

7.0 RADIOACTIVE NOBLE GASES IN AIR ONSITE

The 1996 data consist of krypton-85 concentrations from three permanent sampling stations. The locations of these noble gas sampling stations are shown in Figure 7.1. (All tables, figures, and attachments, in that order, are located at the end of the chapter.) The unlabeled sampling locations in Figure 7.1 show the locations of inactive noble gas sampling stations. Analyses for xenon were discontinued at the beginning of 1995, and the stations located at the DDZ77 transformer, Gravel Pit, U.S. Environmental Protection Agency (EPA) Farm, and E-MAD were shut down. In October 1995, the stations at Gate 200 South, Area 12 Camp, and Gate 400 were discontinued, leaving three stations in operation for the last quarter of 1995 and for 1996. The three stations now operating are: BJY, Area 20 Camp, and Pahute Substation. At these three locations, weekly air samples were collected and analyzed for Krypton-85 using liquid scintillation counting.

The 1996 results for krypton-85 are consistent with the number of counts from the liquid scintillation counter. Quench standards for krypton-85 are currently not available to determine the degree of quenching and the true counting efficiency; therefore, the values reported have not been compensated for any quench caused by the matrix. The data user should be aware of this limitation.

The information given in Attachment 7.1, consists of: (1) an alphabetic station description; (2) the dates of sample collection given as the date sample collection began and ended (samples were collected for approximately a one week period); (3) the krypton concentrations in $\mu\text{Ci}/\text{mL} \times 10^{-12}$ with one standard deviation (1s, counting error); and (4) the analytical detection limit (DL). The detection limit is defined at the beginning of this report. The units of $10^{-12} \mu\text{Ci}/\text{mL}$ are equivalent to pCi/m^3 . Attachment 7.1 contains these data for the calendar year 1996. An alphabetic notation denotes a missing value. Five categories of causes for the missing values are identified by the footnote codes and defined at the bottom of each page of the attachment. Ninety-four percent of the krypton concentrations are above the corresponding DL. The average DL is $6.35 \times 10^{-12} \mu\text{Ci}/\text{mL}$. The DLs have a lognormal statistical distribution with a median of $5.84 \times 10^{-12} \mu\text{Ci}/\text{mL}$. The standard deviation of the krypton DL's is $2.52 \times 10^{-12} \mu\text{Ci}/\text{mL}$.

Figures 7.2 through 7.5 are time series plots of the data in Attachment 7.1. Figure 7.2 contains the data for all the stations combined. Figures 7.3 through 7.5 provide one plot for each station. Note that these time series plots have one of two ordinate scales: either 0 to 1.0×10^{-10} or 0 to 5.0×10^{-11} . The plots for the individual stations contain the detection limits, indicated by the solid line. In previous years' reports, the approximate 95 percent confidence interval of the concentrations were indicated in the individual station plots. These were not used in this 1996 report, because over time, noble gas concentrations have decreased to a level such that the standard deviations are approximately an order of magnitude smaller than the result values; thus, the confidence limits tend to plot as overlapping lines. The abscissa value is the date sampling started. In general, these plots show most of the values around environmental background levels (approximately 27). Figure 7.2, containing the time series of all three sampling locations combined, also contains a "locally weighted scatterplot smoother" line. This type of graphic line is a statistical device intended to smooth out the variability in the data and approximate the underlying trend in the data. Figure 7.2 also shows an obvious outlier about mid-year from the Pahute Substation. This value of 9.56×10^{-11} was from the sample collection beginning on July 10, 1996. The records for this sample were checked and no analytical problems were found; however, the value is an obvious outlier and was not used in the statistical analyses.

An exploratory data analysis was performed on the krypton data for each of the stations using probability plot and goodness of fit test methods. All stations combined fit a normal but not a lognormal distribution when the high outlying observation at Pahute Substation was deleted from the data. The normal distribution was chosen for further statistical analyses to satisfy the underlying assumptions of the analysis of variance (ANOVA) methods. Table 7.1 gives the basic descriptive statistics of the stations where annual krypton data were collected. The overall mean given in this table is typical of environmental conditions at NTS. A one-way ANOVA was used to compare the three locations for equality of krypton means. The ANOVA output is shown in Table 7.2. In an ANOVA table, the degrees of freedom, sum of squares, mean squares, and the computed value of the F-statistic are shown; the p-value is the probability associated with the F-statistic. This is the probability that significant differences among the stations would be found if the null hypothesis were true. Since this probability is much larger than the usual 5 percent critical value, the conclusion is that there are no significant differences.

DUPLICATE ANALYSES

In 1996, 55 duplicate analyses of krypton-85 samples were performed. Of these, 42 were valid analyses that can be matched to valid results. In the remaining cases, there were analytical problems with either the first analysis or the duplicate analysis. The differences between the results (the value reported in Attachment 7.1) and the corresponding duplicates were subjected to several statistical analyses. These differences were shown to have a normal distribution using a probability plot. An ANOVA showed no significant differences due to sampling location. A time series plot showed no evidence of any time dependent trends. The mean value of these differences is -1.28×10^{-12} $\mu\text{Ci}/\text{mL}$, the standard deviation is 14.24×10^{-12} $\mu\text{Ci}/\text{mL}$, and the standard error is 2.20×10^{-12} $\mu\text{Ci}/\text{mL}$. A one-sample t-test showed that the mean of the differences is not significantly different from zero.

HISTORICAL TRENDS

Krypton concentrations have been reported in NTS annual environmental reports since 1982, from three to eleven stations annually. Before 1982, EPA operated the noble gas network. The krypton historical data is shown in Table 7.3. Note that data for the PILE DRIVER location exist only for the years 1987 through 1990, and these are the years in which no data was collected at the EPA Farm. For these years, a noble gas sampler was moved 1.5 miles northwest from the EPA Farm to the vicinity of the PILE DRIVER event. PILE DRIVER was a weapons effects test detonated on June 2, 1966. The move from the EPA Farm was made when the farm was closed and the move back was made when electrical power was disconnected from the PILE DRIVER location. An assumption can be made that these stations were close enough together that the moves would not significantly affect the concentrations; thus, these stations probably can be considered as one.

Table 7.3 shows that most of the data is clustered between 20 and 30 $\mu\text{Ci}/\text{mL} \times 10^{-12}$, with a few values in the 40 to 50 range. These three high values occurred at the Area 20 Camp in 1985, 1986, and 1987. During this time period, there were several accidental ventings within three miles of this camp. The remaining data in Table 7.3 shows a very consistent pattern of values clustered about 25 $\mu\text{Ci}/\text{mL} \times 10^{-12}$. Including the high values from the Area 20 Camp, the data in Table 7.3 have an average of 26.7×10^{-12} $\mu\text{Ci}/\text{mL}$ and a standard deviation of 4.6×10^{-12} $\mu\text{Ci}/\text{mL}$; thus, most of the data is within one standard deviation of the mean. This is unusual consistency for environmental data and indicates that for the years 1982 through 1996 there has been no historical trend in krypton concentrations on the NTS.

CONCLUSION

The 1996 krypton-85 concentrations in NTS air were all around the world-wide background concentration of 27×10^{-12} $\mu\text{Ci}/\text{mL}$, except for one outlying value. This value was a concentration of 95.6×10^{-12} $\mu\text{Ci}/\text{mL}$ at Pahute Substation for the sample collected between August 10 and 17, 1996. No reason is known for this atypical value, and samples immediately preceding and following it were at background levels. Historical krypton-85 data is also typically at background levels, except for the atypical values at Area 20 Camp in 1985, 1986, and 1987 which were attributed to atmospheric pumping of krypton seeping upward from underground tests on Pahute Mesa.

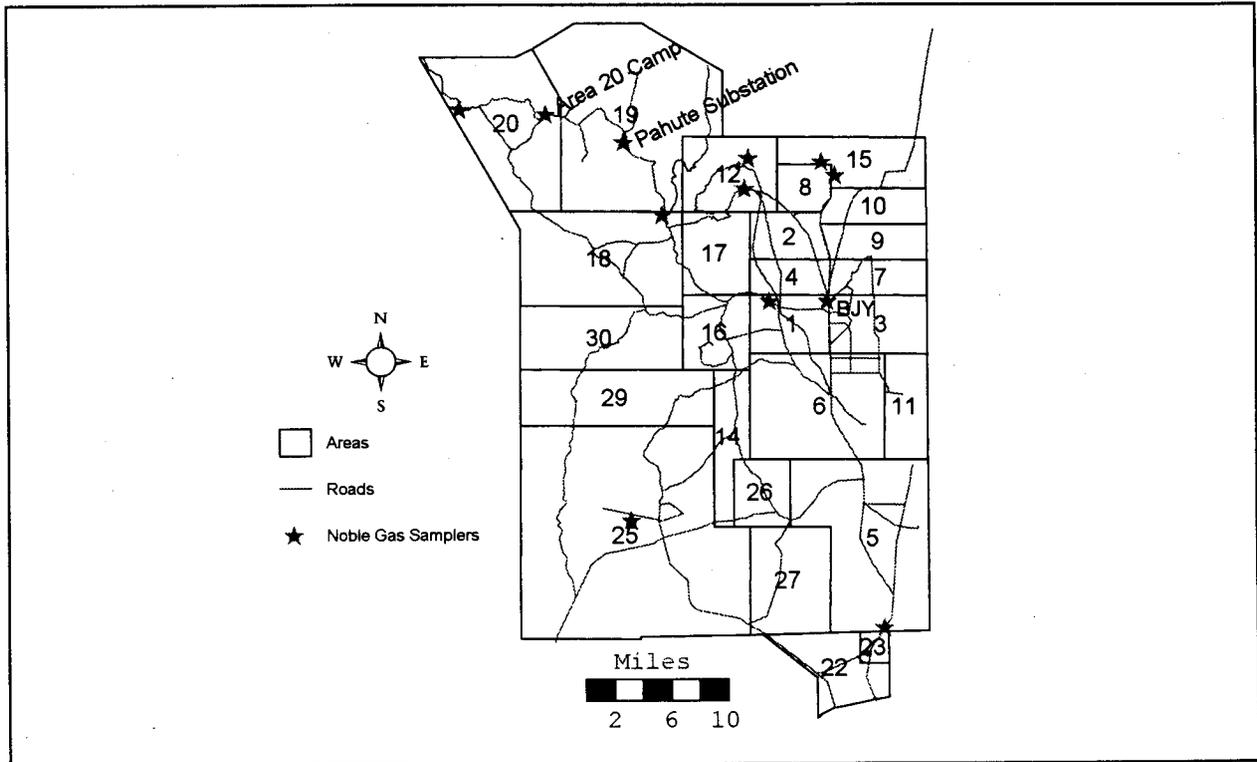


Figure 7.1 Nevada Test Site Map With Noble Gas Sampling Locations

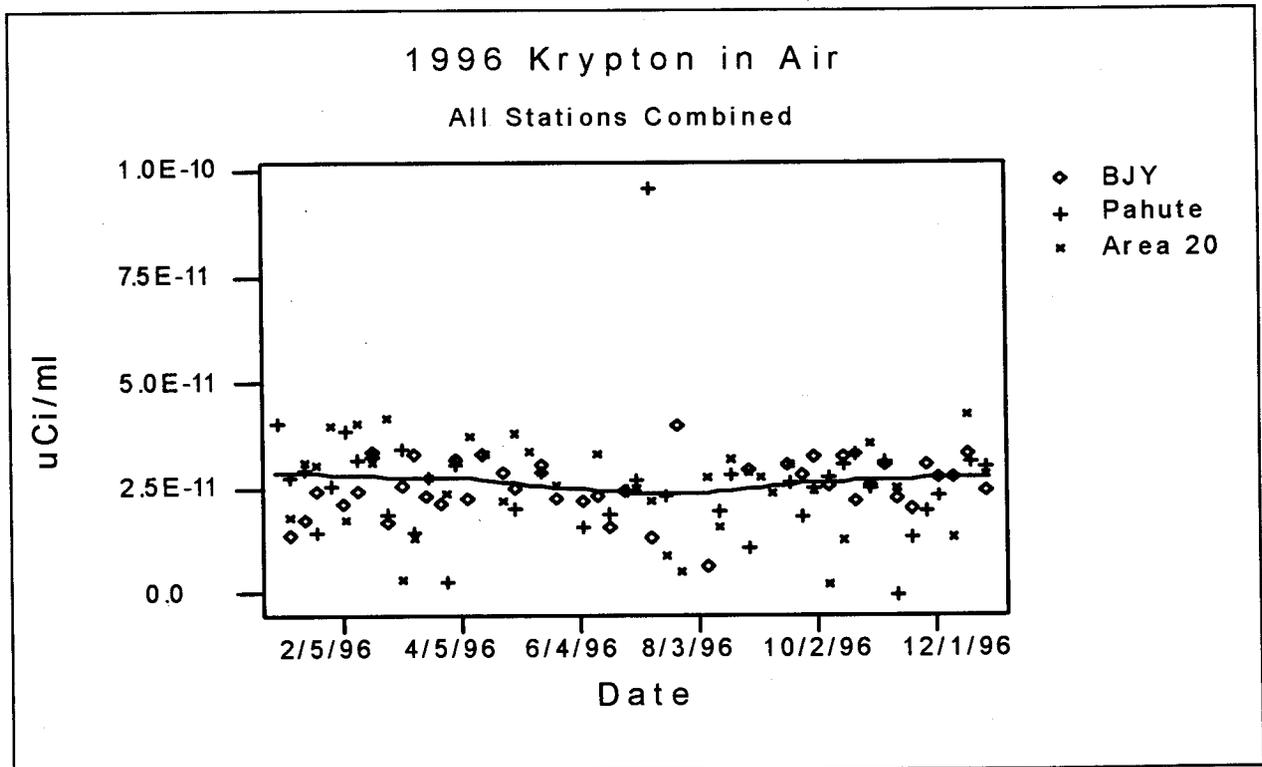


Figure 7.2 Time Series Plot of All Kr Results

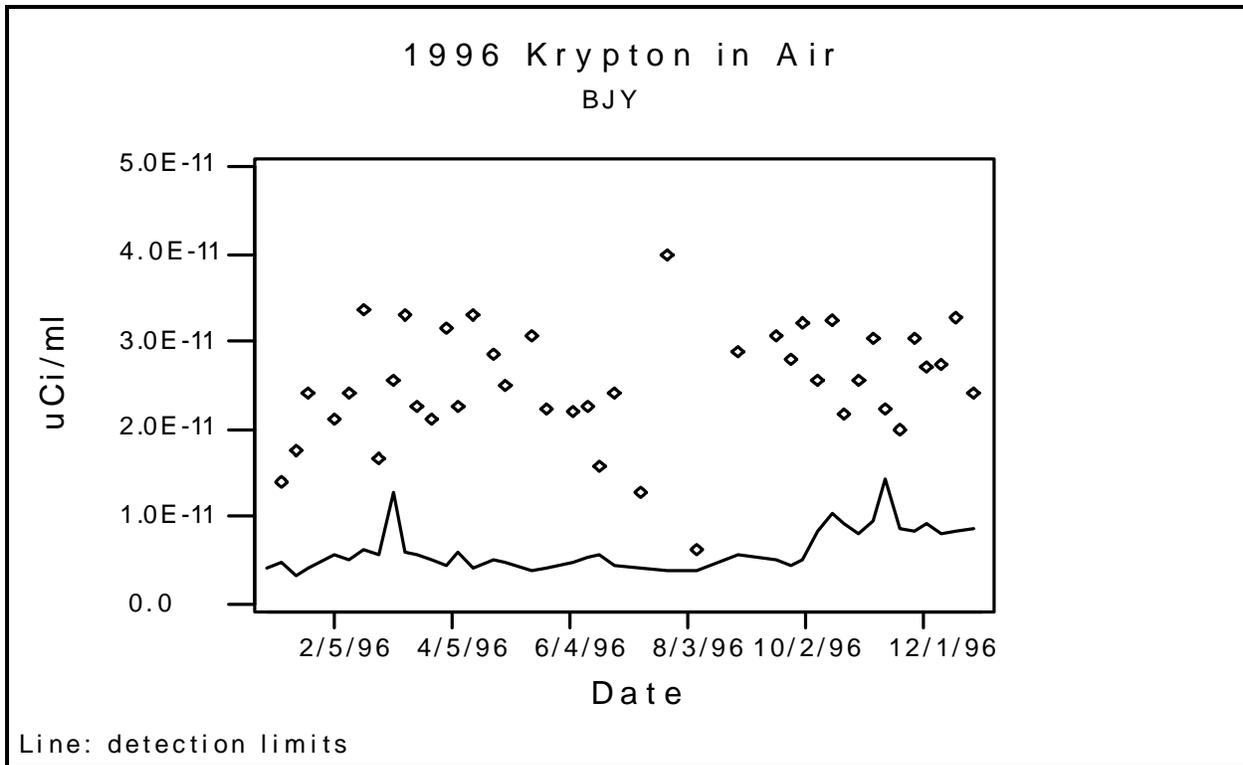


Figure 7.3 Time Series Plot of BGY Kr Results

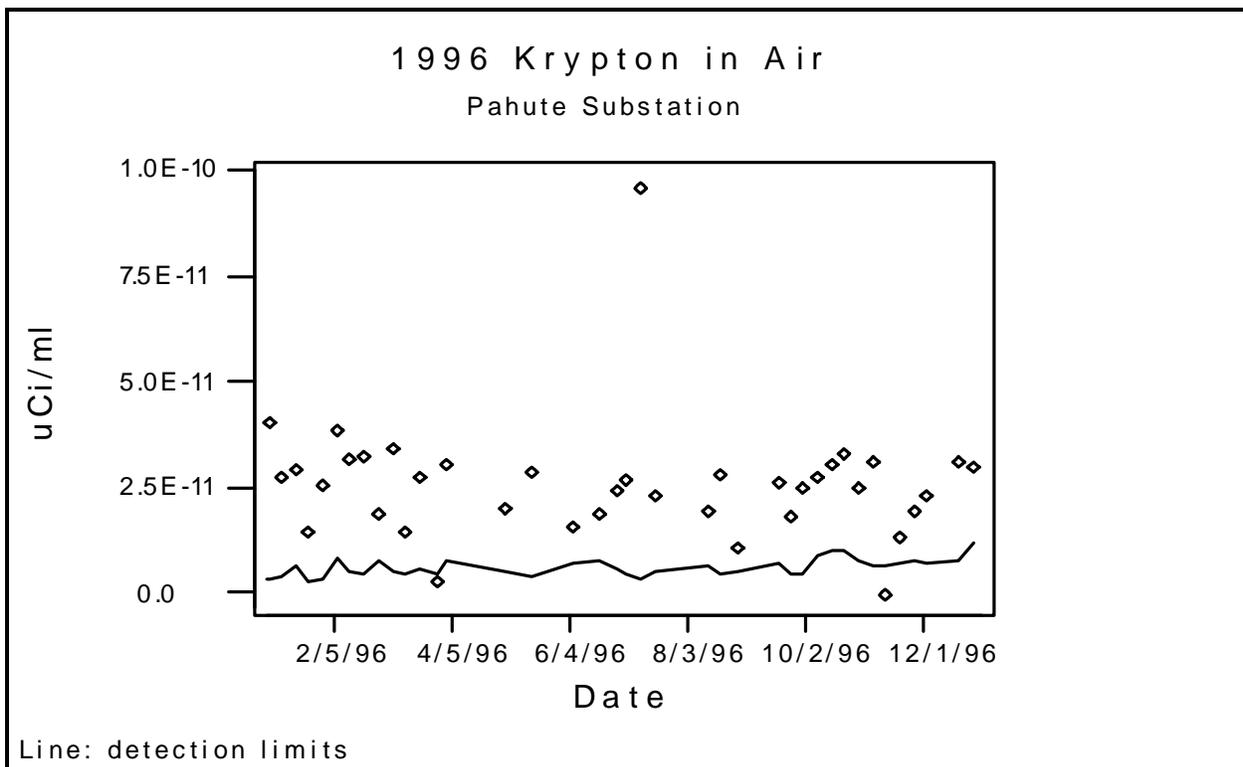


Figure 7.4 Time Series Plot of Pahute Substation Kr Results

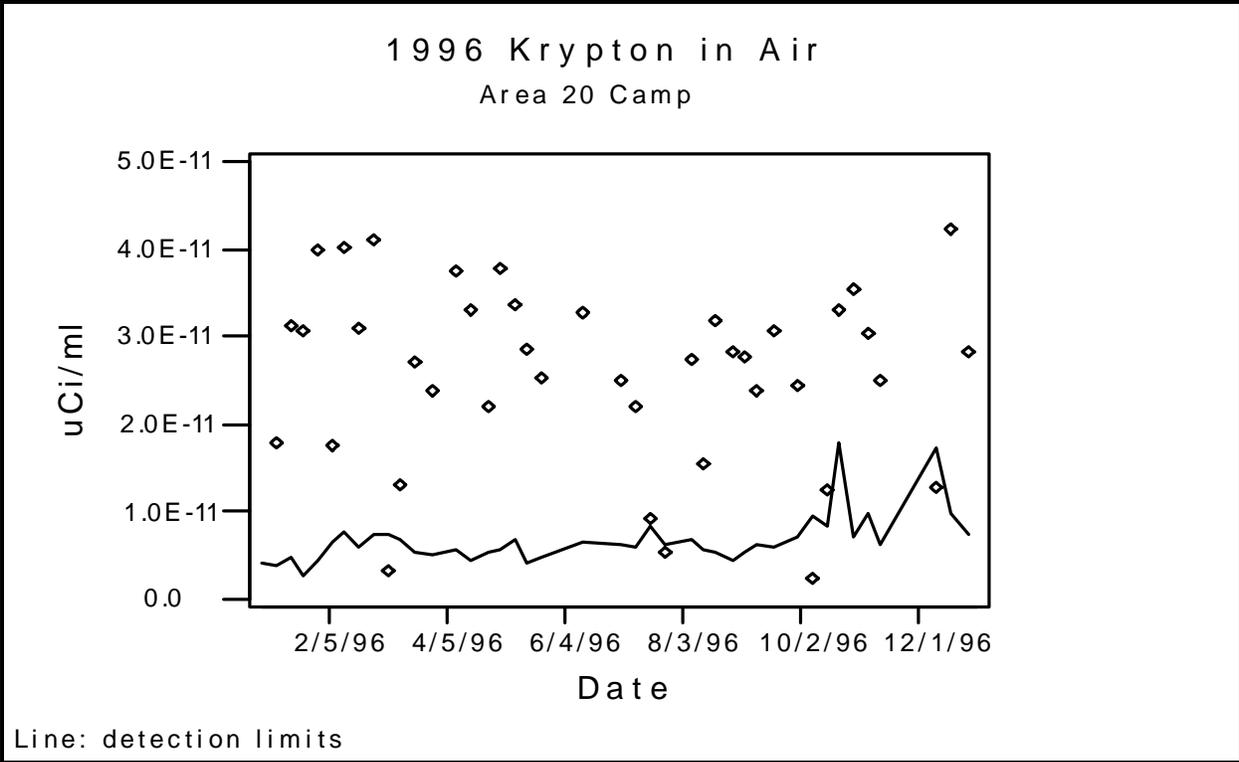


Figure 7.5 Time Series Plot of Area 20 Camp Kr Results

Table 7.3 NTS Krypton History

Location	Historical Krypton Annual Averages, $\mu\text{Ci}/\text{mL} \times 10^{-12}$														
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
BJY	25.4	26.5	28.0	29.0	30.0	25.3	23.7	24.1	23.3	24.0	25.8	26.9	25.3	27.5	25.4
Gravel Pit	*	*	*	30.0	29.0	26.2	22.8	22.4	24.8	24.0	26.6	26.8	26.1	*	*
Gate 200 South	*	25.3	26.0	27.0	27.0	27.3	23.4	22.7	22.6	22.5	26.6	26.8	23.8	28.4	*
Area 12 Camp	24.5	24.8	27.0	28.0	30.0	25.7	26.9	22.9	23.9	23.6	25.9	25.7	24.3	27.4	*
EPA Farm	25.4	24.9	28.0	30.0	31.0	*	*	*	*	23.4	26.3	26.0	26.0	*	*
PILED RIVER	*	*	*	*	*	26.2	24.4	22.3	24.2	*	*	*	*	*	*
Gate 400	*	*	*	*	*	*	*	*	*	*	24.5	26.5	24.6	27.0	*
Pahute Substation	*	*	*	*	*	*	*	*	*	*	24.4	27.3	23.1	27.2	24.8
Area 20 Camp	*	22.5	31.0	46.0	58.0	39.3	28.8	26.8	29.3	31.7	29.5	28.4	26.5	33.7	25.9
DDZ77 Trans.	*	*	*	*	*	*	*	*	*	*	24.3	27.4	29.7	*	*
E-MAD North	24.4	25.3	27.0	29.0	32.0	26.4	22.5	22.1	21.4	23.8	27.7	25.6	25.8	*	*

* Missing data value, station inactive for the year.

Attachment 7.1 Sample Results for ⁸⁵Kr - 1996

Sampling Location	Sampling Dates		10 ⁻¹² μCi/mL		
	Start	End	Concentration	Standard Deviation	Detection Limit
Area 1, BJY	12/26/95	01/03/96	45.6	1.35	3.57
Area 1, BJY	01/03/96	01/08/96	(b)		
Area 1, BJY	01/08/96	01/16/96	14.0	1.51	4.72
Area 1, BJY	01/16/96	01/22/96	17.6	1.06	3.14
Area 1, BJY	01/22/96	01/31/96	24.1	2.43	4.26
Area 1, BJY	01/31/96	02/05/96	(d)		
Area 1, BJY	02/05/96	02/12/96	21.2	3.13	5.78
Area 1, BJY	02/12/96	02/20/96	24.2	2.82	5.04
Area 1, BJY	02/20/96	02/27/96	33.7	3.59	6.38
Area 1, BJY	02/27/96	03/05/96	16.8	3.01	5.64
Area 1, BJY	03/05/96	03/11/96	25.6	6.53	12.7
Area 1, BJY	03/11/96	03/18/96	32.9	3.44	6.07
Area 1, BJY	03/18/96	03/25/96	22.7	3.03	5.52
Area 1, BJY	03/25/96	04/01/96	21.2	2.71	4.92
Area 1, BJY	04/01/96	04/08/96	31.5	2.66	4.53
Area 1, BJY	04/08/96	04/15/96	22.6	3.27	6.02
Area 1, BJY	04/15/96	04/25/96	32.9	2.47	4.12
Area 1, BJY	04/25/96	05/01/96	28.5	2.88	5.02
Area 1, BJY	05/01/96	05/09/96	25.0	2.71	4.83
Area 1, BJY	05/09/96	05/15/96	(c)		
Area 1, BJY	05/15/96	05/23/96	30.6	2.36	3.87
Area 1, BJY	05/23/96	06/05/96	22.3	2.40	4.27
Area 1, BJY	06/05/96	06/12/96	21.9	2.72	4.88
Area 1, BJY	06/12/96	06/19/96	22.7	2.95	5.34
Area 1, BJY	06/19/96	06/26/96	15.7	2.98	5.65
Area 1, BJY	06/26/96	07/03/96	24.1	2.54	4.51
Area 1, BJY	07/03/96	07/10/93	(c)		
Area 1, BJY	07/10/96	07/17/96	12.9	2.22	4.15
Area 1, BJY	07/17/96	07/24/96	(a)		
Area 1, BJY	07/24/96	07/31/96	38.8	2.39	3.74
Area 1, BJY	07/31/96	08/08/96	(c)		
Area 1, BJY	08/08/96	08/20/96	6.19	1.95	3.81
Area 1, BJY	08/20/96	08/28/96	(b)		
Area 1, BJY	08/28/96	09/04/96	29.0	3.22	5.71
Area 1, BJY	09/04/96	09/10/96	(b)		
Area 1, BJY	09/10/96	09/17/96	(c)		

Missing value code, due to:

- (a) Instrument malfunction.
- (b) Sample lost in analysis.
- (c) No sample collected, insufficient sample, no pressure in sample bottle, sampler failed, loss of power.
- (d) Unknown or undocumented cause.

Attachment 7.1 (Sample Results for ⁸⁵Kr - 1996, cont.)

<u>Sampling Location</u>	<u>Sampling Dates</u>		<u>10⁻¹² μCi/mL</u>		
	<u>Start</u>	<u>End</u>	<u>Concentration</u>	<u>Standard Deviation</u>	<u>Detection Limit</u>
Area 1, BJY	09/17/96	09/24/96	17.8	2.68	5.00
Area 1, BJY	09/24/96	09/30/96	28.0	2.56	4.44
Area 1, BJY	09/30/96	10/08/96	32.1	2.95	5.13
Area 1, BJY	10/08/96	10/15/96	25.5	2.82	8.22
Area 1, BJY	10/15/96	10/22/96	32.3	3.55	10.3
Area 1, BJY	10/22/96	10/29/96	21.8	3.07	9.20
Area 1, BJY	10/29/96	11/05/96	25.6	2.78	8.07
Area 1, BJY	11/05/96	11/12/96	30.3	3.24	9.45
Area 1, BJY	11/12/96	11/19/96	22.3	4.58	14.3
Area 1, BJY	11/19/96	11/26/96	19.8	2.82	8.50
Area 1, BJY	11/26/96	12/03/96	30.4	2.98	8.47
Area 1, BJY	12/03/96	12/10/96	27.1	3.16	9.25
Area 1, BJY	12/10/96	12/17/96	27.3	2.76	7.89
Area 1, BJY	12/17/96	12/26/96	32.7	2.96	8.34
Area 1, BJY	12/26/96	01/02/97	24.0	2.93	8.60
Area 19, Pahute Substation	12/26/95	01/03/96	30.2	1.34	3.84
Area 19, Pahute Substation	01/03/96	01/08/96	40.5	1.22	3.26
Area 19, Pahute Substation	01/08/96	01/16/96	27.4	1.29	3.74
Area 19, Pahute Substation	01/16/96	01/22/96	28.9	2.09	6.32
Area 19, Pahute Substation	01/22/96	01/29/96	14.6	1.66	2.97
Area 19, Pahute Substation	01/29/96	02/06/96	25.3	2.07	3.47
Area 19, Pahute Substation	02/06/96	02/12/96	38.1	4.57	8.20
Area 19, Pahute Substation	02/12/96	02/20/96	31.8	2.89	5.04
Area 19, Pahute Substation	02/20/96	02/27/96	32.1	2.07	4.60
Area 19, Pahute Substation	02/27/96	03/05/96	18.8	3.97	7.58
Area 19, Pahute Substation	03/05/96	03/12/96	34.1	3.09	5.30
Area 19, Pahute Substation	03/12/96	03/19/96	14.4	2.56	4.80
Area 19, Pahute Substation	03/19/96	03/28/96	27.1	3.27	5.90
Area 19, Pahute Substation	03/28/96	04/02/96	2.82	2.17	4.39
Area 19, Pahute Substation	04/02/96	04/09/96	30.7	4.28	7.83
Area 19, Pahute Substation	04/09/96	04/16/96	(c)		
Area 19, Pahute Substation	04/16/96	04/25/96	(c)		
Area 19, Pahute Substation	04/25/96	05/02/96	(a)		
Area 19, Pahute Substation	05/02/96	05/09/96	20.2	2.88	5.30
Area 19, Pahute Substation	05/09/96	05/15/96	(c)		
Area 19, Pahute Substation	05/15/96	05/23/96	28.8	2.32	3.86
Area 19, Pahute Substation	05/23/96	06/05/96	(c)		

Missing value code, due to:

- (a) Instrument malfunction.
- (b) Sample lost in analysis.
- (c) No sample collected, insufficient sample, no pressure in sample bottle, sampler failed, loss of power.
- (d) Unknown or undocumented cause.

Attachment 7.1 (Sample Results for ⁸⁵Kr - 1996, cont.)

Sampling Location	Sampling Dates		10 ⁻¹² μCi/mL		
	Start	End	Concentration	Standard Deviation	Detection Limit
Area 19, Pahute Substation	06/05/96	06/19/96	15.7	3.67	7.07
Area 19, Pahute Substation	06/19/96	06/27/96	18.5	4.04	7.73
Area 19, Pahute Substation	06/27/96	07/03/96	24.4	3.25	5.93
Area 19, Pahute Substation	07/03/96	07/10/96	26.7	2.46	4.22
Area 19, Pahute Substation	07/10/96	07/17/96	95.6	2.86	3.51
Area 19, Pahute Substation	07/17/96	07/25/96	23.2	2.80	5.04
Area 19, Pahute Substation	07/25/96	07/31/96	(c)		
Area 19, Pahute Substation	07/31/96	08/07/96	(c)		
Area 19, Pahute Substation	08/07/96	08/13/96	(c)		
Area 19, Pahute Substation	08/13/96	08/20/96	19.0	3.27	6.13
Area 19, Pahute Substation	08/20/96	08/28/96	27.8	2.53	4.36
Area 19, Pahute Substation	08/28/96	09/04/96	10.4	2.71	5.28
Area 19, Pahute Substation	09/04/96	09/10/96	(c)		
Area 19, Pahute Substation	09/10/96	09/19/96	(c)		
Area 19, Pahute Substation	09/19/96	09/24/96	26.2	2.44	6.90
Area 19, Pahute Substation	09/24/96	09/30/96	18.1	2.50	4.58
Area 19, Pahute Substation	09/30/96	10/08/96	25.1	2.66	4.75
Area 19, Pahute Substation	10/08/96	10/15/96	27.2	3.03	8.94
Area 19, Pahute Substation	10/15/96	10/22/96	30.1	3.37	9.77
Area 19, Pahute Substation	10/22/96	10/29/96	33.0	3.51	10.2
Area 19, Pahute Substation	10/29/96	11/05/96	24.9	2.56	7.38
Area 19, Pahute Substation	11/05/96	11/12/96	31.0	2.28	6.15
Area 19, Pahute Substation	11/12/96	11/19/96	-0.60	1.83	6.23
Area 19, Pahute Substation	11/19/96	11/26/96	13.1	2.20	6.73
Area 19, Pahute Substation	11/26/96	12/03/96	19.5	2.64	7.88
Area 19, Pahute Substation	12/03/96	12/10/96	22.8	2.44	7.05
Area 19, Pahute Substation	12/10/96	12/19/96	(c)		
Area 19, Pahute Substation	12/19/96	12/26/96	31.0	2.81	7.86
Area 19, Pahute Substation	12/26/96	01/02/97	29.6	4.08	12.2
Area 20, Camp	12/26/95	01/03/96	38.3	1.57	4.42
Area 20, Camp	01/03/96	01/08/96	(c)		
Area 20, Camp	01/08/96	01/16/96	18.0	1.28	3.90
Area 20, Camp	01/16/96	01/22/96	31.3	1.67	4.89
Area 20, Camp	01/22/96	01/29/96	30.7	1.70	2.61
Area 20, Camp	01/29/96	02/06/96	39.8	2.85	4.61

Missing value code, due to:

- (a) Instrument malfunction.
- (b) Sample lost in analysis.
- (c) No sample collected, insufficient sample, no pressure in sample bottle, sampler failed, loss of power.
- (d) Unknown or undocumented cause.

Attachment 7.1 (Sample Results for ⁸⁵Kr - 1996, cont.)

Sampling Location	Sampling Dates		10 ⁻¹² μCi/mL		
	Start	End	Concentration	Standard Deviation	Detection Limit
Area 20, Camp	02/06/96	02/12/96	17.5	3.48	6.64
Area 20, Camp	02/12/96	02/20/96	40.3	4.41	7.84
Area 20, Camp	02/20/96	02/27/96	30.9	3.37	5.98
Area 20, Camp	02/27/96	03/05/96	41.2	4.22	7.41
Area 20, Camp	03/05/96	03/12/96	3.17	3.68	7.49
Area 20, Camp	03/12/96	03/19/96	13.1	3.58	6.98
Area 20, Camp	03/19/96	03/28/96	27.1	2.98	5.30
Area 20, Camp	03/28/96	04/02/96	23.7	2.75	4.96
Area 20, Camp	04/02/96	04/09/96	(a)		
Area 20, Camp	04/09/96	04/16/96	37.4	3.37	5.75
Area 20, Camp	04/16/96	04/25/96	33.1	2.66	4.51
Area 20, Camp	04/25/96	05/02/96	22.0	2.88	5.23
Area 20, Camp	05/02/96	05/09/96	37.9	3.28	5.59
Area 20, Camp	05/09/96	05/15/96	33.5	3.80	6.81
Area 20, Camp	05/15/96	05/23/96	28.6	2.45	4.16
Area 20, Camp	05/23/96	05/30/96	25.3	2.63	4.64
Area 20, Camp	05/30/96	06/05/96	(c)		
Area 20, Camp	06/05/96	06/12/96	(c)		
Area 20, Camp	06/12/96	06/19/96	32.8	3.37	6.57
Area 20, Camp	06/19/96	06/27/96	(c)		
Area 20, Camp	06/27/96	07/03/96	(a)		
Area 20, Camp	07/03/96	07/10/96	25.1	3.46	6.34
Area 20, Camp	07/10/96	07/18/96	22.0	3.29	6.05
Area 20, Camp	07/18/96	07/25/96	9.09	4.16	8.30
Area 20, Camp	07/25/96	07/31/96	5.35	3.13	6.27
Area 20, Camp	07/31/96	08/07/96	(c)		
Area 20, Camp	08/07/96	08/13/96	27.3	3.79	6.97
Area 20, Camp	08/13/96	08/20/96	15.5	3.05	5.78
Area 20, Camp	08/20/96	08/28/96	31.9	3.03	5.26
Area 20, Camp	08/28/96	09/04/96	28.4	2.63	4.53
Area 20, Camp	09/04/96	09/10/96	27.6	3.06	5.50
Area 20, Camp	09/10/96	09/18/96	23.7	3.34	6.18
Area 20, Camp	09/18/96	09/24/96	30.7	3.36	6.01
Area 20, Camp	09/24/96	09/30/96	(c)		
Area 20, Camp	09/30/96	10/08/96	24.4	3.82	7.12
Area 20, Camp	10/08/96	10/15/96	2.30	2.90	9.65

Missing value code, due to:

- (a) Instrument malfunction.
- (b) Sample lost in analysis.
- (c) No sample collected, insufficient sample, no pressure in sample bottle, sampler failed, loss of power.
- (d) Unknown or undocumented cause.

Attachment 7.1 (Sample Results for ⁸⁵Kr - 1996, cont.)

<u>Sampling Location</u>	<u>Sampling Dates</u>		<u>10⁻¹² μCi/mL</u>		
	<u>Start</u>	<u>End</u>	<u>Concentration</u>	<u>Standard Deviation</u>	<u>Detection Limit</u>
Area 20, Camp	10/15/96	10/22/96	12.4	2.72	8.48
Area 20, Camp	10/22/96	10/29/96	33.1	5.81	17.9
Area 20, Camp	10/29/96	11/05/96	35.4	2.64	7.12
Area 20, Camp	11/05/96	11/12/96	30.3	3.41	9.89
Area 20, Camp	11/12/96	11/19/96	25.1	2.21	6.22
Area 20, Camp	11/19/96	11/21/96	(b)		
Area 20, Camp	11/21/96	11/26/96	(b)		
Area 20, Camp	11/26/96	12/03/96	(c)		
Area 20, Camp	12/03/96	12/10/96	(d)		
Area 20, Camp	12/10/96	12/17/96	12.9	5.31	17.2
Area 20, Camp	12/17/96	12/26/96	42.2	3.54	9.81
Area 20, Camp	12/26/96	01/02/97	28.2	2.66	7.51

Missing value code, due to:

- (a) Instrument malfunction.
- (b) Sample lost in analysis.
- (c) No sample collected, Insufficient sample, No pressure in sample bottle, sampler failed, loss of power.
- (d) Unknown or undocumented cause.