9.0 ONSITE GROSS ALPHA AND GROSS BETA IN WATER

Water sampling for gross alpha and gross beta levels is done quarterly. For data analysis purposes, the sampling locations are divided into seven types. The types of water sampling stations are listed below.

- Potable water or supply wells are the wells that supply water for human consumption. These wells may also be used to supply water for industrial and construction purposes. In 1996, samples were collected quarterly from ten supply wells.

- Industrial wells or non-potable water wells are wells that supply water only for industrial and construction purposes. Samples were collected quarterly from two industrial wells.

- Potable water end points or water supply distribution end points are locations where water is drawn for human consumption. These are typically faucets in buildings such as offices and cafeterias. In 1996, samples were collected quarterly from seven end points.

- Natural springs are places where ground water comes to the surface. They are used by the fauna of the NTS and sometimes are dry when visited for sampling. Samples were collected annually, in July, from eight natural springs.

- Sewage lagoons are the end points for the several sanitary sewage systems operated on the NTS. Water is lost from these lagoons primarily by evaporation. Samples are collected quarterly from nine lagoons.

- Open reservoirs are man-made water storage ponds for waters. Most are adjacent to wells, but this type also includes the reservoirs that supply the concrete batch plants (Mud Plants) and the Area 23 recreational swimming pool (which is now empty). Samples are collected annually, in July, from nine open reservoirs. An additional six open reservoirs were scheduled for sampling but were dry on the sampling date.

- Containment ponds are used to contain the effluents from the tunnels. The water in these typically has elevated levels of tritium. Loss of water is primarily by evaporation. In 1996, the only tunnel that had an effluent seepage was the E tunnel. It has an effluent flow and two containment ponds, which are arranged so that the first pond overflow is collected in the second pond. These waters are collectively named the E Tunnel Containment Ponds. They are sampled quarterly.

Gross alpha analyses are performed only for potable water wells and water supply distribution end points. Gross beta analyses are performed for all types of samples; however, open reservoirs and natural springs are sampled only once a year. The names of the sampling locations in each of these type classifications are given in the attachments to this chapter.

Sampling locations, sampling dates, measured concentrations, analytic standard deviations, and minimal detectable concentrations (MDC) for gross alpha and gross beta in water appear in Attachments 9.1 and 9.2. (Figures, tables and attachments, in that order, are found at the end of the chapter.) Figure 9.1 is a map of the NTS showing the water sampling locations.

Several changes were made in the sampling network during 1996 in response to the reduced level of activities on the NTS. Well C in Area 6 broke down in early 1996 and was taken out of service rather than repaired. Well U-20 in Area 20 is operated only when needed and thus is usually out of service when visited for sampling. Both Well C and Well U-20 are industrial water wells. Often, faucet sampling locations are inside buildings that are locked when visited for water sampling. When this occurs, the samplers usually collect samples from adjacent locations that are on the same water supply, such as the building across the street or next door. Thus the data attachments contain Area 1 samples collected from Building 101 and the Area 1 Ice House. Likewise the Area 12 samples were collected at Building 12-23, the Medical Aid station, and the Area 12 Ice House.

GROSS ALPHA IN WATER

Gross alpha levels in water for 1996 were measured quarterly at 10 potable water supply wells, 2 industrial water wells, and 7 potable water end points for a total of 19 locations not counting the use of adjacent buildings. The data are presented in Attachment 9.1. Note that alpha analyses are not done for the open waters: reservoirs, ponds, lagoons, and springs. Descriptive statistics by location and type are given in Table 9.1. Table 9.2 presents descriptive statistics by quarter. The mean for all sampling locations combined is slightly smaller than that reported for 1995, but the 1996 median is slightly larger. For the entire network, all results are positive, and approximately 10 percent are less than their individual detection limits.

Time series plots of the alpha levels versus date of sampling showed no interesting patterns. The data for each quarter is approximately uniformly spread over a range of zero to 15×10^{-9} µCi/mL with no distinction for the type of sampling location. Figure 9.3 shows the alpha levels by sampling date.

In previous years, except for 1994, neither the normal nor lognormal statistical distribution has characterized the observed gross alpha concentrations particularly well. This has necessitated the use of nonparametric statistics to test for the significance of differences between subgroups within the data. Concentrations observed in 1996 follow this pattern of not fitting a regular statistical distribution, as illustrated in the normal probability plot of the gross alpha data from all sampling stations combined, as shown in Figure 9.2. This figure shows a good fit to a normal distribution for results above a value of 5.0×10^{-9} but below this value the data appear to have the shape of a lognormal distribution. This change point is not related to the detection limits. The median MDC is 1.39×10^{-9} µCi/mL, which is about the point at which the line of data values crosses the solid line just above the zero value.

The Kruskal-Wallis test is the nonparametric equivalent of the one way analysis of variance (ANOVA). It is valid for a wide variety of distributional shapes, at the price of lower statistical power (less ability to detect differences when they exist) than classical ANOVA. Table 9.3 gives the results of a Kruskal-Wallis test for differences between the types of water samples. In the Kruskal-Wallis test, a statistic is calculated for each level of the grouping variable, which, if concentrations within groups had the same median, has a standard normal distribution. This statistic appears in the output under the heading “Z-value.” The Z-values for each row of the test output indicate, on a scale of a standardized normal variable, how much the ranks of that row deviate from the overall mean rank. The Kruskal-Wallis statistic has approximately a Chi-square distribution with degrees of freedom equal to one less than the number of categories. Table 9.3 shows that none of the groups have a median that is significantly different from the overall median. The dotplots of the data values that appear in Table 9.3 show that the data for the three types of samples are spread over the range of values but somewhat clustered at lower values. The data were also analyzed using a parametric ANOVA. Because the data are not normal, this analysis can only be considered suggestive. This analysis found a significant difference between sampling locations but no differences between types of sampling stations or between times of sample collection.

To quantify measurement errors for gross alpha in water, the empirical coefficients of variation was calculated for each measurement from the counting statistics. The coefficient of variation is defined as the standard deviation divided by the corresponding mean value. These are displayed as a histogram in Figure 9.4. This figure shows that most of the coefficients of variation are less than 0.4, hence one can say that in general the standard deviations are less than half the mean values.

The MDC are a measure of the sensitivity of an analytical procedure. The MDC is defined at the beginning of this report, on page Ex-3. Figure 9.5 presents a histogram of the 1996 gross alpha in water MDCs. This figure shows that, except for two outliers, the detection limits are less than 2×10^{-9} µCi/mL. The two outliers are from samples collected at Well C-1 on May 9, 1997, and October 7, 1997. An examination of these data points in Attachment 9.1 shows that these high detection limits are associated with measured concentrations that are also high, and that the MDCs are substantially lower than the corresponding measured values. The median MDC is 1.39×10^{-9} µCi/mL.

GROSS ALPHA HISTORICAL TRENDS

Alpha in water measurements were begun in 1984 and data exist from 1984 to the present for only three sampling locations. Data exist from 1990 to the present for an additional eleven sampling locations. Because of this scarcity of data, the historical trends are presented graphically in Table 9.4 and Figure 9.6 as the annual averages from five of the sampling stations. In Figure 9.6 the solid line is a "locally weighted scatterplot smoother line," a graphical tool for eliciting trends in data. An obvious feature in Figure 9.6 is the peak in the line occurring in 1987. No physical explanation of this peak has been found. The legend entry for Area 23 Cafeteria is for the data from the Mercury Cafeteria. Mercury is in Area 23. A notable feature of the historical data evident in Figure 9.6 is the layering of the annual averages by sampling location. The highest data values are mostly from the Area 6 Cafeteria. The second highest layer is mostly from the Area 23 Cafeteria and the data from both cafeterias are almost all above the smoother line. The rest of the sampling location averages are below the line and layered from highest to lowest as Well J-13, Building 4221, and Area 2 Restroom.

GROSS BETA IN WATER

Gross beta concentrations in water were measured at 10 supply wells, 2 industrial wells, 7 potable water end points, 9 open reservoirs, 7 natural springs, 9 sewage lagoons, and 3 containment ponds, for a total of 47 sampling locations. The individual sample collection dates, sample values, analytical standard deviations, and MDCs appear in Attachment 9.2. Descriptive statistics are given in Table 9.5. In this table, no individual location statistics are given for the open reservoirs and natural springs because these locations were sampled only once during the year. The sample values for these locations appear in Attachment 9.2. The values in Table 9.5 for the containment pond statistics are about an order of magnitude higher than the values from the other types of sampling locations. This is to be expected since the containment ponds were constructed to contain the effluents from nuclear experiments performed inside the tunnels and thus have a source of radioactivity other than environmental exposure. The median MDC for all sampling locations and all sample collection dates is 1.23×10^{-9} µCi/mL. All sample results were positive and exceeded the individual MDCs.

Table 9.6 summarizes the gross beta in water data by the quarter of the year of sample collection and by type of sampling location. First quarter collection dates range from January 9 to February 13, 1996; second quarter from May 7 to May 30, 1996; third quarter from July 11 to August 8, 1996; and fourth quarter from October 1 to November 6, 1996. Figure 9.7 presents a time series plot of the gross beta in water results for the supply Wells and drinking water end points.

Statistical hypothesis testing must account for the statistical distribution of the data in order to yield valid conclusions. ANOVA tests assume that the residuals are normally distributed. This assumption is checked by probability plotting and normality testing on the residuals from an ANOVA. The residuals are the differences between the observed data and the values predicted by the ANOVA model. In Figure 9.8, the residuals from the ANOVA test described in the next paragraph are plotted. This test used the natural logarithms of the gross beta in water data. The straightness of the plot indicates the lognormal probability distribution is a good approximation to the probability distribution of these data. The bottom right of Figure 9.8 show the results of a normality test of these residuals. These results show a very good fit to a normal statistical distribution. The lognormal distribution has been found to be appropriate for gross beta in water results in previous years reports. Hence the 1996 gross beta in water data will be treated as lognormally distributed for statistical testing.

Table 9.7 presents the results of a two-way ANOVA performed on the logarithms of observed gross beta in water concentrations. This analysis tested for differences between sampling location types and quarter of sample collection. Since the data are statistically unbalanced and contain some empty cells, a General Linear Model procedure was used for this analysis. The containment pond data were deleted from this analysis since these data are not actually environmental in origin. The results of this analysis indicated no differences between quarters and very significant differences between location types. An interaction term could not be used since this results in a rank deficient ANOVA with this data set. The pattern of differences among the location types that caused the significance can be elicited using a one-way ANOVA.

Results of a one-way ANOVA comparing the natural logarithms of gross beta concentrations among types of sampling locations appears in Table 9.8. Containment pond data were deleted from this analysis. This analysis showed the same level of significance as the two-way analysis of the previous paragraph. The advantage of the one-way analysis is that the program used for this analysis provides a Tukey’s multiple comparison procedure that shows the pattern of differences between types of locations that caused the significant results. The Tukey’s test showed that the sewage lagoons have significantly higher concentrations than the other types of locations.

An analysis of time trends in concentrations over the year was done for the 1994 and earlier reports. During those years, weekly samples were collected. In 1995 and 1996, only quarterly samples were collected. Four time periods a year are not adequate to find a statistical significance for moderate time trends over a year. Thus the investigation of such trends ceased in 1995.

Measurement error for gross beta in water is generally small. This is quantified by means of empirical coefficients of variation, which is the analytical standard deviation divided by the measured concentration. Empirical coefficients of variation for gross beta in water appear in Figure 9.9. This figure indicates that analytic standard deviations tend to be approximately an order of magnitude less than the observed concentrations.

Analytic standard deviations only account for counting variability. Other sources of variability include sample preparation variability, sample collection variability, and variability in the sampled waters. Prior to 1995, these types of variation were investigated using sampling duplicates. Because of reduced budgets, the duplicates program was significantly reduced in 1995 and thus the statistical analysis of duplicates was discontinued.

GROSS BETA IN WATER HISTORICAL TRENDS

Detailed reporting of historical trends for all sampling locations would result in an unwieldy document. Instead, two representative locations were chosen from the open reservoirs, natural springs, supply wells, and potable water end points. The wells chosen for this report differ from those used in previous reports. The choices for this report emphasize a continuous record from the beginning of the historically available data, in 1967. The sampling stations chosen for this report are:

Water Source	Operational Area	Sampling Location
End Point	6	Cafeteria
End Point	23	Cafeteria
Supply Well	6	Well C-1
Supply Well	5	Well 5C
Natural Springs	5	Cane Spring
Natural Springs	12	Captain Jack Spring
Open Reservoir	5	Well 5B Reservoir
Open Reservoir	18	Camp 17 Reservoir

Table 9.9 lists the historical gross beta in water data. The Area 23 Cafeteria is an alternate name for the Mercury Cafeteria. Time series plots of the data in Table 9.9 appear in Figures 9.10 through 9.13, one plot for each of the types of sampling locations. Note that Figure 9.12 has a different ordinate scale than the other gross beta time series plots. Also, the 1997 annual average for Captain Jack Spring, a value of 65.8 µCi/mL x 10^{-9}, is not plotted in Figure 9.12. This high value is due to a single weekly sample that was an order of magnitude higher than the remaining weekly values for that year. No historical trends were analyzed for waters from sewage lagoons or containment ponds. There is relatively little variability in concentrations of samples taken from sewage lagoons. Concentrations from containment ponds vary greatly among years, depending upon the type of experimental activities conducted within the tunnels during the years, so few meaningful conclusions could be drawn.

In general, historical trends for levels of gross beta in water are not as clear as those of gross beta in air. Underground waters, such as samples from wells, would not have been affected by atmospheric nuclear testing. Gross beta in air shows declining levels since 1970, about the time atmospheric testing ended (see Figure 2.8). No such trend is evident in the water data. There are obvious differences between sampling locations, but no long term trends are evident.

Concentrations of gross beta, as well as other contaminants, observed at Reitman Seep are typically greater than those from the other natural springs. This occurs because samples from Reitman Seep usually contain sediment, which carries more contaminants than clear water.

CONCLUSIONS

Gross alpha and beta levels in water in 1996 are approximately the same as the levels reported in 1995. No statistically significant differences were found between quarter of sample collection, but there were very significant differences between sample collection locations and types of locations. The sitewide annual average for gross alpha for 1996 is 5.83×10^{-9} µCi/mL, and the median is 5.95×10^{-9} µCi/mL. For gross beta the sitewide annual average, excluding containment ponds, for 1996 is 11.60×10^{-9} µCi/mL, and the median is 7.38×10^{-9} µCi/mL.

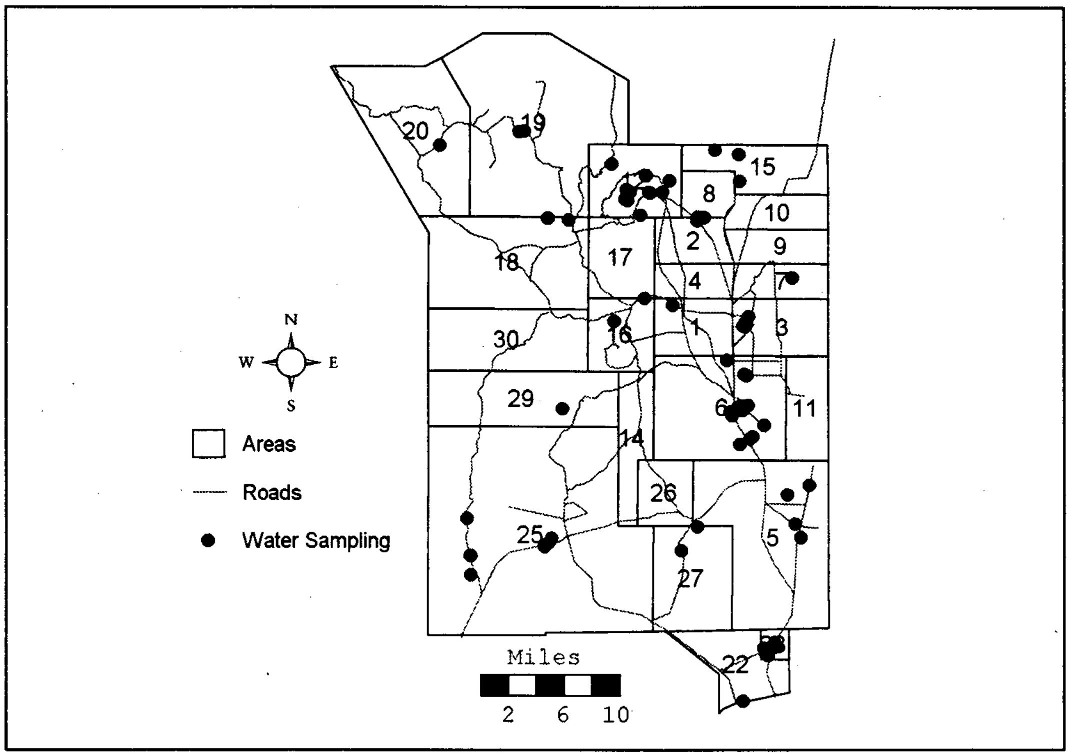

Figure 9.1 Locations of Water Sampling Stations on NTS

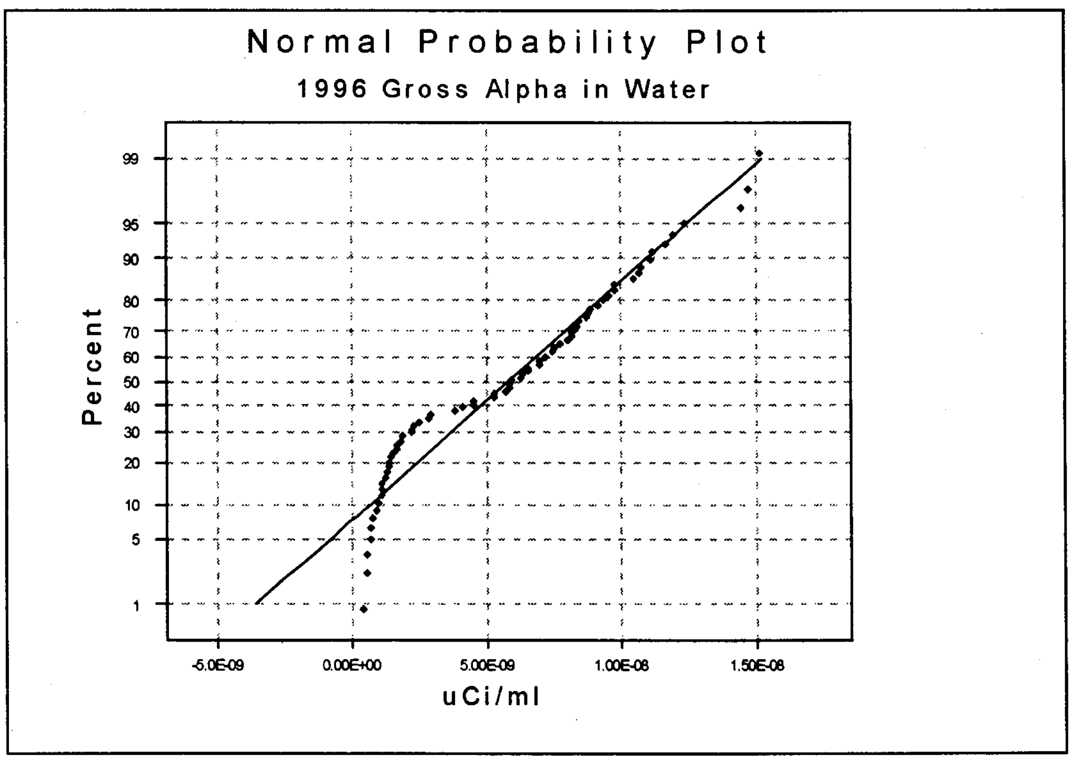

Figure 9.2 Probability Plot of All Gross Alpha in Water Results

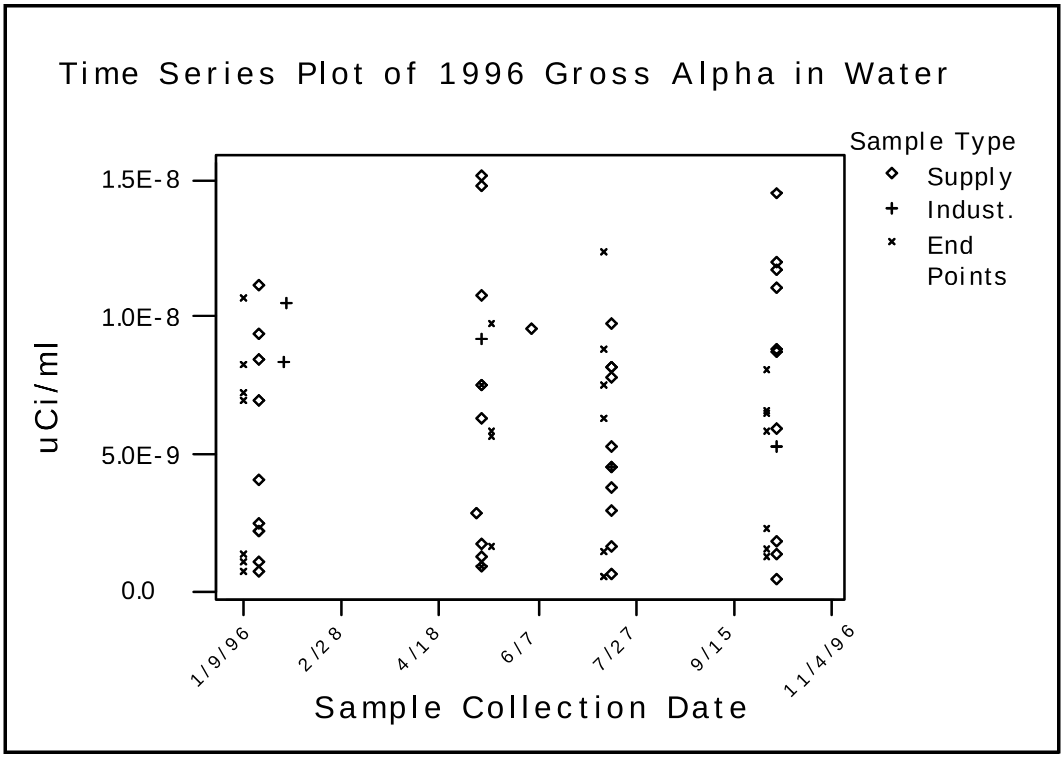

Figure 9.3 Time Series Plot of Gross Alpha in Water Results

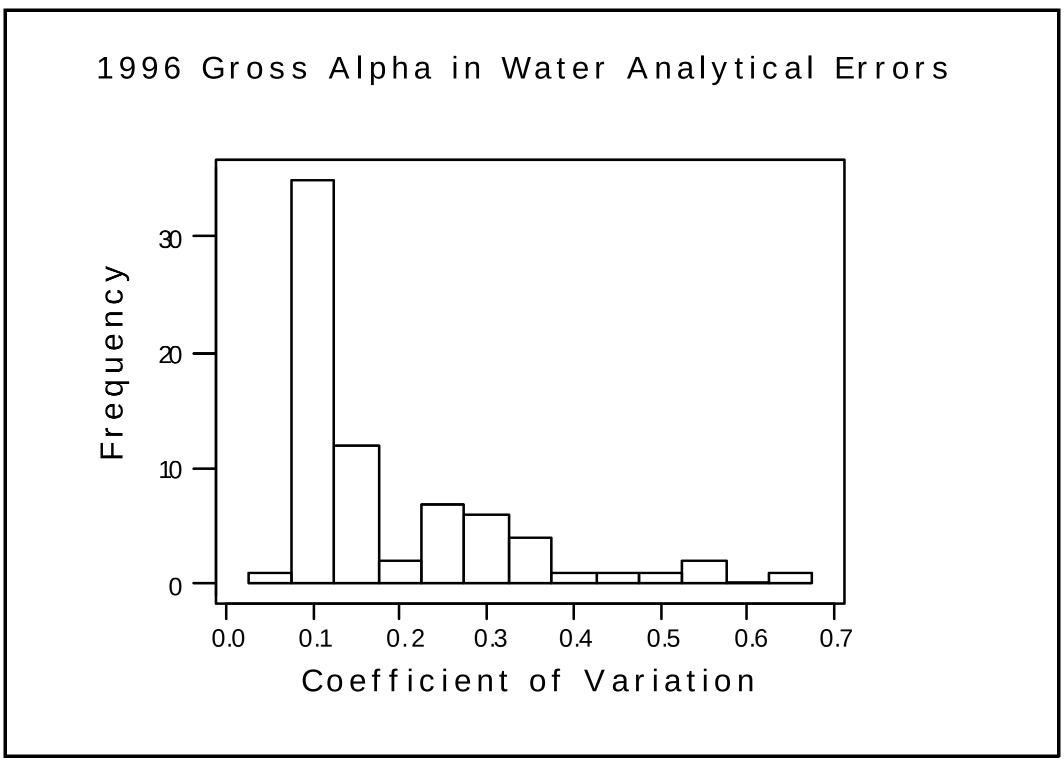

Figure 9.4 Histogram of 1996 Gross Alpha in Water Analytical Errors

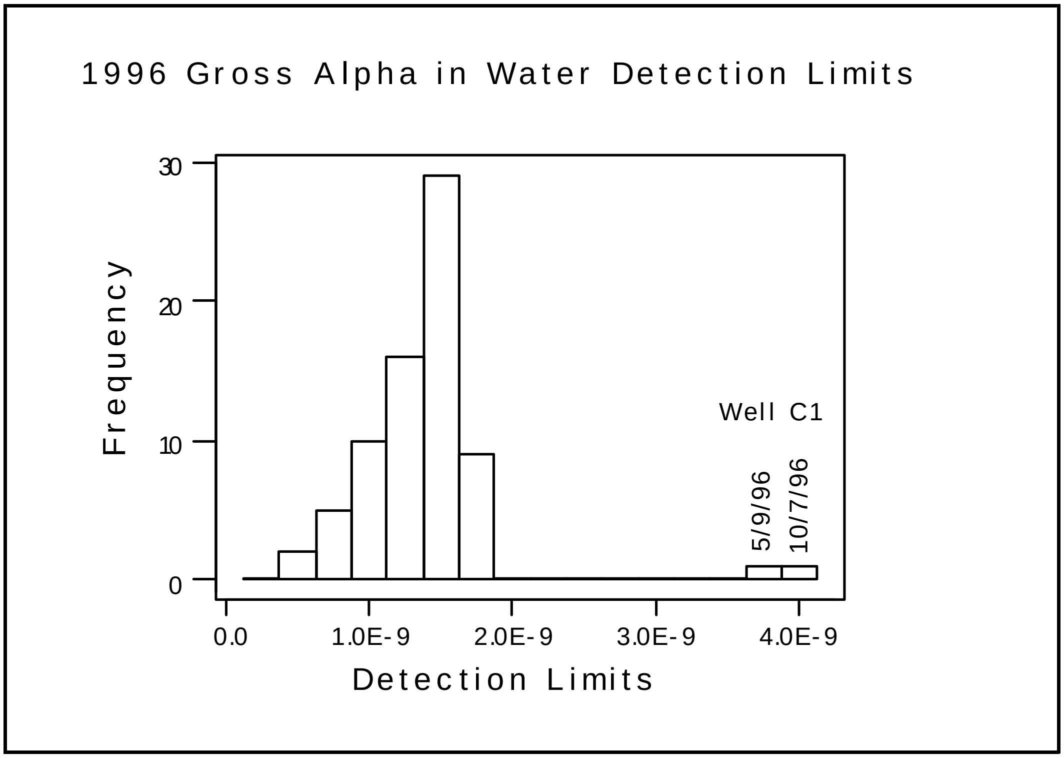

Figure 9.5 Histogram of 1996 Gross Alpha in Water Detection Limits

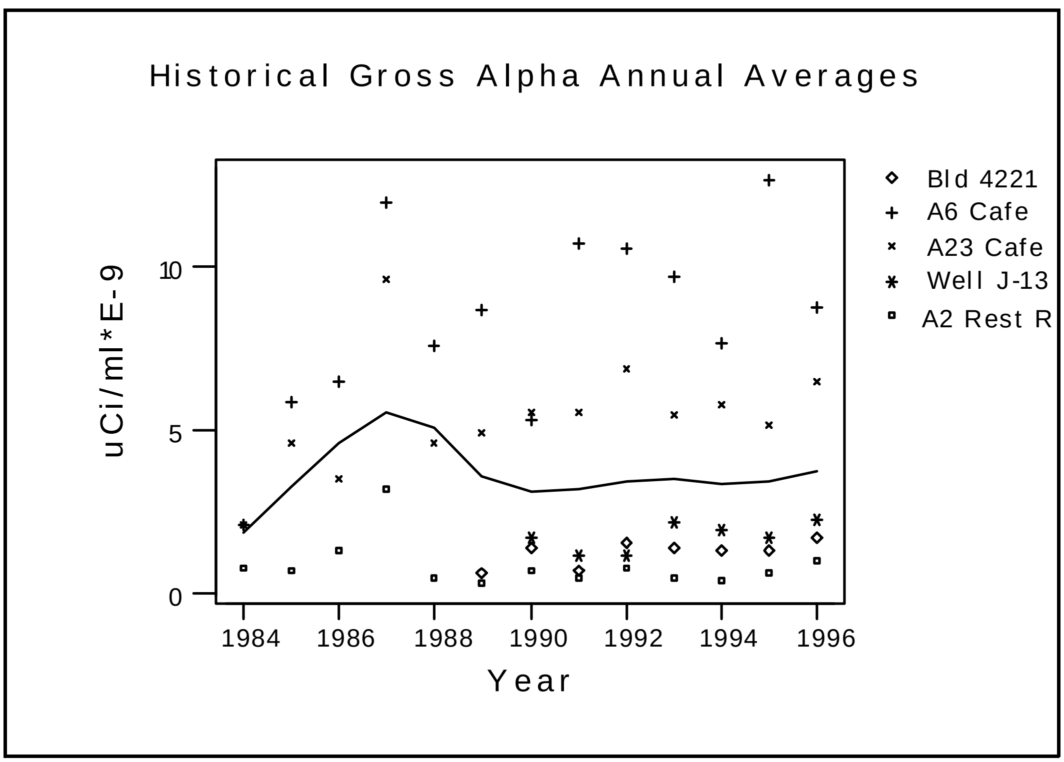

Figure 9.6 Time Series Plot of Historical Gross Alpha in Water Data

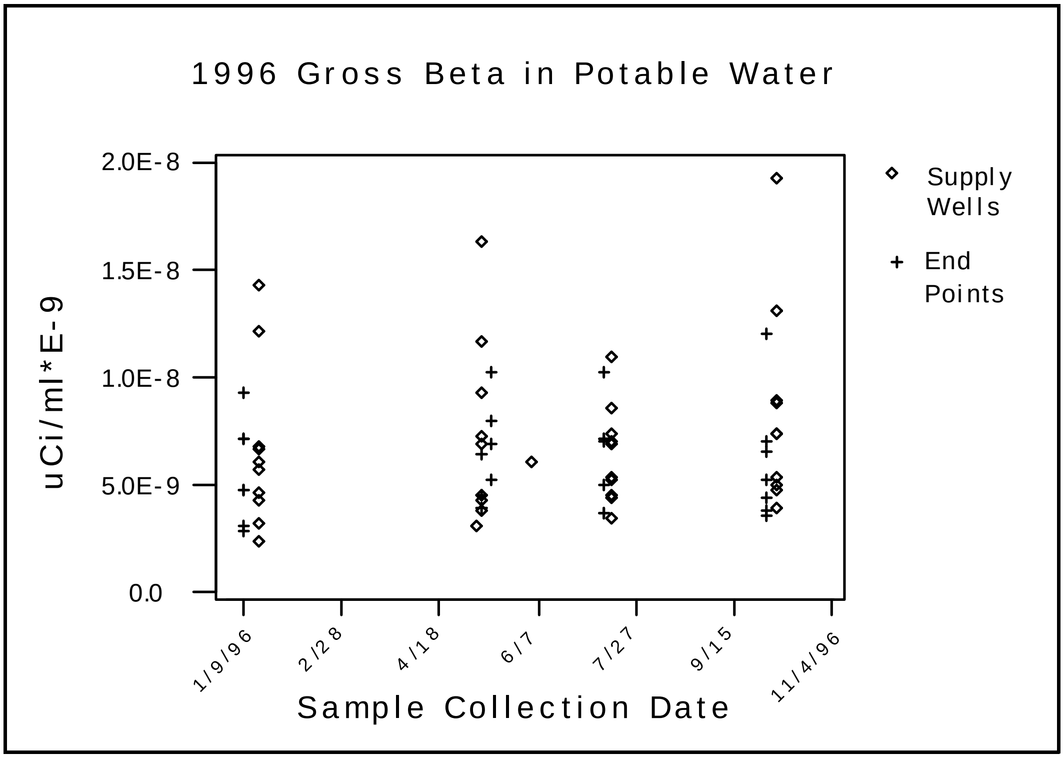

Figure 9.7 Time Series Plot for Gross Beta in Water

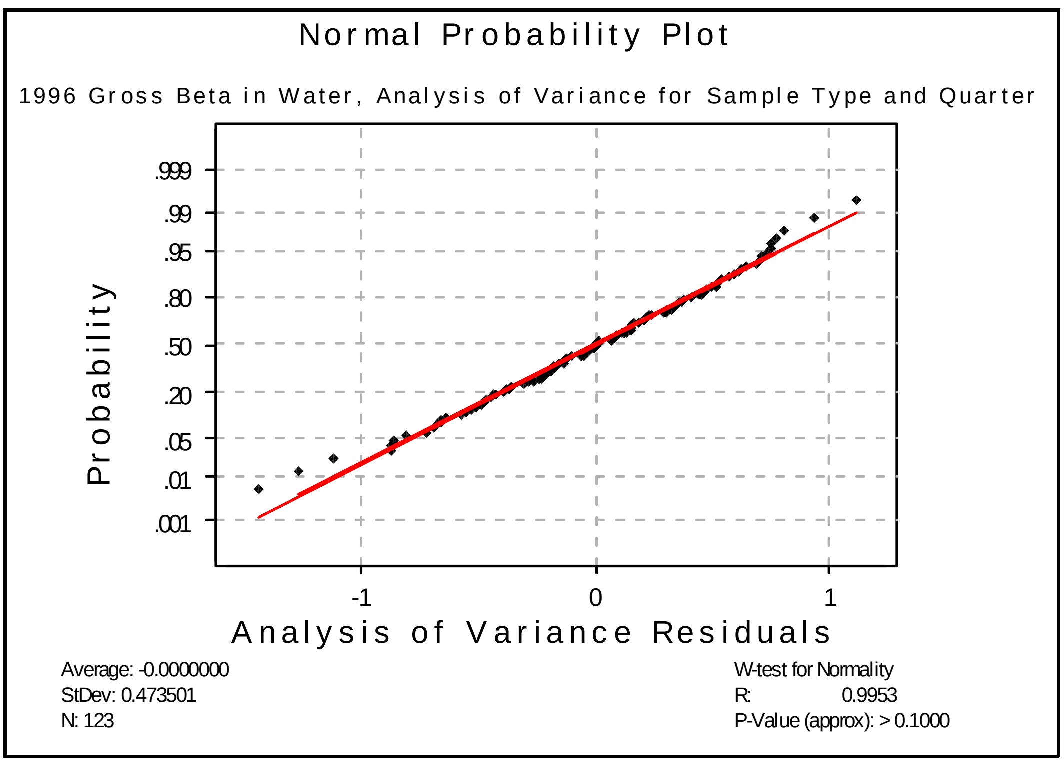

Figure 9.8 Probability Plot of ANOVA Residuals

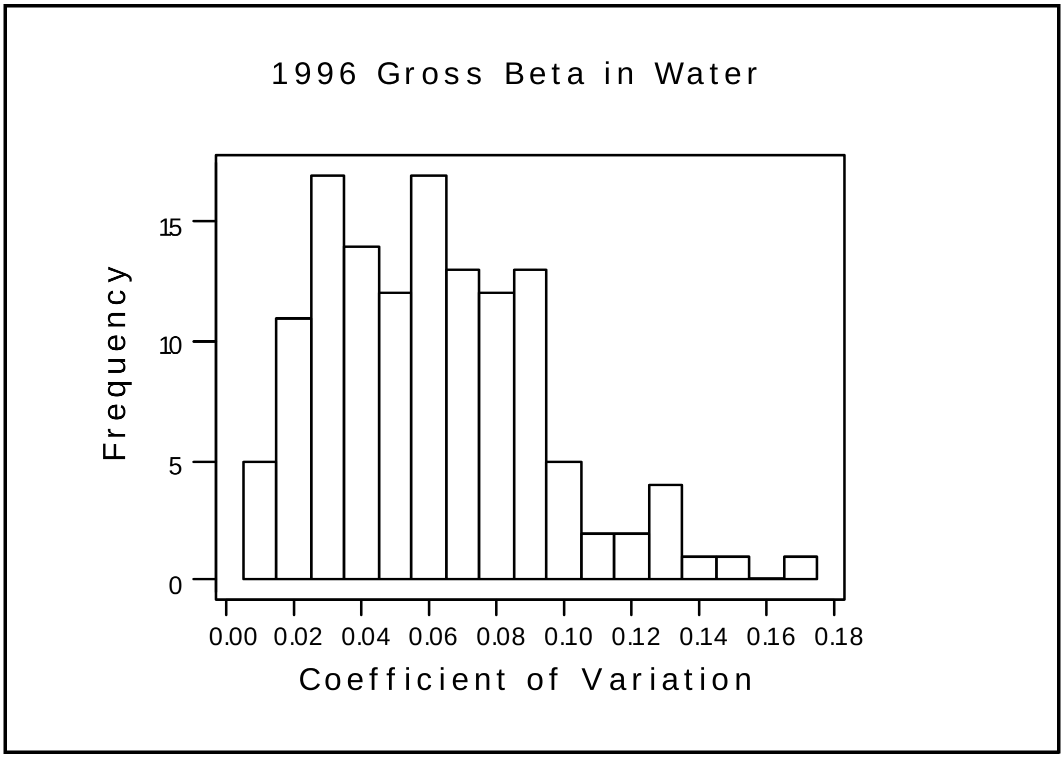

Figure 9.9 Histogram of Gross Beta in Water Relative Errors

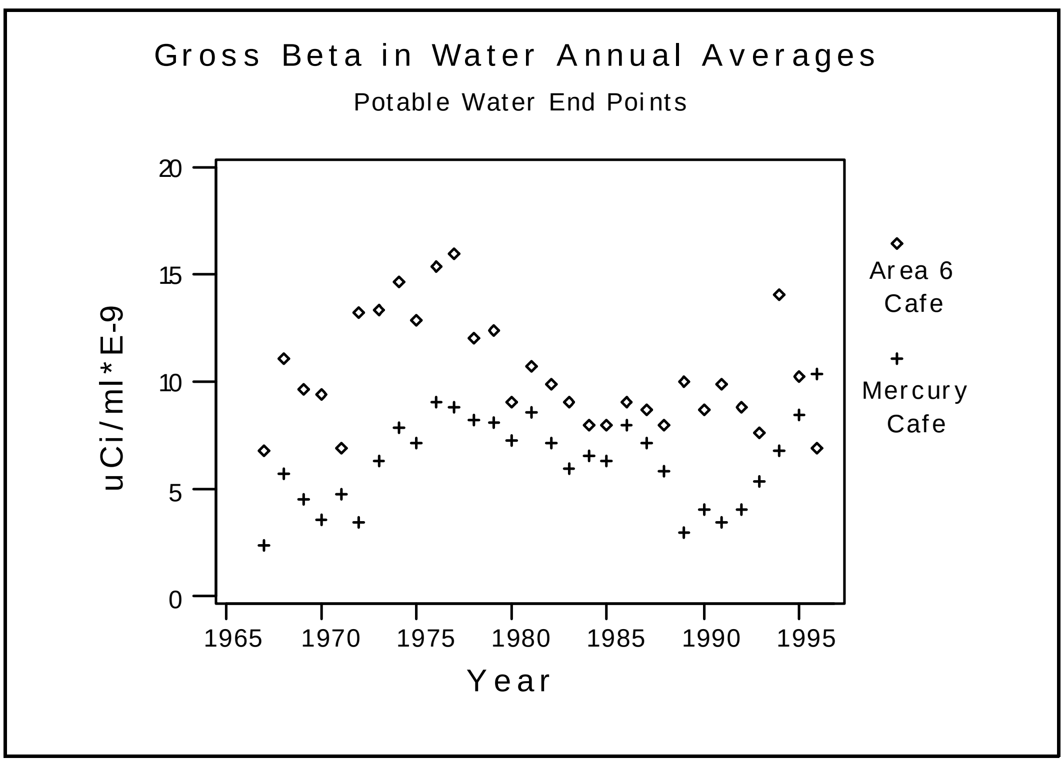

Figure 9.10 Time Series Plot of Annual Averages

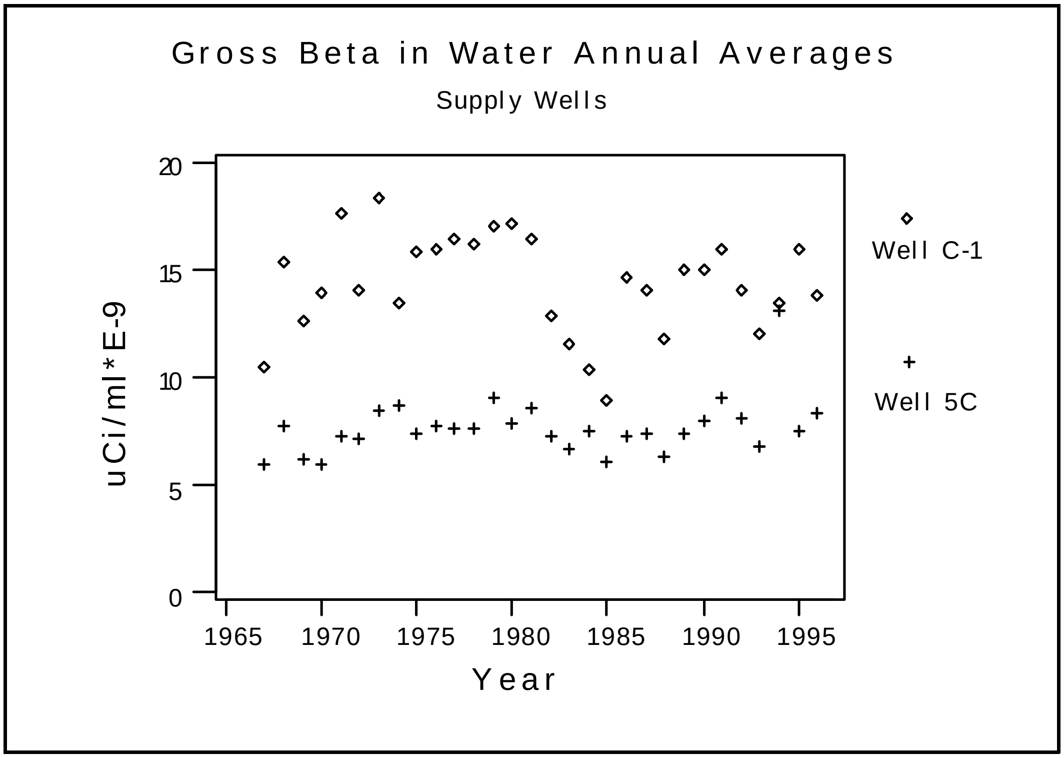

Figure 9.11 Time Series Plot of Annual Averages

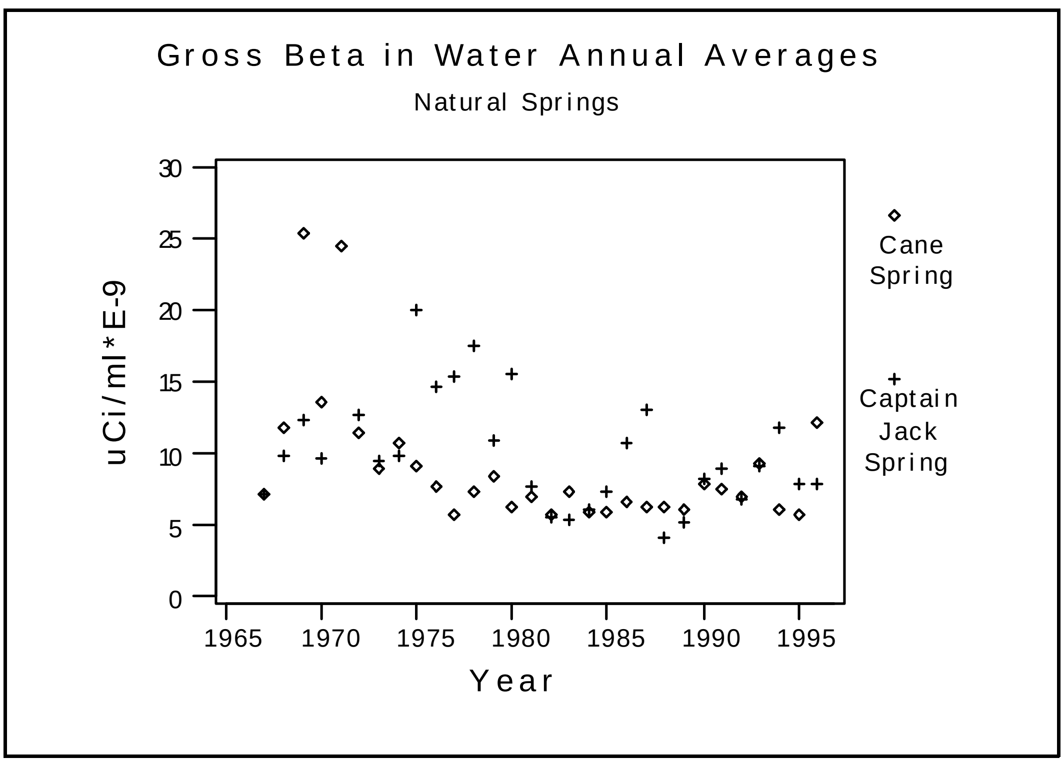

Figure 9.12 Time Series Plot of Annual Averages

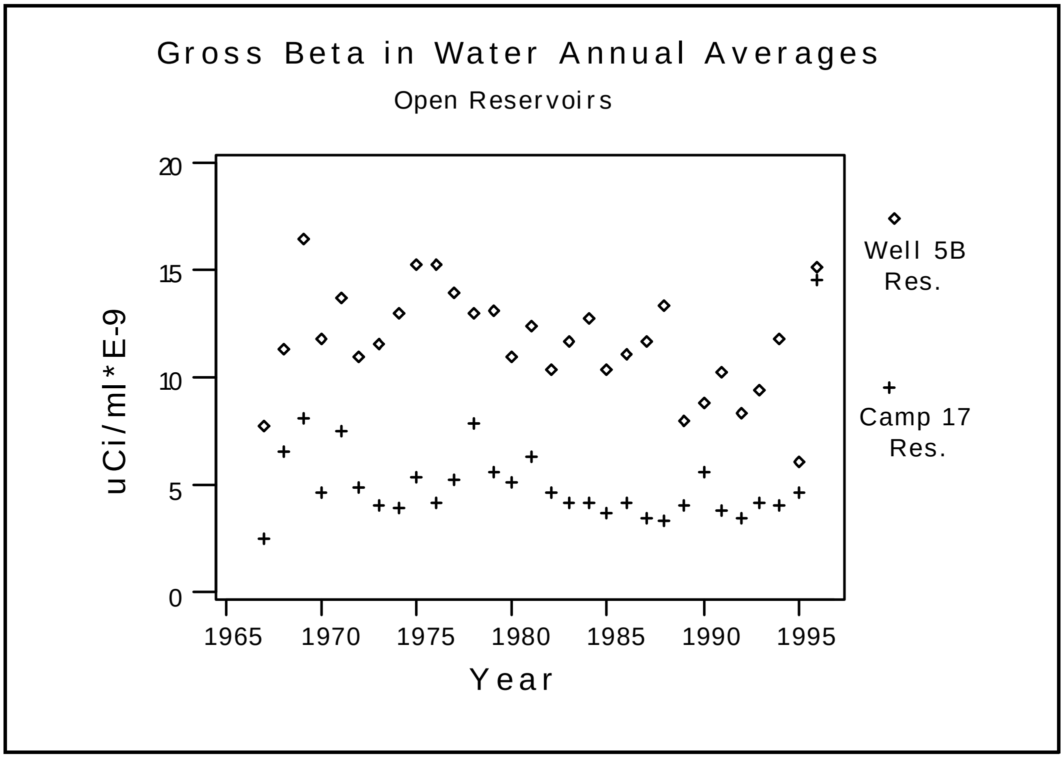

Figure 9.13 Time Series Plot of Annual Averages

Table 9.1 Descriptive Statistics for Gross Alpha in Water by Sampling Location, (µCi/mL × 10^{-9})

Station Name	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
SUPPLY WELLS						
Well 5B	4	6.12	6.11	0.71	5.27	6.99
Well 5C	4	11.99	12.16	3.37	8.43	15.20
Well No. 4A	4	9.91	10.33	1.61	7.78	11.20
Well No. 4	4	9.28	9.06	1.12	8.19	10.80
Well C-1	4	8.28	7.90	6.04	2.52	14.80
Well UE-16D	4	6.66	7.83	3.03	2.19	8.79
Well HTH No. 8	4	0.77	0.79	0.29	0.41	1.08
Army Well No. 1	4	5.40	3.52	4.24	2.86	11.70
Well J-12	4	1.48	1.70	0.54	0.69	1.83
Well J-13	4	2.33	1.77	1.54	1.25	4.54
All Supply Wells	40	6.22	6.11	4.42	0.41	15.20
INDUSTRIAL WELLS						
Well UE-5C	4	11.99	12.16	3.37	8.43	15.20
Well U-20	1	8.36				
All Industrial Wells	5	7.56	8.36	2.57	4.50	10.50
POTABLE WATER						
Building 101	4	7.52	7.52	0.45	6.96	8.07
Area 2, Restroom	4	1.02	1.00	0.41	0.54	1.53
Area 6, Cafeteria	4	8.84	8.65	0.41	0.54	1.53
Building 6-900	4	8.18	8.55	1.68	5.85	9.78
Building 12-23	4	0.90	0.88	0.35	0.53	1.31
Mercury Cafeteria	4	6.48	6.45	0.57	5.83	7.21
Building 4221	4	1.70	1.55	0.42	1.38	2.31
All Potable Water	24	4.69	4.00	3.84	0.53	12.40
All Stations Combined	73	5.83	5.95	4.05	0.41	15.20

Table 9.2 Descriptive Statistics for Gross Alpha in Water by Quarter of Year, (µCi/mL × 10^{-9})

Quarter	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
1	19	5.47	6.96	3.84	0.69	11.20
2	18	6.25	6.05	4.67	0.89	15.20
3	18	5.28	4.91	3.57	0.53	12.40
4	18	6.33	6.34	4.28	0.41	14.50

Table 9.3 Kruskal-Wallis Test for Equality of Gross Alpha Results by Type of Water Source

Type	N	Median	Average Rank	Z
Supply Wells	40	6.110	39.1	0.95
Industrial Wells	5	8.360	47.4	1.14
End Points	28	5.840	32.1	-1.56
Overall	73	37.0		

```
End         .
Points    .:.:.::. :  ...  . .. . ..:.: ...  .: ..       .. .
         +---------+---------+---------+---------+---------+-------

Supply
Wells                    .  .         .  .   .
         +---------+---------+---------+---------+---------+-------

Industrial  . ..
Wells       :.::. .          :..:..: .. .  .  .    .
         +---------+---------+---------+---------+---------+-------
        0.0       3.0       6.0       9.0       12.0      15.0

                         µCi/mL*E-9
```

Table 9.4 Historical Gross Alpha Annual Averages from Selected Sampling Locations, (µCi/mL ×10^{-9})

Year	Building 4221	Area 6 Cafeteria	Mercury Cafeteria	Well J-13	Area 2 Restroom
1984	-	2.1	2.1	-	0.8
1985	-	5.9	4.6	-	0.7
1986	-	6.5	3.5	-	1.3
1987	-	12.0	9.6	-	3.2
1988	-	7.6	4.6	-	0.5
1989	0.6	8.7	4.9	-	0.3
1990	1.4	5.3	5.6	1.7	0.7
1991	0.7	10.7	5.6	1.2	0.5
1992	1.6	10.6	6.9	1.2	0.8
1993	1.4	9.7	5.5	2.2	0.5
1994	1.3	7.7	5.8	2.0	0.4
1995	1.3	12.7	5.2	1.7	0.6
1996	1.7	8.8	6.5	2.3	1.0

Table 9.5 Descriptive Statistics for Gross Beta in Water by Sampling Location, (µCi/mL × 10^{-9})

Station Name	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
SUPPLY WELLS						
Well 5B	4	11.98	11.95	0.92	10.90	13.10
Well 5C	4	8.35	8.75	1.16	6.65	9.23
Well 4A	4	6.62	6.53	0.63	6.07	7.34
Well 4	4	7.10	7.13	0.31	6.77	7.38
Well C-1	4	13.78	15.30	6.06	5.23	19.30
Well UE-16D	4	6.38	7.18	2.77	2.39	8.77
Well HTH No. 8	4	3.57	3.58	0.30	3.24	3.89
Army Well No. 1	4	4.85	5.33	1.20	3.06	5.67
Well J-12	4	4.55	4.59	0.21	4.27	4.74
Well J-13	4	4.58	4.48	0.32	4.32	5.04
All Supply Wells	40	7.18	6.39	3.76	2.39	19.30
INDUSTRIAL WELLS						
Well UE-5C	4	7.62	7.58	1.46	6.31	9.00
Well U-20	1	2.68				
All Industrial Wells	5	6.63	6.39	2.55	2.68	9.00
POTABLE WATER						
Building 101	4	6.23	6.54	0.99	4.80	7.05
Area 2, Restroom	4	3.73	3.83	0.66	2.84	4.42
Area 6, Cafeteria	4	6.91	7.17	1.15	5.28	8.00
Building 6-900	4	7.09	7.10	0.09	6.96	7.18
Building 12-23	4	3.71	3.62	0.56	3.12	4.47
Mercury Cafeteria	4	10.43	10.20	1.13	9.31	12.00
Building 4221	4	4.71	4.91	0.62	3.81	5.19
All Potable Water	28	6.11	5.88	2.35	2.84	12.00
OPEN RESERVOIRS						
All Open Reservoirs	9	11.90	14.50	5.94	4.63	18.80
NATURAL SPRINGS						
All Natural Springs	7	9.21	8.06	2.53	6.26	13.40

Table 9.5 (Descriptive Statistics for Gross Beta in Water by Sampling Location, [µCi/mL × 10^{-9}], cont.)

Station Name	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
CONTAINMENT PONDS						
E Tunnel Effluent	4	120.5	97.8	71.8	61.2	225.0
E Tunnel Pond No. 2	1	92.6				
E Tunnel Pond No. 1	2	135.0	135.0	1.4	134.0	136.0
All Containment Ponds	7	120.6	99.6	52.7	61.2	225.0
SEWAGE LAGOONS						
RWMS	4	29.80	31.40	11.44	14.80	41.60
Yucca	4	16.94	19.45	8.85	4.56	24.30
DAF	4	23.35	21.15	6.13	18.90	32.20
LANL	4	30.12	29.30	6.92	22.60	39.30
Area 12	4	7.71	6.95	2.83	5.43	11.50
Area 22	4	33.33	32.95	10.09	22.00	45.40
Area 23	4	25.38	19.95	13.14	16.90	44.70
Reactor Control	2	14.75	14.75	1.06	14.00	15.50
Area 25 Central Supply	4	16.93	14.55	6.23	12.70	25.90
All Sewage Lagoons	34	22.46	22.10	11.07	4.56	45.40
All Sampling Locations Combined Except Containment Ponds	123	11.60	7.38	9.45	2.39	45.40

Table 9.6 Gross Beta in Water Averages by Type of Sampling Location and 1996 Quarter of Sample Collection, (µCi/mL × 10^{-9})

Location Type	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Supply Wells	6.63	7.31	6.38	8.38
Industrial Wells	5.72	6.31	6.39	9.00
Potable Water	5.60	6.46	6.29	6.10
Open Reservoirs			11.90	
Natural Springs			9.21	
Containment Ponds	180.5	61.2	115.1	96.1
Sewage Lagoons	18.93	29.94	23.24	18.65

Table 9.7 Two Way ANOVA for Differences Between Sample Types and Quarter of Sample Collection on Ln (µCi/mL) - 1996

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-Value	Probability
Type	5	31.7616	6.3523	26.48	0.0
Quarter	3	0.8846	0.2949	1.23	0.303
Error	114	27.3527	0.2399		
Total	122	59.9197			

Table 9.8 One Way ANOVA for Differences Between Sample Types on Ln (µCi/mL) - 1996

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-Value	Probability
Type	5	31.682	6.336	26.25	0.0
Error	117	28.237	0.241		
Total	122	59.920			

```
                                                 Individual 95 Percent Confidence Intervals for
                          Mean of   Standard      Mean Based on Pooled Standard Deviation
Type            N         Ln        Deviation    -------+---------+---------+---------

End Points      28     -18.983      0.381           (--*---)
Industrial       5     -18.913      0.490       (--------*-------)
Supply          40     -18.868      0.476               (--*--)
Springs          7     -18.534      0.267                 (------*-------)
Reservoirs       9     -18.386      0.591                     (-----*------)
Lagoons         34     -17.754      0.585                                     (--*--)
                                                 -------+---------+---------+---------
Pooled Standard Deviation = 0.491                      -19.00    -18.50    -18.00
```

Table 9.9 Historical Gross Beta Annual Averages for Representative Locations ($\mu Ci/mL \times 10^{-9}$) - 1996

Year	Area 6 Cafeteria	Mercury Cafeteria	Well C-1	Well 5C	Cane Spring	Capt. Jack Spring	Well 5B Reservoir	Camp 17 Reservoir
1967	6.8	2.4	10.5	6.0	7.2	7.2	7.7	2.5
1968	11.1	5.7	15.3	7.7	11.7	9.8	11.3	6.5
1969	9.6	4.5	12.6	6.2	25.4	12.4	16.4	8.1
1970	9.4	3.6	13.9	6.0	13.5	9.7	11.8	4.6
1971	6.9	4.8	17.6	7.3	24.5	65.8	13.7	7.5
1972	13.2	3.5	14.0	7.1	11.5	12.7	10.9	4.9

Table 9.9 (Historical Gross Beta Annual Averages for Representative Locations [µCi/mL × 10^{-9}] - 1996, cont.)

Year	Area 6 Cafeteria	Mercury Cafeteria	Well C-1	Well 5C	Cane Spring	Capt Jack Spring	Well 5B Res.	Camp 17 Res.
1973	13.3	6.3	18.3	8.4	8.9	9.5	11.6	4.0
1974	14.6	7.8	13.5	8.7	10.7	9.8	13.0	3.9
1975	12.8	7.1	15.8	7.4	9.1	20.0	15.2	5.3
1976	15.3	9.0	15.9	7.7	7.6	14.6	15.2	4.2
1977	15.9	8.8	16.4	7.6	5.8	15.3	13.9	5.2
1978	12.0	8.2	16.2	7.6	7.3	17.5	13.0	7.8
1979	12.4	8.1	17.0	9.0	8.4	10.9	13.1	5.6
1980	9.0	7.3	17.1	7.8	6.2	15.5	10.9	5.1
1981	10.7	8.6	16.4	8.6	7.0	7.7	12.4	6.3
1982	9.9	7.2	12.9	7.3	5.8	5.6	10.3	4.7
1983	9.1	6.0	11.6	6.7	7.3	5.3	11.7	4.2
1984	8.0	6.5	10.4	7.5	5.9	6.1	12.7	4.2
1985	8.0	6.3	8.9	6.1	5.9	7.4	10.3	3.7
1986	9.0	8.0	14.6	7.3	6.6	10.7	11.1	4.2
1987	8.7	7.2	14.1	7.4	6.2	13.1	11.7	3.4
1988	8.0	5.8	11.8	6.3	6.3	4.1	13.3	3.3
1989	10.0	3.0	15.0	7.4	6.1	5.1	8.0	4.0
1990	8.7	4.0	15.0	8.0	7.9	8.3	8.8	5.6
1991	9.9	3.5	16.0	9.0	7.5	9.0	10.2	3.8
1992	8.8	4.1	14.0	8.1	6.9	6.8	8.3	3.5
1993	7.6	5.4	12.0	6.8	9.3	9.1	9.4	4.2
1994	14.0	6.8	13.4	13.1	6.1	11.7	11.8	4.1
1995	10.2	8.5	16.0	7.5	5.7	7.8	6.1	4.6
1996	6.9	10.4	13.8	8.3	12.1	7.8	15.1	14.5