally exposed individual is calculated as follows:

$$D^T(\theta) = RBPF * S_F * \Sigma_i\ [x_i(\theta) * DFB_i]$$

where:

$D^T(\theta)$ = total body dose rate due to immersion in a semi-infinite cloud of gas at the controlling distance in sector "θ", in mrem/yr. The program computes one total body dose rate value for each sector in which the user has specified a controlling distance and reports only the maximum value;

θ = one of sixteen 22.5° sectors surrounding the reactor site, designated N, NNE, NE, ... etc.; (WNW);

RBPF = Reactor Building (Containment) Purge Factor - This factor is used to calculate the length of time (fractional duty cycle) that the purge fans will be in operation. It is calculated by comparing the highest dose rate (DOSER) to its applicable release limit, taking into account the allocation factor for the release point (RBPF = Allocation* Limit/DOSER). This factor is calculated only for Unit One and Two Reactor Building (Containment) Purges. For all other releases, this factor is set to 1.0;

S_F = dimensionless attenuation factor accounting for the dose reduction due to shielding by residential structures. The NRC recommended value is 0.7 (for maximum individual);

$x_i(\theta)$ = average ground-level concentration of nuclide "i" at the receptor location in the sector at angle "θ" from the release point, as defined in Section 3.2.1.a; and

DFB_i = total body dose factor for a semi-infinite cloud of radionuclide "i", which includes the attenuation of 5 g/cm² of tissue, in mrem-m³/ρCi-yr

3.2.1.c Annual Skin Dose Rate

The annual dose rate to the skin of the maximally exposed individual due to noble gases is calculated as follows. (See Regulatory Guide 1.109-20 equation B-9)

$$D^S(\theta) = RBPF \left[1.11 * S_F * \Sigma_i (x_i(\theta) * DF_i^{\gamma}) + \Sigma_i (x_i(\theta) * DFS_i) \right]$$

where:

$D^S(\theta)$ = skin dose due to immersion in a semi-infinite cloud of gas at the user-specified controlling distance in sector "θ", in mrem;

> NOTE
>
> The program computes a skin dose value for each sector in which the user has specified a controlling distance, but prints out only the maximum value.

RBPF = Reactor Building (Containment) Purge Factor as defined in Section 3.2.1.b.

1.11 = average ratio of tissue to air energy absorption coefficient;

S_F = dimensionless attenuation factor accounting for the dose reduction due to shielding by residential structures. The value is 0.7 (for maximum individual);

$x_i(\theta)$ = is the average ground-level concentration of nuclide "i" at the receptor location in the sector at angle "θ" from the release point, as defined in Section 3.2.1;

θ = one of sixteen 22.5° sectors surrounding the reactor site, designated N, NNE, NE, ... etc., (WNW);

DF_i^{γ} = gamma air dose factor for a semi-infinite cloud of radionuclide "i", in mrad-m³/ρCi-yr; and

DFS_i = beta skin dose factor for a semi-infinite cloud of radionuclide "i", which includes the attenuation by the outer "dead" layer of skin, in mrem-m³/ρCi-yr.

3.2.2 I-131, Tritium and Particulate Release Dose Rate Effects

The annual dose rate to the maximally exposed individual for I-131, tritium and radionuclides in particulate form with half-lives greater than eight days is calculated as follows:

$$DR^{TOT} = RBPF * \left[DR^{I} + DR^{G} + DR^{M} \right]$$

where:

RBPF = Reactor Building (Containment) Purge Factor as defined in Section 3.2.1.b;

DR^{I} = dose rate to the controlling age group (infant) associated with the inhalation of radioiodines and particulates, as calculated in Section 3.4.1.b;

DR^{G} = dose rate from direct exposure to activity deposited on the ground plane, as calculated in Section 3.4.1.a; and

DR^{M} = dose rate to the controlling age group (infant) and the controlling organ for ingestion of food (milk), as calculated in Section 3.4.1.d.

Calculation of the annual dose rate considers the infant as the most restrictive age group. The organs that are considered as contributing to the dose rate are: skin, bone, liver, total body, thyroid, kidney, lung, and GI-LLI. The food pathway for the infant is considered to be from milk only. All three pathways will contribute to the total body dose, while the skin will be affected by only the ground plane pathway. The other organs are affected only by the inhalation and food pathways.

3.3 Dose Due to Noble Gases

The air dose in unrestricted areas due to noble gases released in gaseous effluents shall be less than or equal to 5 mrad for gamma radiation and 10 mrad for beta radiation for any calendar quarter for each unit. The objective of less than or equal to 10 mrad of gamma radiation and 20 mrad of beta radiation for a calendar year per unit (2.5 mrad and 5 mrad respectively per quarter) should be used for planning releases.

NOTE
The following equations have been simplified from equations in NUREG-0133, Rev. 0, in that there are no free-standing stacks at ANO. The equations were further simplified in that there are no long term (i.e., continuous) releases. The individual stack vents are sampled weekly and are assigned a release period of 168 hours per sample (i.e., considered as short term (batch) releases). Individual samples are to be taken for each waste gas tank release and reactor building (containment) purge.

3.3.1 Beta and Gamma Air Doses from Noble Gas Releases

Using the average ground level concentration of radionuclide "i" at the receptor location calculated in Section 3.2.1.a, the associated annual gamma or beta air dose may be calculated by the following equation. (See Regulatory Guide 1.109-20 equation B-5.)

$$D^{\gamma}(\theta) \ \underline{\text{or}} \ D^{\beta}(\theta) = \Sigma_i \left[x_i(\theta) * (DF_i^{\gamma} \ \underline{\text{or}} \ DF_I^{\beta}) \right]$$

where:

$D^{\gamma}(\theta)$ or $D^{\beta}(\theta)$ = the gamma or beta air dose for the controlling distance in sector "θ". (Only the maximum value is reported), and

DF_i^{γ} or DF_i^{β} = gamma or beta air dose factors for a uniform semi-infinite cloud of nuclide "i", in mrad-m³/ρCi-yr.

3.4 Dose Due to I-131, Tritium, and Particulates in Gaseous Effluents

The calculational methodology for determining the dose to an individual from I-131, tritium, and radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released to unrestricted areas as specified in the Appendix 1 and Appendix 2 Limitations is in this section.

The child is the controlling age group unless stated otherwise.

The inhalation and ground plane pathways are considered to exist at all locations. The grass-cow-milk, grass-cow-meat, and vegetation pathways are used where applicable.

It is assumed that iodines are in the elemental form.

A dispersion parameter of 2.8E-6 sec/m³ (per ANO-2 SAR, Section 2.3.4.4) is used for "w" in the inhalation pathway since the majority of gaseous activity released from the site is within the 8 to 24 hours time frame (i.e., reactor building [containment] purges and waste gas decay tanks).

The equation is:

$$D^{TOT} = D^{G} + D^{I} + D^{V} + D^{L} + D^{M} + D^{F}$$

where:

D^{TOT} = total dose;

D^{G} = dose contribution from ground plane deposition as calculated in Section 3.4.1.a;

D^{I} = dose contribution from inhalation of radioiodines, tritium, and particulates (>8 days) as calculated in Section 3.4.1.b;

D^{V} = dose contributions from consumption of vegetation (defined as produce) for humans and stored feed for cattle. See Section 3.4.1.c for calculations;

D^{L} = dose contributions from consumption of fresh leafy vegetables (defined as garden products) for humans and pasture grass for cattle. See Section 3.4.1.c for calculations;

D^{M} = dose contribution from consumption of cow's milk; and

> NOTE
>
> Consumption by the cow of both stored feeds and pasture grasses is taken into account when calculating this dose contribution. Concentration factors for both food sources are calculated.

D^{F} = dose contribution from consumption of meat.

> NOTE
>
> Consumption by the cow of both stored feeds and pasture grasses is taken into account when calculating this dose contribution. Concentration factors for both types of animal are calculated.

3.4.1 Total Dose from Atmospherically Released Radionuclide

After the calculation of the concentration factors from the applicable parts of Section 3.4.1, the maximum individual dose as calculated for controlling age group "a" and controlling organ "j", in sector θ at the controlling distance "r" is given from:

$D^G(r,\theta,j,a)$ (Section 3.4.1.a) for ground plane deposition

$D^I(r,\theta,j,a)$ (Section 3.4.1.b) for inhalation

$D^V(r,\theta,j,a) = \sum_i DFI_{ija} U_a^v C_i^v(r,\theta)$ for produce

$D^L(r,\theta,j,a) = \sum_i DFI_{ija} U_a^L C_i^L(r,\theta)$ for leafy vegetables

$D^M(r,\theta,j,a) = \sum_i DFI_{ija} U_a^m C_i^m(r,\theta)$ for cow's milk

$D^F(r,\theta,j,a) = \sum_i DFI_{ija} U_a^F C_i^F(r,\theta)$ for meat

where:

a = controlling age group (infant, child, teen, or adult);

j = controlling organ (bone, liver, total body, thyroid, kidney, lung, or GI-LLI);

r = user-selected distance from the release point to the receptor location in a particular sector, in kilometers. (The controlling distance is the same for all airborne pathways, 1.05 km.);

θ = one of sixteen 22.5° sectors surrounding the reactor site, designated N, NNE, NE, ... etc., (WNW);

DFI_{ija} = dose conversion factor for ingestion of nuclide "i", organ "j", and age group "a", in mrem/ρCi;

NOTE
Values used in these tables are taken from Tables E-11 through E-14 of Regulatory Guide 1.109. DFI_{ija} is selected according to the controlling organ and age group as specified in the database.

U_a^V, U_a^L, U_a^M, U_a^F = ingestion rates for produce, leafy vegetables, cow's milk, and meat, respectively, for individuals in age group "a". Values used are taken from Table E-5 of Regulatory Guide 1.109.);

C_i^V, D_i^L, C_i^M, D_i^F = concentration of nuclide "i" for produce, leafy vegetables, cow's milk, and meat, respectively, in ρCi/kg or ρCi/liter.

The program calculates that maximum individual dose for each sector surrounding the plant in which the user has specified a controlling distance for each of the following pathways: A) ground plane deposition; B) inhalation and the ingestion of; C) produce; D) leafy vegetables; E) cow's milk; and F) meat. Only the receptor point receiving the maximum dose value is printed.

3.4.1.a Dose from Ground Plane Deposition

The dose D^G from direct exposure to activity deposited on the ground plane is calculated as follows (see Regulatory Guide 1.109-24, equations C-1 and C-2):

$$D^G(r,\theta,j,a) = \{S_F*1.0 \times 10^{12}* \Sigma_i \left[\lambda_i^{-1} * (1 - e^{-\lambda_i t_b}) \right]\} * DOQ(r,\theta) * Q_i * DFG_{ij}$$

where:

r = user-selected distance from the release point to the receptor location in a particular sector, in kilometers. The controlling distance is the same for all airborne pathways (1.05 km);

θ = one of sixteen 22.5° sectors surrounding the reactor site, designated N, NNE, NE ... etc., (WNW);

a = user-selected age group (infant, child, teen, adult) which is the same controlling age group used for all airborne pathways (child);

j = user-selected organ (bone, liver, total body, thyroid, kidney, lung, GI-LLI) which is the same controlling organ used for all airborne pathways;

{ } = represents the concentration factor stored in the database;

S_F = dimensionless attenuation factor accounting for the dose reduction due to shielding by residential structures. The value is 0.7 (for maximum individual);

1.0×10^{12} = number of ρCi per Ci;

λ_i = decay constant of nuclide "i" in hr^{-1};

t_b = length of time over which the accumulation is evaluated (nominally 15 years which is the approximate midpoint of facility operating life or 1.31×10^5 hours);

DOQ(r,θ) = average relative deposition of the effluent at the receptor location "r" in sector "θ", considering depletion of the plume during transport, in m^{-2};

Q_i = release of nuclide "i" in curies, and

DFG_{ij} = open field ground plane dose conversion factor for organ "j" (total body or skin) from radionuclide "i", in mrem-m²/ρCi-hr. The dose factor is selected according to the user-specified controlling age group "a" and controlling organ "j".

3.4.1.b Dose from Inhalation of Radionuclides in Air

The dose D^I to organ "j" of age group "a" associated via inhalation of radioiodines and particulates is (see Reg. Guide 1.109-25, Equations C-3 and C-4):

$$D^I(r,\theta,j,a) = 3.17 \times 10^4 * R_a * \Sigma_i \left[Q_i * D2DPX/Q(r,\theta) * DFA_{ija} \right]$$

where:

r = user-selected distance from the release point to the receptor location in a particular sector, in kilometers. The controlling distance is the same for all airborne pathways (1.05 km);

θ = one of sixteen 22.5° sectors surrounding the reactor site, designated N, NNE, NE ... etc., (WNW);

j = user-selected organ (bone, liver, total body, thyroid, kidney, lung, GI-LLI) and is the same controlling organ as that used for all airborne pathways;

a = user-selected age group (infant, child, teen, adult) and is the same controlling age group as that used for all airborne pathways;

3.17×10^4 = number of ρCi/Ci divided by the number of seconds/year;

R_a = annual air intake for individuals in age group "a" (in m^3/year). The air intake factor is selected in accordance with the user-specified controlling age group;

Q_i = release of nuclide "i" in curies;

D2DPX/Q(r,θ) = annual average atmospheric dispersion factor of the radionuclide at the receptor location "r" in sector "θ" (in sec/m^3) as calculated; and

> NOTE
> This includes depletion (for radioiodines and particulates) and radioactive decay of the plume.

DFA_{ija} = inhalation dose factor for radionuclide "i", organ "j", and age group "a". The inhalation dose factor is selected in accordance with the user-specified controlling age group "a" and controlling organ "j".

3.4.1.c Dose from Nuclide Concentrations in Vegetation

> NOTE
> To reduce the computational overhead of the computer, the calculations for dose resulting from nuclide concentrations in forage, produce and leafy vegetables is performed in three steps.

First, the concentration factors (CF) are computed and stored in the database. The concentration factor includes all the parameters that are considered constant for each nuclide and agricultural activity, such as the radioactive decay constant, removal rate constant, exposure time, etc.

Second, the deposition rate from the plume is multiplied by the concentration factor and the nuclide activity to produce the nuclide concentration as follows:

$$C_i^V(r,\theta) = CF_i * DOQ(r,\theta) * Q_i$$

where:

$C_i^V(r,\theta)$ = concentration of nuclide "i" at the receptor location (r,θ);

CF_i = concentration factor of nuclide "i";

$DOQ(r,\theta)$ = relative deposition of nuclide "i". For the short term dispersion option, DOQ is replaced by (F x DOQ), where F is the short term dispersion correction factor;

Q_i = quantity of nuclide "i" released in curies.

For carbon-14 and tritium, the nuclide concentration is calculated from the concentration factor times the decayed and depleted X/Q for radioiodines and particulates (D2DPX/Q), times the quantity of nuclide "i" released in curies. For the short term dispersion option, D2DPX/Q is replaced by F x D2DPX/Q, where F is the short term dispersion correction factor.

$C_T^V(r,\theta) = CF_T * D2DPX/Q(r,\theta) * Q_T$ for tritium, and

$CF^V_{14}\ (r,\theta) = CF_{14} * D2DPX/Q(r,\theta) * Q_{14}$ for carbon-14

Third, the nuclide concentrations for a particular pathway (produce, leafy vegetables, cow's milk, and meat) are summed and multiplied by: 1) the ingestion rate for a particular age group and 2) the dose conversion factor:

$$D(r,\theta,j,a) = \Sigma_i \left[(DFI_{ija} * U_a * C_i^V(r,\theta) \right]$$

where:

r = user-selected distance from the release point to the receptor location in a particular sector, in kilometers (1.05 km);

θ = one of sixteen 22.5° sectors surrounding the reactor site, designated N, NNE, NE ... etc., (WNW);

j = user-selected organ (bone, liver, total body, thyroid, kidney, lung, GI-LLI), and is the same controlling organ as that used for all airborne pathways;

a = user-selected age group (infant, child, teen, adult), and is the same controlling age group as that used for all airborne pathways;

DFI_{ija} = dose conversion factor for ingestion of nuclide "i", organ "j", and age group "a", in mrem/ρCi, according to the controlling organ and age group;

U_a = annual ingestion rate of food in a particular pathway (kilograms/year or liters/year) for individuals in age group "a", according to the controlling age group; and

$C_i^v(r,\theta)$ = concentration of nuclide "i" at the receptor location (r,θ).

3.4.1.c.1 Calculating Vegetation Concentration Factors

NUREG-0133 calculations for radioiodines and particulate radionuclides (except tritium and carbon-14), the concentration factor of nuclide "i" in and on vegetation is estimated as follows:

$$CF_i^v = CONST*\left(\frac{r}{y_v*\lambda_i}\right)*e^{-\lambda_i t_h}*f$$

where:

CF_i^v = concentration factor of radionuclide "i" in vegetation (forage, produce, or leafy vegetables), in m^2-hr/kg;

CONST = 1.14×10^8 number of ρCi per Ci (10^{12}) divided by the number of hours per year (8760);

r = is the fraction of deposited activity retained on crops, leafy vegetables, or pasture grass, from airborne radioiodine and particulate deposition:

r = 1.00 for radioiodines

r = 0.20 for particulates

Y_v = agricultural productivity (yield or vegetation area density), in kg (wet weight)/m²:

- Y_s = 2.0 kg/m² for stored animal feed for grass-animal-man pathways
- Y_ρ = 0.7 kg/m² for pasture grass for grass-animal-man pathways
- Y_1 = 2.0 kg/m² for leafy vegetation (fresh) for crop/vegetation-man pathways
- Y_g = 2.0 kg/m² for garden produce (stored vegetables) for crop/vegetation-man pathways

λ_i = is the decay constant of nuclide "i" in hr^{-1};

t_h = is a holdup time that represents the time interval between harvest and consumption of the food, in hours:

- t_h = 0 hours for pasture grass consumed by animals
- t_h = 2160 hours for stored feed consumed by animals
- t_h = 24 hours for leafy vegetables consumed by humans
- t_h = 1440 hours for produce consumed by humans

f = is the fraction of leafy vegetables or produce grown in garden of interest:

- f = 0.76 for the fraction of produce ingested, grown in garden of interest. (This is f_g in equation C-13 of Regulatory Guide 1.109) f = 1.00 for the fraction of <u>leafy vegetables</u> grown in garden of interest. (This is f_1 in equation C-13 of Regulatory Guide 1.109)

f = 1.00 for all other pathways

3.4.1.c.2 <u>Concentration Factor for Carbon-14</u>

For carbon-14, the concentration factor <u>in and on</u> vegetation is estimated as follows (see Regulatory Guide 1.109-26, equation C-8):

$$CF^{V}_{14} = 2.2 \times 10^{7} * \rho$$

where:

CF^{V}_{14} = concentration factor of carbon-14 in and on vegetation, in m^2-hr/kg; and

ρ = is defined as the ratio of total annual release time (for C-14 atmospheric releases) to the total annual time during which photosynthesis occurs (taken to be 4400 hours), under the condition that the value of "ρ" should never exceed unity. For continuous C-14 releases, "ρ" is taken to be unity.

(Thus, the value of 2.2×10^{7} is stored for CF^{V}_{14} in lieu of a site specific value for "ρ".)

3.4.1.c.3 <u>Concentration Factor for Tritium</u>

The concentration factor for tritium in vegetation is calculated from the tritium concentration in air surrounding the vegetation (see Regulatory Guide 1.109-27, equation C-9):

$$CF^{V}_{T} = \frac{1.2 \times 10^{7}}{H}$$

where:

CF^{V}_{T} = concentration factor for tritium in vegetation (in m^2-hr/kg); and

H = absolute humidity at the location of the vegetation, in g/m^3. (The regulatory default value for "H" is 8.0 $grams/m^3$.)

(Thus, the value 1.5×10^{6} is stored for CF^{V}_{T} in lieu of a site specific value for "H".)

3.4.1.c.4 Nuclide Concentrations in Produce and Leafy Vegetables

The concentrations in and on produce and leafy vegetables of all radioiodine and particulate nulcides "i" (except carbon-14 and tritium) are calculated as follows:

$$C_i^V(r,\theta) = CF_i^V * DOQ(r,\theta) * Q_i$$ for produce; and

$$C_i^L(r,\theta) = CF_i^L * DOQ(r,\theta) * Q_i$$ for leafy vegetables

where:

CF_i^V = concentration factor of nuclide "i" in produce;

CF_i^L = concentration factor of nuclide "i" in leafy vegetables;

(Note that the difference between CF_i^V and CF_i^L are the values for t_h and f_1.)

$DOQ(r,\theta)$ = relative deposition of the radionuclide "i" at the receptor (r,θ); and

Q_i = release of nuclide "i" (in curies).

The C-14 and H-3 nuclide concentrations are calculated from the concentration factors times the decayed and depleted radioiodine relative deposition D2DPX/Q times the fraction grown in the garden of interest ($f_g = 0.76$, $f_1 = 1.0$):

$$C_T^V(r,\theta) = CF_T^V * D2DPX/Q(r,\theta) * Q_T * f_g$$

$$C_T^L(r,\theta) = CF_T^L * D2DPX/Q(r,\theta) * Q_T * f_1$$ for tritium

$$C^V_{14}(r,\theta) = CF^V_{14} * D2DPX/Q(r,\theta) * Q_{14} * f_g$$

$$C^L_{14}(r,\theta) = CF^L_{14} * D2DPX/Q(r,\theta) * Q_{14} * f_1$$ for carbon-14

3.4.1.d Nuclide Concentration in Cow's Milk

The radionuclide concentration in cow's milk is dependent upon the quantity and contamination level of feed consumed by the animal. The concentration is estimated (see Regulatory Guide 1.109-27, equations C-10 and C-11) as follows:

$$C_i^m(r,\theta) = \{F_m * Q_F * e^{-\lambda_i t_f} * [f_p * f_s * CF_i^v + (1 - f_p) * CF_i^{v^1} + f_p * (1 - f_s) * CF_i^{v^1}]\} * D(r,\theta) * Q_i$$

where:

$C_i^m(r,\theta)$ = is the concentration of nuclide "i" in cow's milk at the receptor location (r,θ), in ρCi/liter;

{ } = the expression in brackets represents the concentration factor. (Note that the concentration factor for cow's milk involves two different vegetation concentration factors (see below).);

F_m = average fraction of the cow's daily intake of radionuclide "i" (which appears in each liter of milk), in days/liter;

Q_F = amount of feed consumed by the cow per day, in kg/day (wet weight);

λ_i = decay constant of nuclide "i" in hr^{-1};

t_f = average transport time of the activity from the feed into the milk and to the receptor (a value of 2 days is assumed);

f_p = fraction of the year that cows graze on pasture;

f_s = fraction of daily feed that is pasture grass when the cow grazes on pasture;

CF_i^v = vegetation concentration factor of nuclide "i" on pasture grass with the holdup time t_h = 0 days, in ρCi/kg. (Refer to the explanation of the vegetation concentration factor calculation);

$CF_i^{v^1}$ = vegetation concentration factor of nuclide "i" in stored feeds with the holdup time t_h = 90 days, in ρCi/kg. (Refer to the explanation of the vegetation concentration factor calculations);

$D(r,\theta)$ = relative deposition $DOQ(r,\theta)$ of the radionuclides, except carbon-14 and tritium. For carbon-14 and tritium, the decayed and depleted dispersion factor $D2DPX/Q(r,\theta)$ for radioiodines and particulates (in sec/m^3) is used; and

Q_i = is the release of nuclide "i" in curies.

3.4.1.e Nuclide Concentration in Meat

The radionuclide concentration in meat is dependent upon the quantity and contamination level of feed consumed by the animal. The concentration is estimated (see Regulatory Guide 1.109-27, equations C-11 and C-12) as follows:

$$C_i^f(r,\theta) = \{F_f * Q_F * e^{-\lambda_i t_s} * [f_p * f_s * CF_i^v + (1 - f_p) * CF_i^{v^1} + f_p * (1 - f_s) * CF_i^{v^1}]\} * D(r,\theta) * Q_i$$

where:

NOTE
All parameters used in this pathway are for beef cattle.

$C_i^f(r,\theta)$ = concentration of nuclide "i" in animal flesh at the receptor location (r,θ) in ρCi/liter;

{ } = the expression in brackets represents the concentration factor (Note that the concentration factor for meat involves two different vegetation concentration factors);

F_f = average fraction of the animal's daily intake of radionuclide "i" which appears in each kilogram of flesh (in days/kg);

Q_f = amount of feed consumed by the animal per day in kg/day (wet weight);

λ_i = decay constant of nuclide "i" in hr^{-1};

t_s = average time from slaughter of the animal to consumption by humans (20 days);

f_p = fraction of the year that animals graze on pasture;

f_s = fraction of daily feed that is pasture grass when the animal grazes on pasture;

CF_i^v = vegetation concentration factor of nuclide "i" on pasture grass with the holdup time t_h = 0 days in ρCi/kg. (Refer to the explanation of the vegetation concentration factor calculation);

$CF_i^{v^1}$ = vegetation concentration factor of nuclide "i" in stored feeds with the holdup time t_h = 90 days, in ρCi/kg. (Refer to the explanation of the vegetation concentration factor calculation);

$D(r,\theta)$ = relative deposition DOQ(r,θ) of the radionuclides, except carbon-14 and tritium. For carbon-14 and tritium, the decayed and depleted dispersion factor D2DPX/Q(r,θ) for radioiodines and particulates (in sec/m³) is used;

Q_i = is the release of nuclide "i" (in curies).

3.5 Gaseous Effluent Projected Dose Calculation

3.5.1 The quarterly projected dose is based upon the methodology of Sections 3.3 and 3.4, and is expressed as follows:

$$D_{QP} = \left[\frac{D_{QC} + D_{RP}}{T} \right] * 92$$

where:

D_{QP} = Quarterly projected dose (mrem);

D_{QC} = cumulative dose for the quarter (mrem);

D_{RP} = dose for current release (mrem);

T = current days into quarter; and

92 = number of days per quarter.

3.6 Dose to the Public Inside the Site Boundary

3.6.1 Liquid Releases

Dose to the public inside the site boundary due to liquid releases will be due to ingestion of fish caught from the discharge canal and exposure to sediment along the discharge canal bank while fishing.

3.6.1.a Dose Due to Ingestion of Fish

Dose due to ingestion of fish is calculated using the methodology given in Section 2.2, Liquid Dose Calculation.

3.6.1.b Dose Due to Exposure to Shoreline Sediments

Dose from external exposure to shoreline sediments is calculated from equation A-7 of Regulatory Guide 1.109, Rev. 1, 10/77.

$$R_{apj} = 110{,}000 \frac{U_{ap} * M_p * W}{F} * \Sigma_i \left[Q_i * T_i * D_{aipj} * [\exp(-\lambda_i t_p)] * [1 - \exp(-\lambda_i t_b)] \right]$$

where:

R_{apj} = is the total annual dose to organ "j" of individuals of age group "a" from all of the nuclides "i" in pathway in mrem/yr;

U_{ap} = is the usage factor that specifies exposure time for the maximum individual of age group "a" in hours from Table E-5 of Regulatory Guide 1.109. 67 hours for shoreline recreation for a teen was chosen. Adult is the controlling age group for ingestion but the maximum usage factor (teen) was used rather than the adult factor to ensure a conservative dose estimate;

M_p = is the mixing ratio (reciprocal of dilution factor);

W = is the shoreline width factor from Table A-2 of Regulatory Guide 1.109. The discharge canal value of 0.1 was chosen;

F = is the flow rate of the liquid effluent in ft^3/sec. This was determined by:

$$F(ft^3/sec) = \text{waste volume (gal/yr)} * \left[\frac{.134\ ft^3}{1\ gal}\right] * \left[\frac{1\ yr}{8760\ hr}\right] * \left[\frac{1\ hr}{3600\ sec}\right]$$

Q_i = is the release of nuclide "i" in Ci/yr;

T_i = is the radioactive half-life of nuclide "i", in days, from <u>Radioactive Decay Data Tables</u>, Technical Information Center, U. S. Dept. of Energy, 1981;

D_{aipj} = is the dose factor specific to age group "a", nuclide "i", and organ "j" from Table E-6 of Regulatory Guide 1.109;

λ_i = is the radioactive decay constant of nuclide "i" in hr^{-1};

t_p = is the average transit time for nuclides to reach the point of exposure. A value of 0 hours was chosen due to the proximity of the discharge canal to the plant; and

t_b = is the period of time for which sediment is exposed to the contaminated water in hours. The mid-point of plant operating life, 15 years was chosen per Regulatory Guide 1.109.

3.6.2 Airborne Release

3.6.2.a Dose Due to Noble Gases

Dose to fisherman at the discharge canal can be calculated by the ratio of dispersion factor for the discharge canal (1.6E-4 sec/m³ from Table 2-45 SAR, Unit 1, 100 meters downwind in a southerly direction) and the usage factor of 67 hours of shoreline recreation to the values used in Section 3.3 of this manual.

$$\text{Dose at discharge canal} = D^T(\theta) * \left[\frac{1.6E-4}{2.8E-6}\right] * \left[\frac{67\ hr}{8670\ hr}\right]$$

where $D^T(\theta)$ is the noble gas dose calculated by Section 3.3.

3.6.2.b Dose Due to Iodine, Tritium and Particulates from Gaseous Effluents

Section 3.4 calculates total dose for iodine, tritium and particulates as the sum of:

$$D^{TOT} = D^G + D^I + D^V + D^L + D^M + D^F$$

where:

D^G = ground plane deposition;

D^I = inhalation;

D^V = consumption of vegetation;

D^L = consumption of fresh leafy vegetables;

D^m = consumption of milk; and

D^F = consumption of meat and poultry;

The only contributions relevant to fishing activities at the discharge canal are ground plane deposition and inhalation. As D^G and D^I are not independently available, a conservative estimate can be obtained by using the same correction factor developed for noble gas dose to the total dose calculated in Section 3.4 for iodine, tritium and particulates. Depletion of the plume as it travels downwind can be ignored since the fraction remaining in the plume at 100 meters (discharge canal) and 1046 meters (site boundary) are both greater than 90% according to Figure 3 of Regulatory Guide 1.111.

The only activity inside the plant site by members of the public that might contribute a significant dose is fishing along the banks of the discharge canal. Travel along public roads would involve short exposure time and tours of the facility are conducted according to radiological control procedures enforced at the plant to control exposure. Fishing is the only uncontrolled activity.

4.0 ENVIRONMENTAL SAMPLING STATIONS - RADIOLOGICAL

Environmental samples will be collected as specified in the Appendix 1 and Appendix 2 Limitations. The approximate locations of selected sample sites are shown on Figure 4-1 for illustrative purposes.

Table 4-1 lists the approximate distances and directions of the sample stations from the plant.

FIGURES

FIGURE 4-1

RADIOLOGICAL SAMPLE STATIONS

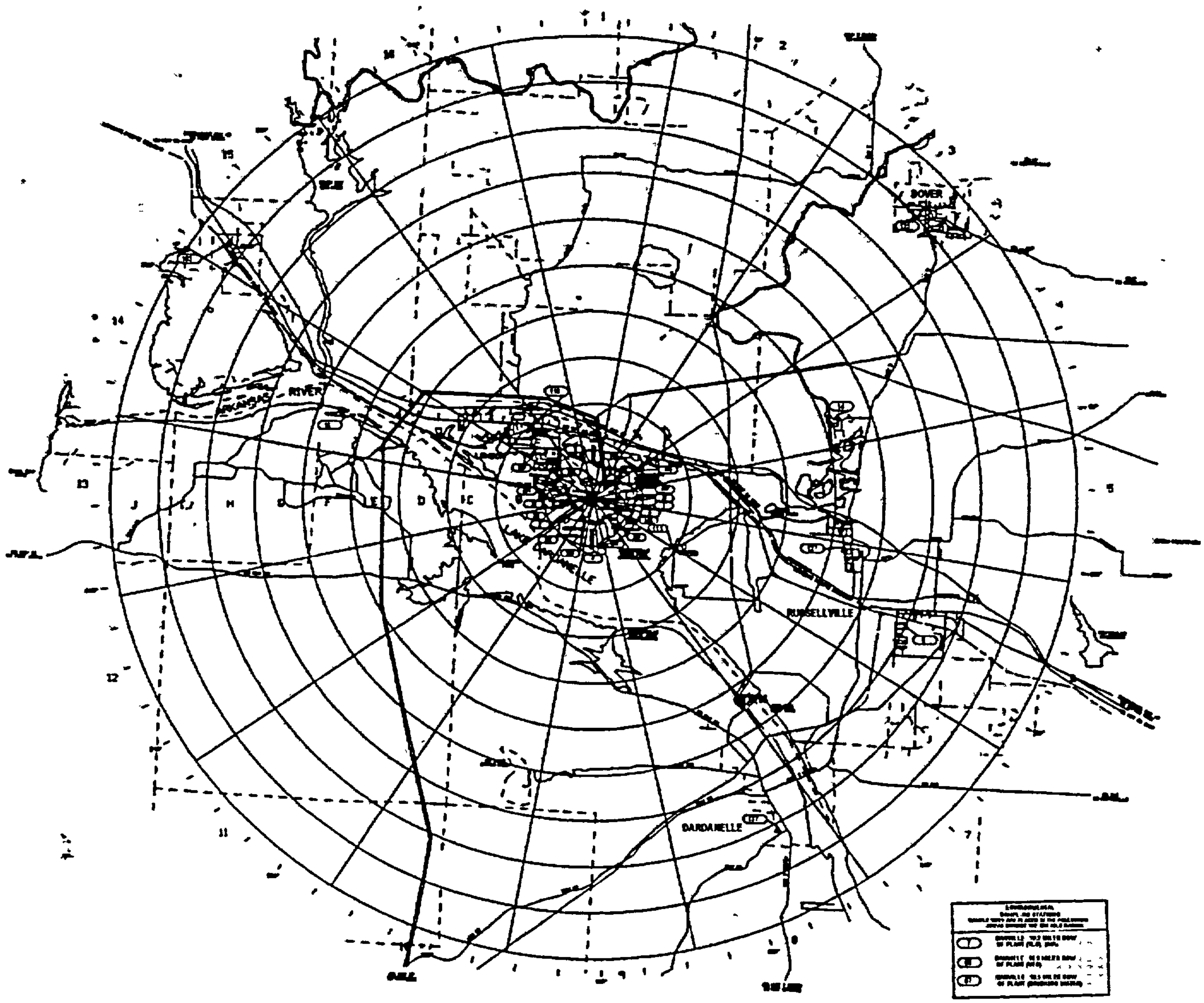


FIGURE 4-1

RADIOLOGICAL SAMPLE STATIONS

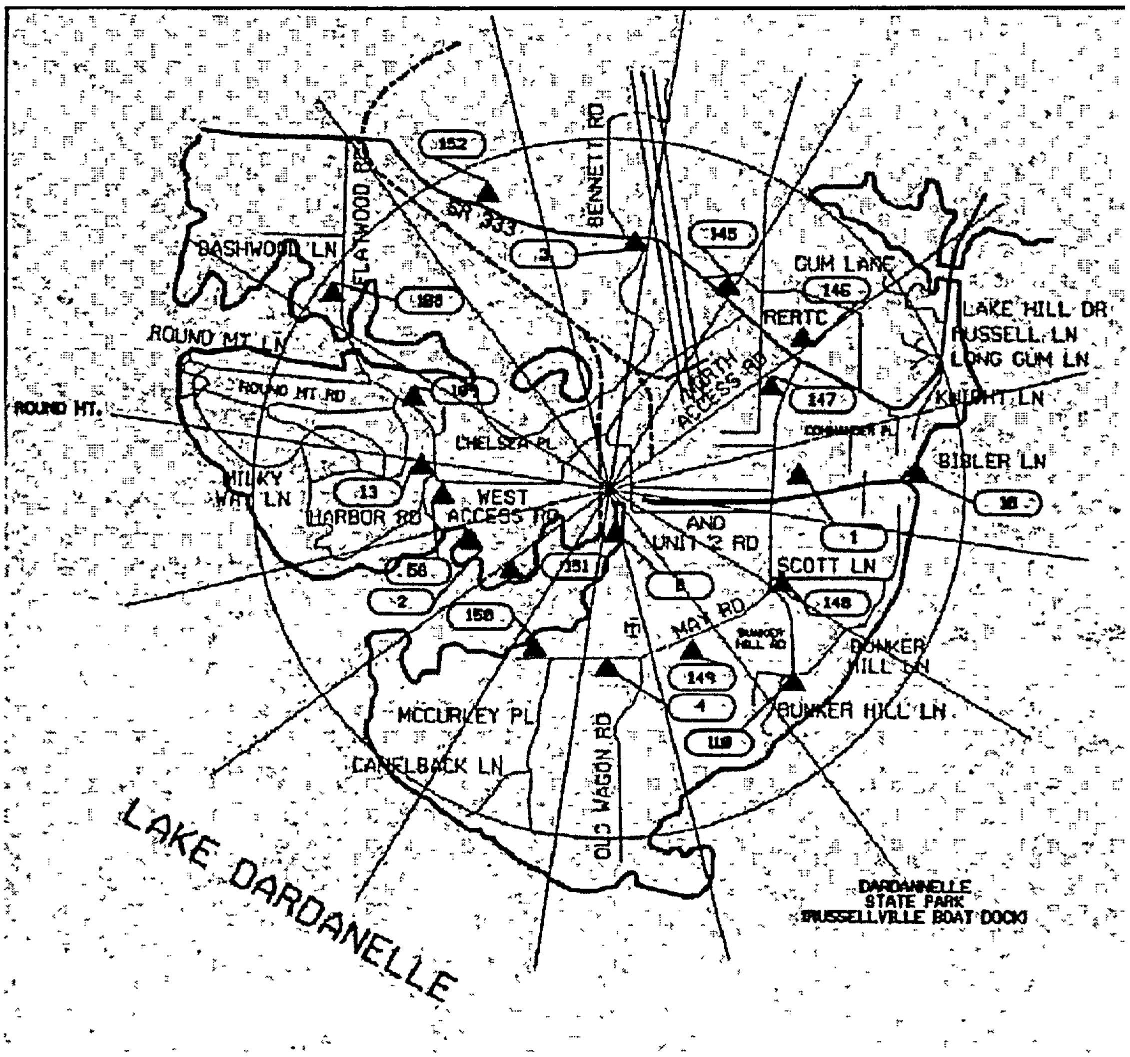
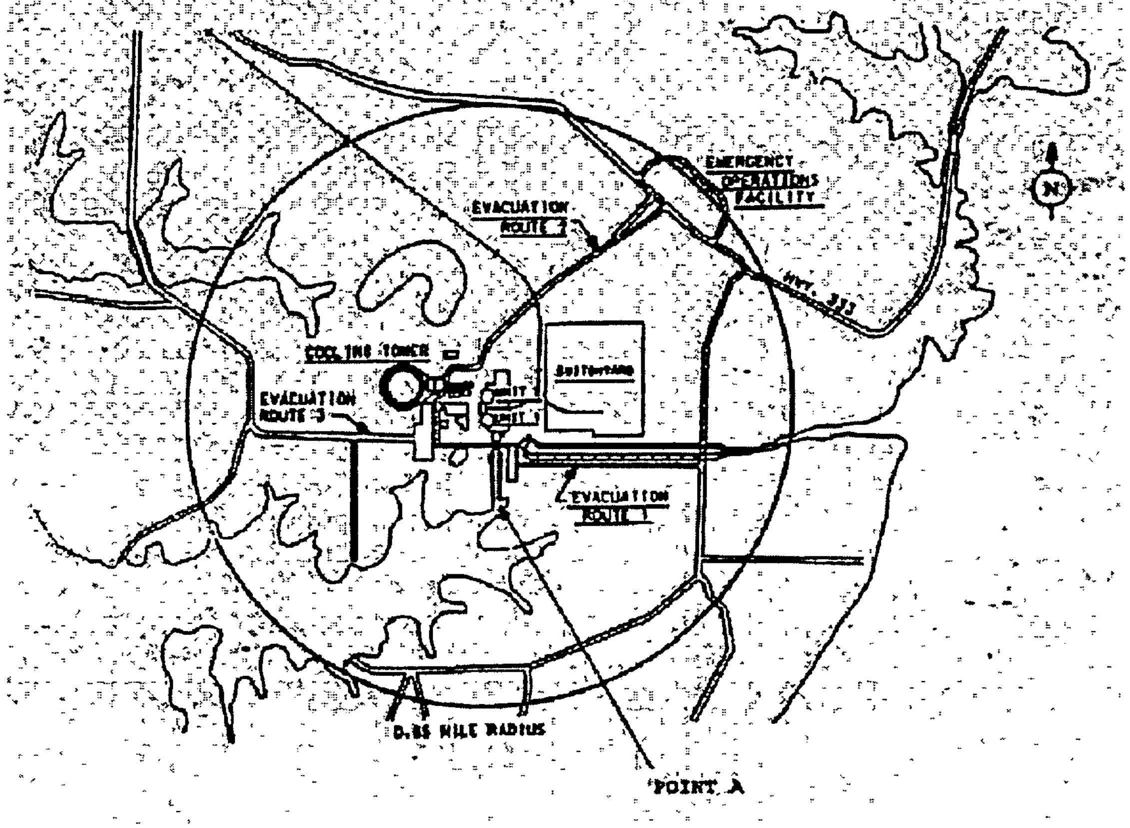


FIGURE 4-2.

MAXIMUM AREA BOUNDARY FOR RADIOACTIVE RELEASE CALCULATION (EXCLUSION AREAS)

GASES — 1046 METER RADIUS
LIQUIDS — END OF DISCHARGE CANAL (POINT A)



TABLES

TABLE 4-1
Environmental Sampling Stations - Radiological

Sample Station Number: 1
Approximate Direction and Distance from Plant: 90° - 0.6 miles
Sample Types: 1) Airborne radioiodines
2) Airborne particulates
3) Direct radiation
Sample Station Location:

The TLD is on a pole near the meteorology tower approximately 0.6 miles east of ANO.

Sample Station Number: 2
Approximate Direction and Distance from Plant: 240° - 0.5 miles
Sample Types: 1) Airborne radioiodines
2) Airborne particulates
3) Direct radiation
Sample Station Location:

IF traveling from ANO,
THEN go approximately 0.2 miles west toward Gate 4. Turn left (at the east end of the sewage treatment plant) and go approximately 0.1 miles. Turn right and go approximately 0.1 miles. The sample station is on the right.

Sample Station Number: 3
Approximate Direction and Distance from Plant: 6° - 0.7 miles
Sample Types: 1) Direct radiation
Sample Station Location:

IF traveling west on Highway 333,
THEN go approximately 0.35 miles from Gate 2 at ANO. TLD is located on utility pole on south side of Highway 333 S.

IF traveling east on Highway 333,
THEN go approximately 0.9 miles from junction of Highway 333 and Flatwood Road. TLD is located on utility pole on south side of Highway 333 S.

Sample Station Number: 4
Approximate Direction and Distance from Plant: 176° - 0.5 miles
Sample Types: 1) Direct radiation
Sample Station Location:

Go approximately 0.25 miles south from bridge over intake canal. Turn right onto May Road. Proceed approximately 0.1 miles west of May Cemetery entrance. The TLD is located on a utility pole on the south side of May Road.

Sample Station Number: 6
Approximate Direction and Distance from Plant: 111° - 7.0 miles
Sample Types: 1) Airborne radioiodines
2) Airborne particulates
3) Direct radiation
Sample Station Location:

Go to the Entergy local office which is located off Highway 7T in Russellville, AR (305 South Knoxville Avenue). The sample station is in the southeast corner of the back lot.

Sample Station Number: 7
Approximate Direction and Distance from Plant: 209° - 19.3 miles
Sample Types: 1) Airborne radioiodines
2) Airborne particulates
3) Direct radiation
Sample Station Location:

Turn west at junction of Highway 7 and Highway 27 in Dardanelle, AR. Proceed to junction of Highway 27 and Highway 10 in Danville, AR. Turn right onto Highway 10 and proceed a short distance to the Entergy supply yard, which is on the right adjacent to an Entergy substation. The sample station is in the southwest corner of the supply yard.

Sample Station Number: 8
Approximate Direction and Distance from Plant:
Sample Types: 1) Surface water (composite) 180° - 0.1 miles
2) Shoreline sediment 245° - 0.7 miles
3) Fish 230° - 0.6 miles
Sample Station Location:

Plant discharge canal

Sample Station Number: 10
Approximate Direction and Distance from Plant: 90° - 0.5 miles (intake canal)
Sample Types: 1) Surface water (grab)
Sample Station Location:

Surface water (grab) is collected at plant intake canal.

Sample Station Number: 13
Approximate Direction and Distance from Plant: 278° - 0.5 miles
Sample Types: 1) Broad leaf vegetation
Sample Station Location:

IF traveling west from ANO toward Gate 4,
THEN go approximately 0.4 miles from ANO. Turn right onto Flatwood Road. Go a short distance. The sample may be collected from either side of Flatwood Road.

TABLE 4-1
Environmental Sampling Stations - Radiological

Sample Station Number: 14 Approximate Direction and Distance from Plant: 70° - 5.3 Sample Types: 1) Drinking water Sample Station Location: From junction of Highway 7 and Water Works Road, go approximately 0.8 miles west on Water Works Road. The sample station is on the left at the intake to the Russellville city water system from the Illinois Bayou.
Sample Station Number: 16 Approximate Direction and Distance from Plant: 290° - 5.5 miles Sample Types: 1) Shoreline sediment 2) Fish Sample Station Location: Panther Bay, located on the south side of the Ar River across from the mouth of Piney Creek.
Sample Station Number: 36 Approximate Direction and Distance from Plant: 140° - 0.05 miles Sample Types: 1) Pond water 2) Pond sediment Sample Station Location: The sample station is at the Wastewater Holding Pond on the ANO site east of the discharge canal.
Sample Station Number: 55 Approximate Direction and Distance from Plant: 209° - 16.6 miles Sample Types: 1) Broadleaf Vegetation Sample Station Location: From Dardanelle, travel south on Highway 27. Go approximately 15.5 miles to the intersection of Highways 27 and 154. The sample station is located at this intersection.
Sample Station Number: 56 Approximate Direction and Distance from Plant: 273° - 0.4 miles Sample Types: 1) Airborne radioiodines 2) Airborne particulates 3) Direct Radiation Sample Station Location: If traveling west from ANO, the sample station is located at the west end of the sewage treatment plant near the facility blower building.

TABLE 4-1
Environmental Sampling Stations - Radiological

Sample Station Number: 57 Approximate Direction and Distance from Plant: 208° - 19.5 miles Sample Types: 1) Drinking water Sample Station Location: Go to Danville and turn left on Fifth Street. Go approximately three blocks. The Danville public water supply treatment facility is located on the left.
Sample Station Number: 108 Approximate Direction and Distance from Plant: 313° - 0.9 miles Sample Types: 1) Direct radiation Sample Station Location: IF traveling from Highway 333, THEN turn south onto Flatwood Road and go approximately 0.4 miles. The TLD is on a utility pole on the right. IF traveling north on Flatwood Road, THEN go approximately 0.4 miles from sample station 109. The TLD is on a utility pole on the left.
Sample Station Number: 109 Approximate Direction and Distance from Plant: 290° - 0.6 miles Sample Types: 1) Direct radiation Sample Station Location: IF traveling west from ANO toward Gate 4, THEN go approximately 0.4 miles and turn right onto Flatwood Road. Go approximately 0.2 miles. The TLD is on a utility pole on the right across from the junction of Flatwood Road and Round Mountain Road.
Sample Station Number: 110 Approximate Direction and Distance from Plant: 140° - 0.7 miles Sample Types: 1) Direct radiation Sample Station Location: From bridge over intake canal, go south approximately 0.25 miles. Turn left and go approximately 0.25 miles. Turn right on Bunker Hill Lane. The TLD is on the first utility pole on the left.
Sample Station Number: 111 Approximate Direction and Distance from Plant: 117° - 2.0 miles Sample Types: 1) Direct radiation Sample Station Location: From junction of Highway 64 and Highway 326 (Marina Road), go approximately 2.1 miles on Marina Road. The TLD is on a utility pole on the left just prior to curve.

TABLE 4-1
Environmental Sampling Stations - Radiological

Sample Station Number: 116
Approximate Direction and Distance from Plant: 320° - 1.9 miles
Sample Types: 1) Direct radiation
Sample Station Location:

Go one block south of the west junction of Highway 333 and Highway 64 in London, AR. The TLD is on a utility pole north of the railroad tracks.

Sample Station Number: 125
Approximate Direction and Distance from Plant: 46° - 9.0 miles
Sample Types: 1) Direct radiation
Sample Station Location:

While traveling north on Highway 7, turn left onto Water Street in Dover, AR. Go one block and turn left onto South Elizabeth Street. Go one block and turn right onto College Street. The TLD is on a utility pole at the southeast corner of the red brick school building, which is located on top of hill.

Sample Station Number: 127
Approximate Direction and Distance from Plant: 97° - 5.2 miles
Sample Types: 1) Direct radiation
Sample Station Location:

The TLD is located on Arkansas Tech Campus on N. Glenwood Street. If traveling south on State Highway 7 from Interstate 40, turn right on N. Glenwood. Follow N. Glenwood for approximately 0.6 miles. The TLD is located on a utility pole (with a No Parking sign on it) across from the northeast corner of Paine Hall.

Sample Station Number: 137
Approximate Direction and Distance from Plant: 150° - 8.1 miles
Sample Types: 1) Direct radiation
Sample Station Location:

At junction of Highway 7 and Highway 28 in Dardanelle, AR, go approximately 0.2 miles on Highway 28. The TLD is on a speed limit sign on the right in front of the Morris R. Moore Arkansas National Guard Armory.

Sample Station Number: 145
Approximate Direction and Distance from Plant: 30° - 0.6 miles
Sample Types: 1) Direct radiation
Sample Station Location:

The TLD is located near the west entrance to the RERTC on a utility pole on the north side of State Highway 333.

TABLE 4-1
Environmental Sampling Stations - Radiological

Sample Station Number: 146
Approximate Direction and Distance from Plant: 50° - 0.6 miles
Sample Types: 1) Direct radiation
Sample Station Location:

The TLD is located on the south end of the east parking lot at the RERTC. The TLD is located on a utility pole.

Sample Station Number: 147
Approximate Direction and Distance from Plant: 63° - 0.6 miles
Sample Types: 1) Direct radiation
Sample Station Location:

The TLD is located on the west side of Bunker Hill Road, approximately 100 yards from the intersection with State Highway 333.

Sample Station Number: 148
Approximate Direction and Distance from Plant: 122° - 0.5 miles
Sample Types: 1) Direct radiation
Sample Station Location:

If traveling east from ANO, turn right on Bunker Hill Road. Travel south for approximately 0.25 miles to the intersection with Scott Lane. The TLD is located on the county road sign post.

Sample Station Number: 149
Approximate Direction and Distance from Plant: 150° - 0.6 miles
Sample Types: 1) Direct radiation
Sample Station Location:

If traveling south on Bunker Hill Road, turn right on May Road. Travel approximately 0.3 miles. The TLD is located on a utility pole on the south side of May Road.

Sample Station Number: 150
Approximate Direction and Distance from Plant: 201° - 0.6 miles
Sample Types: 1) Direct radiation
Sample Station Location:

If traveling south on Bunker Hill Road, turn right on May Road. Travel approximately 0.8 miles. The TLD is located just past the McCurley Place turn off on the north side of May Road on a utility pole.

Sample Station Number: 151
Approximate Direction and Distance from Plant: 220° - 0.4 miles
Sample Types: 1) Direct radiation
Sample Station Location:

If traveling west from ANO, turn south on plant road along the est side of the sewage treatment plant. The TLD is located at the end of this road, near the lake on a metal post.

TABLE 4-1
Environmental Sampling Stations - Radiological

Sample Station Number: 152 Approximate Direction and Distance from Plant: 338° - 0.8 miles Sample Types: 1) Direct radiation Sample Station Location: If traveling.west on State Highway 333 from the RERTC, travel approximately 0.7 miles. The TLD is located on the north side of State Highway 333 on a London City limit sign post.
Sample Station Number: 153 Approximate Direction and Distance from Plant: 305° - 9.2 miles Sample Types: 1) Direct radiation Sample Station Location: Travel State Highway 64 West to Knoxville Elementary School. The TLD is located near the school entrance gate on a utility pole..

APPENDICES

Legend

BL#.#.# = Limitation Bases Number
BS#.#.# = Surveillance Limitation Bases Number
L#.#.# = Limitation Number
S#.#.# = Surveillance Limitation Number

APPENDIX 1

Radioactive Effluent Controls
UNIT 1

1.0 DEFINITIONS

OPERABLE - OPERABILITY

1.1 A system, subsystem, train, component or device shall be operable or have operability when it is capable of performing its specified function(s). Implicit in this definition shall be the assumption that all necessary attendant instrumentation, controls, normal and emergency electrical power sources, 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).

CHANNEL TEST

1.2 A channel test is the injection of an internal or external test signal into the channel to verify its proper response, including alarm and/or trip initiating action, where applicable.

INSTRUMENT CHANNEL CHECK

1.3 An instrument channel check is a verification of acceptable instrument performance by observation of its behavior and/or state; this verification includes comparison of output and/or state of independent channels measuring the same variable.

INSTRUMENT CHANNEL CALIBRATION

1.4 An instrument channel calibration is a test, and adjustment (if necessary), to establish that the channel output responds with acceptable range and accuracy to known values of the parameter which the channel measures or an accurate simulation of these values. Calibration shall encompass the entire channel, including equipment actuation, alarm or trip and shall be deemed to include the channel test.

SOURCE CHECK

1.5 A source check shall be the qualitative assessment of channel response when the channel sensor is exposed to a radioactive source.

LIQUID RADWASTE TREATMENT SYSTEM

1.6 A liquid radwaste treatment system is a system designed and used for holdup, filtration, and/or demineralization of radioactive liquid effluents prior to their release to the environment.

GASEOUS RADWASTE TREATMENT SYSTEM

1.7 A gaseous radwaste treatment system is any system designed and installed to reduce radioactive gaseous effluents by collecting gases from radioactive systems and providing for decay or holdup for the purpose of reducing the total radioactivity prior to release to the environment.

VENTILATION EXHAUST TREATMENT SYSTEM

1.8 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 the release to the environment (such a system is not considered to have any effect on noble gas effluents). Engineered Safety Feature (ESF) atmospheric cleanup systems are not considered to be ventilation exhaust treatment systems.

PURGE - PURGING

1.9 Purge or purging is the controlled process of discharging air or gas from a confinement to reduce the airborne radioactivity concentration in such a manner that replacement air or gas is required to purify the confinement.

MEMBER(S) OF THE PUBLIC

1.10 Member(s) of the public shall include all persons who are not occupationally associated with the plant. This category does not include employees of the utility, its contractors or vendors. Also excluded from the category are persons who enter the site to service equipment or to make deliveries. This category does include persons who use portions of the site for recreational, occupational or other purposes not associated with the plant.

EXCLUSION AREA

1.11 The exclusion area is that area surrounding ANO within a minimum radius of 0.65 miles of the reactor buildings and controlled to the extent necessary by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials.

UNRESTRICTED AREA

1.12 An unrestricted area shall be any area beyond the exclusion area boundary.

FREQUENCY NOTATION

1.13 The frequency notation specified for the performance of Surveillance Limitations shall correspond to the following intervals:

P		Completed prior to each release
S	Shift	At least once per 12 hours
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	Semiannual	At least once per 184 days
R	Refueling	At least once per 18 months
N/A		Not Applicable

BATCH RELEASE

1.14 A "Batch" release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analysis, each batch shall be isolated and then thoroughly mixed to assure representative sampling.

CONTINUOUS RELEASE

1.15 A "Continuous" release is the discharge of liquid waste of a non-discrete volume, e.g. from a volume of a system that has an input flow during the continuous release.