

Statewide Groundwater Monitoring Project for Oklahoma Year 1 Report

Clean Water Act, Ground Water 106 Grant No. I-006400-03

Project 2, Task 200.3 - Fiscal Year 2003/04 Report

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Introduction to Ground Water Monitoring FY' 2003/04

Objective:

The State of Oklahoma has an ambient ground water monitoring program which is administered through the Oklahoma Department of Environmental Quality (DEQ). The primary objective of this project is to assess the quality of groundwater in the State. In the long term, data will be analyzed for trends in order to identify areas where measures should be taken to preserve the beneficial uses of the groundwater. These objectives will be met by sampling a subset of Public Water Supply (PWS) wells to determine current constituent levels. Public Water Supply wells have been selected as the most reasonable choice for this project. Their construction, location, security, and operation should make them a close approximation to dedicated "monitoring wells."

By extended multi-year sampling of a limited subset of wells that are built to similar construction standards and stratified to insure proper randomization, limited assessment and trend statements can be made concerning the State's groundwater quality. Use of sample site stratification will insure proper areal coverage, which will allow for better conclusions to be drawn as a result of the project.

This year approximately 500 water samples were obtained including the necessary QA samples, for laboratory analysis by the State Environmental Laboratory. This resulted in the analysis of an estimated 7,000 parameters.

Selected parameters for measurement.

A total of 16 chemical and physical parameters reflecting secondary drinking water standards and major ions have been selected for analysis.

1. Aluminum
2. Chloride
3. Copper
4. Fluoride
5. Iron
6. Manganese
7. NO₂+NO₃
8. Sulfate
9. Total Dissolved Solids
10. Zinc
11. Calcium
12. Magnesium
13. Sodium
14. Total Alkalinity
15. Carbonate Alkalinity
16. Potassium

Methodology:

1. Selected wells were sampled. Field blanks, duplicates, spikes, etc. were also obtained in order to meet QA/QC requirements.
2. Analyses were completed by the State Environmental Laboratory.
3. Information about measured results were entered into a database.
4. Reports were prepared and made available.

Outputs:

1. Semi-annual reports
2. Final report sent to Oklahoma Secretary of the Environment (OSE)
3. Results made available to the public via the DEQ website

Data Assessment and Summary:

The data assessment phases of this project include an exploratory statistical analysis performed in order to better understand the range, variance and distribution of the data. These exploratory analyses include:

- Calculation of mean
- Calculation of median
- Calculation of quartiles
- Calculation of standard deviation and variance
- Temporal plots and normal probability plots

Results of the statistical analysis effort are contained in the following section. Page one of the data set is a Graphical Summary of the data. It includes all the elements described in the objectives section that are needed to better understand the range, variance and distribution of the data; except Temporal Plots. Temporal plots will be completed when sufficient samples have been collected. However, the first year of samples is not sufficient for that purpose. Three to five sample periods will be necessary in order to give this plot method significant meaning. Page two contains different views of the same data as page one, plus the Normal Probability Plot. The Cumulative Distribution Function plot is on page three, and illustrates how well the data follow a normal distribution pattern.

Explanation of the Graphical Summary

The graphical summary provides graphs to summarize data, as well as an overall statistical summary, all presented within the same window. This information is copied from Minitab software help pages and is paraphrased in places.

Histogram of Data with Normal Curve

The histogram of the data is overlaid with a normal curve to assess the normality of the data. A normal distribution will be symmetric and bell-shaped.

Boxplot

- Boxplots summarize information about the shape, dispersion, and center of the data. They can also help identify outliers.
- The left edge of the box represents the first quartile (Q1), while the right edge represents the third quartile (Q3). Thus the box portion of the plot represents the interquartile range (IQR), or the middle 50% of the observations.
- The line drawn through the box represents the median of the data.
- The lines extending from the box are called whiskers. Whiskers extend outward to indicate the lowest and highest values in the data set (excluding outliers).
- Extreme values, or outliers, are represented by dots. A value is considered an outlier if it is outside of the box (greater than Q3 or less than Q1) by more than 1.5 times the IQR.
- Use the boxplot to assess the symmetry of the data:
- If the data are fairly symmetrical, the median line will be roughly in the middle of the IQR box and the whiskers will be similar in length.
- If the data are skewed, the median may not fall in the middle of the IQR box, and one whisker will likely be noticeably longer than the other.

Confidence Intervals for Mean, Standard Deviation, and Median

A confidence interval is an interval used to estimate a population parameter from sample data. The upper and lower bounds of the confidence intervals for μ (mean), s (standard deviation), and the median are displayed in the graphical summary. In addition, the confidence intervals for μ and the median are displayed graphically.

Confidence intervals are composed of two basic parts:

- Point estimate - a single value computed from the sample data. This value is considered to be an estimate of the parameter of interest. However, it is unlikely that the point estimate is equal to the parameter. Therefore, to account for the possibility of estimation error, the error margin is included in the confidence interval to provide a range of possible parameter values.
- Error margin - determines the width of the confidence interval through the use of probability. To construct the confidence interval, add and subtract the error margin from the point estimate.

If a 95% confidence interval is selected, the method used to construct the interval has a probability of 0.95 of producing an interval containing the parameter of interest. In other words, you can be 95% confident that the true value of the parameter is within the interval. Thus, if one hundred 95% confidence intervals were constructed, you would expect around 95 of the intervals to contain the parameter.

Table of Statistics

Anderson-Darling Normality Test

The Anderson-Darling normality test can help determine whether the data follow a normal distribution. The “A statistic” that the test provides is used to determine the p-value, which ranges from 0 to 1, and indicates how likely it is that the data follows a normal distribution.

First, it must be determined how low the p-value must be to conclude that the data are not normal. A commonly chosen criterion is 0.1. If the p-value is lower than the criterion, it must be concluded that the data do not follow a normal distribution. Otherwise, there is not enough evidence to conclude that the data do not follow a normal distribution.

Mean and N

Mean

The mean, also called the average, is a measure of where the center of the distribution lies. The mean is determined by calculating the sum of all observations divided by the number of observations. The mean is strongly influenced by extreme values.

N

N is the number of non-missing values in the data set.

Standard Deviation (StDev) and Variance

The standard deviation and variance measure dispersion, or how far the observations in a sample deviate from the mean. The standard deviation is analogous to an average distance (independent of direction) from the mean. The variance is the standard deviation squared. Like the mean, the standard deviation (as well as the variance) is very sensitive to extreme values.

Skewness and Kurtosis

Skewness

Skewness refers to a lack of symmetry within a data set. A distribution is skewed if one tail extends farther than the other. A skewness statistic is provided with the graphical summary:

- A value close to 0 indicates symmetrical data.
- Negative values imply negative/left skew.
- Positive values indicate positive/right skew.

Kurtosis

Kurtosis refers to the peak sharpness of a distribution curve. A kurtosis statistic is provided with the graphical summary:

- Values close to 0 indicate normally peaked data.
- Negative values indicate a distribution peak that is flatter than normal.
- Positive values indicate a distribution with a sharper than normal peak.

Minimum and Maximum

One of the easiest ways to assess dispersion within a data set is to compare the minimum and maximum values. The minimum is the smallest value in a data set, and the maximum is the largest value. For the precipitation data the minimum is 1 and the maximum is 10.

Minimum and maximum values are used to calculate the range, which is a statistic often used to describe dispersion within data sets. The range is the (Maximum)-(Minimum). The range is very sensitive to extreme values.

First and Third Quartiles (Q1 and Q3)

The first quartile (Q1, also called the 25th percentile) is the highest value for the lowest 25% of the observations. The third quartile (Q3, also called the 75th percentile) is the lowest value for the highest 25% of the observations. Q1 and Q3 are often used to calculate the interquartile range (IQR), which is also used to describe dispersion. The IQR is the range of the middle 50% of the values, and is calculated by subtracting Q3 from Q1. The IQR is relatively insensitive to extreme values.

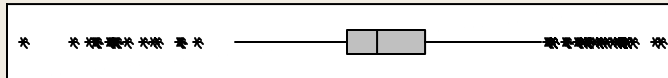
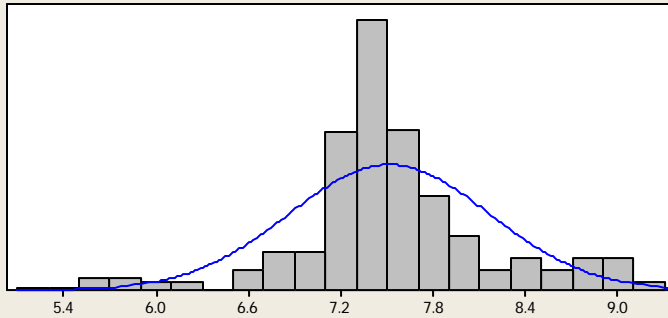
Median

The median, also called the 2nd quartile or 50th percentile, is the middle observation of the data set. The median is determined by ranking the data and locating observation number $([N + 1] / 2)$. If there are an even number of observations, the median is extrapolated as the value midway between that of observation numbers $(N / 2)$ and $([N / 2] + 1)$.

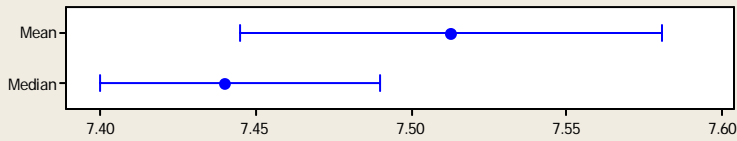
The median is less sensitive to extreme values than the mean. Therefore, the median is often used instead of the mean when data contain outliers, or are skewed.

Statistical Tables and Graphs

Summary for pH



95% Confidence Intervals



Anderson-Darling Normality Test

A-Squared 10.64
P-Value < 0.005

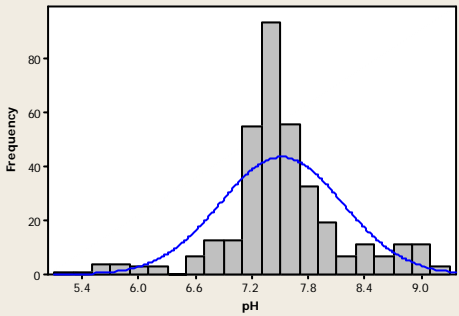
Mean 7.5125
StDev 0.6505
Variance 0.4231
Skewness -0.07003
Kurtosis 1.85193
N 356

Minimum 5.1400
1st Quartile 7.2425
Median 7.4400
3rd Quartile 7.7475
Maximum 9.2800

95% Confidence Interval for Mean
7.4447 7.5803
95% Confidence Interval for Median
7.4000 7.4900
95% Confidence Interval for StDev
0.6060 0.7021

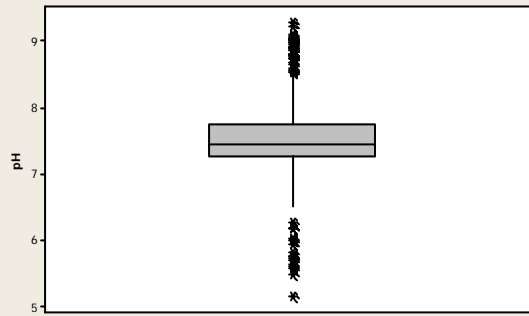
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of pH



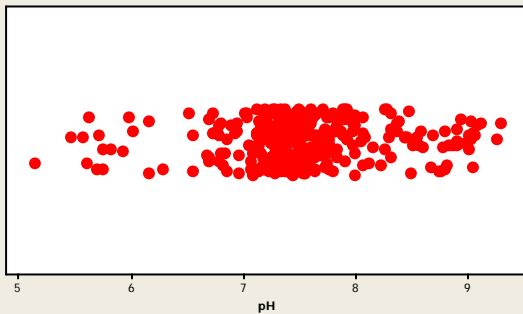
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of pH



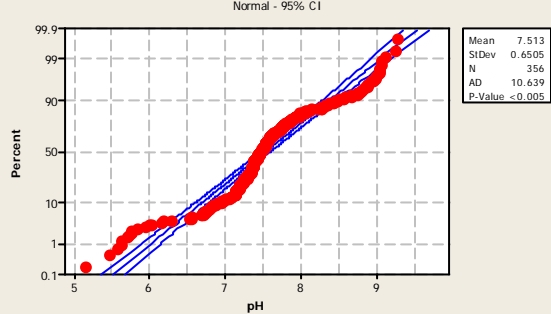
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of pH



Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

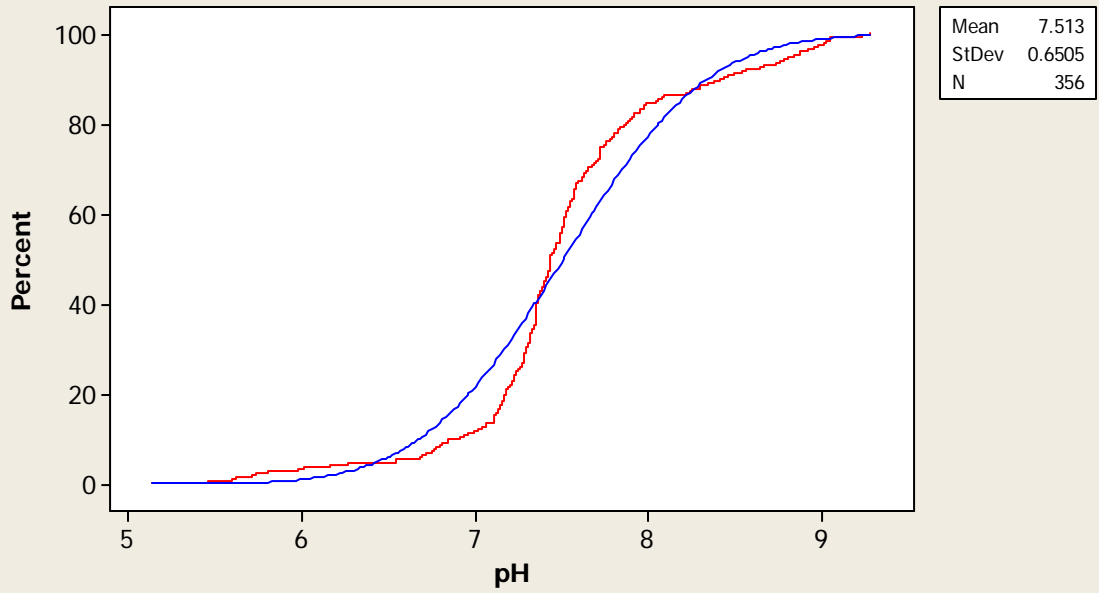
Probability Plot of pH



Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

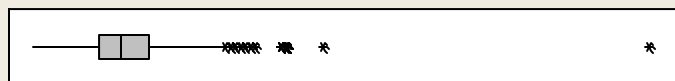
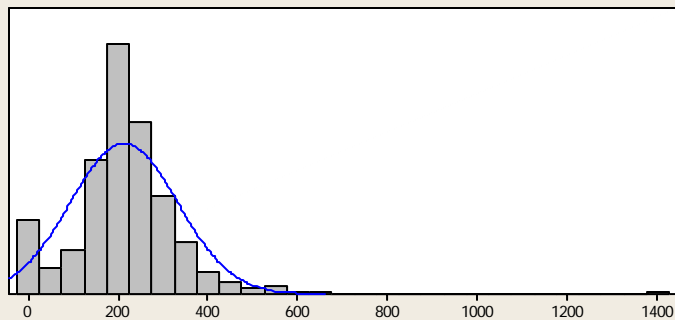
Empirical CDF of pH

Normal

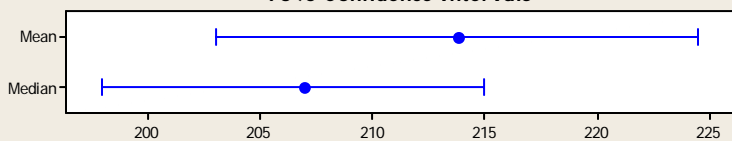


Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Summary for T. Alk.



95% Confidence Intervals



Anderson-Darling Normality Test

A-Squared 7.29
P-Value < 0.005

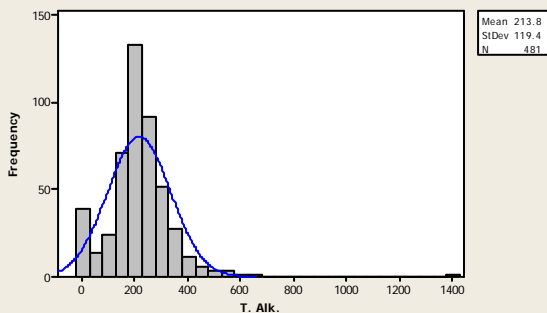
Mean 213.76
StDev 119.45
Variance 14267.74
Skewness 2.1869
Kurtosis 18.9111
N 481

Minimum 10.00
1st Quartile 157.00
Median 207.00
3rd Quartile 269.00
Maximum 1380.00

95% Confidence Interval for Mean
203.06 224.47
95% Confidence Interval for Median
198.00 215.00
95% Confidence Interval for StDev
112.35 127.51

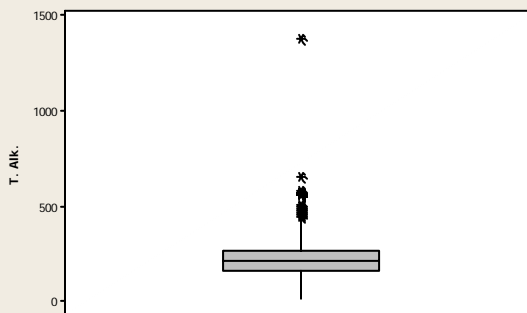
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of T. Alk.



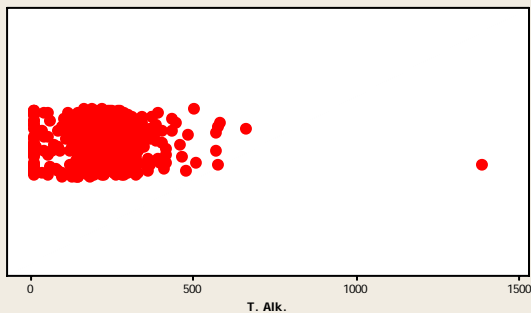
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of T. Alk.



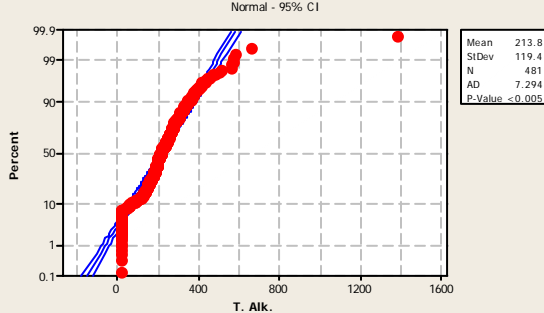
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of T. Alk.



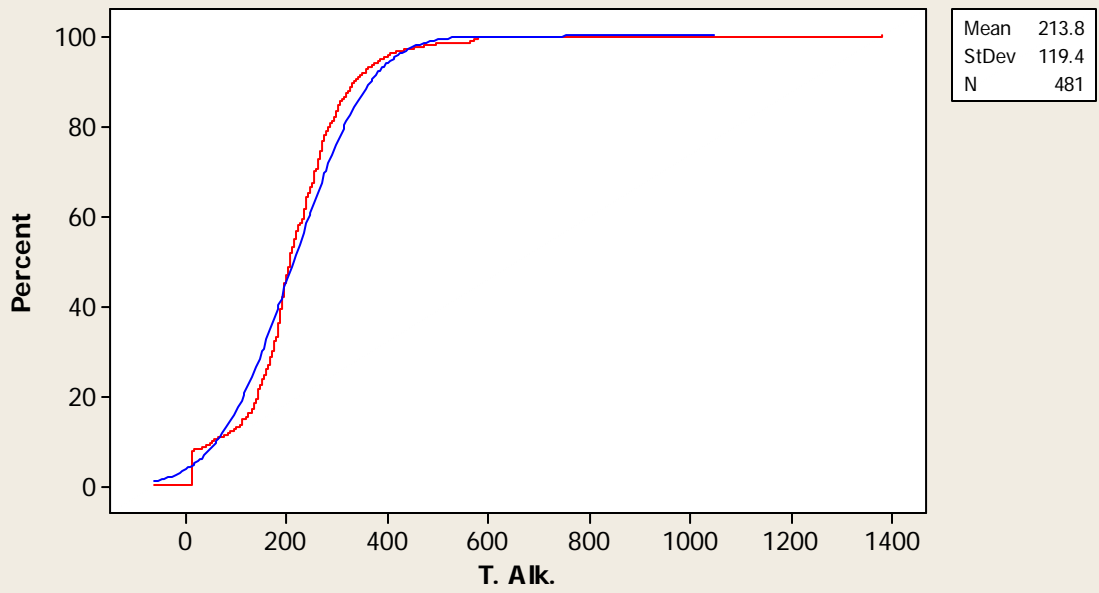
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Probability Plot of T. Alk.



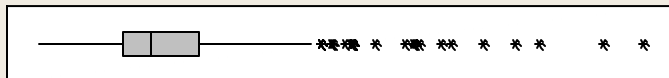
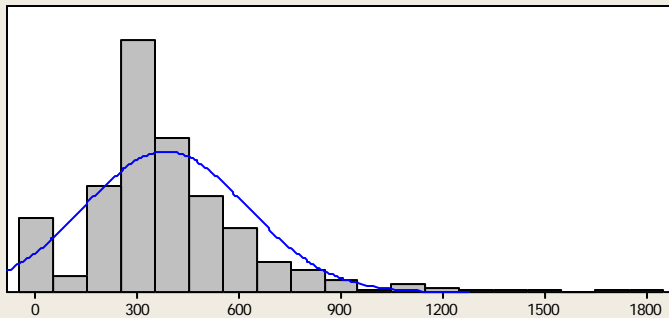
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Empirical CDF of T. Alk. Normal

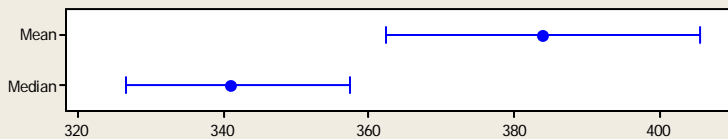


Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Summary for Total Dissolved Solids



95% Confidence Intervals



Anderson-Darling Normality Test

A-Squared 11.64
P-Value < 0.005

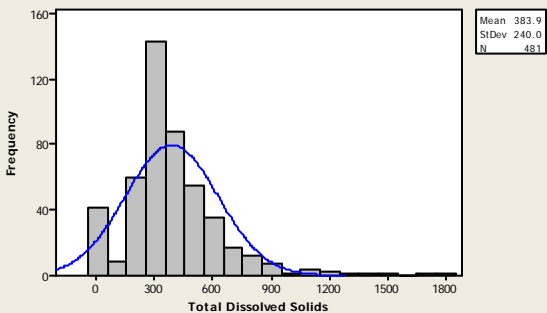
Mean 383.89
StDev 239.98
Variance 57590.63
Skewness 1.69951
Kurtosis 5.99686
N 481

Minimum 10.00
1st Quartile 257.00
Median 341.00
3rd Quartile 482.00
Maximum 1791.00

95% Confidence Interval for Mean
362.39 405.39
95% Confidence Interval for Median
326.53 357.47
95% Confidence Interval for StDev
225.71 256.19

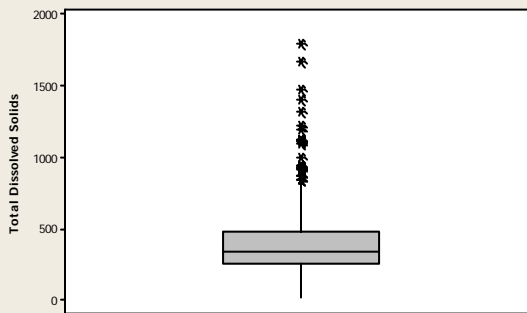
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of Total Dissolved Solids



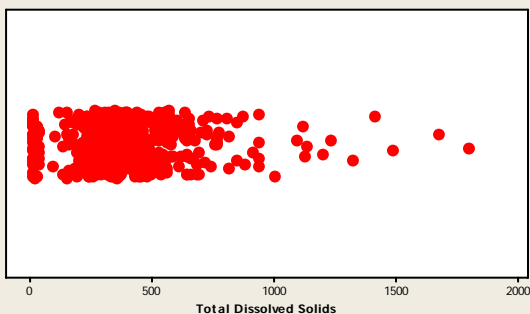
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Total Dissolved Solids



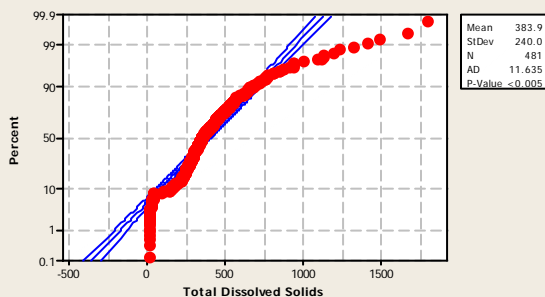
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of Total Dissolved Solids



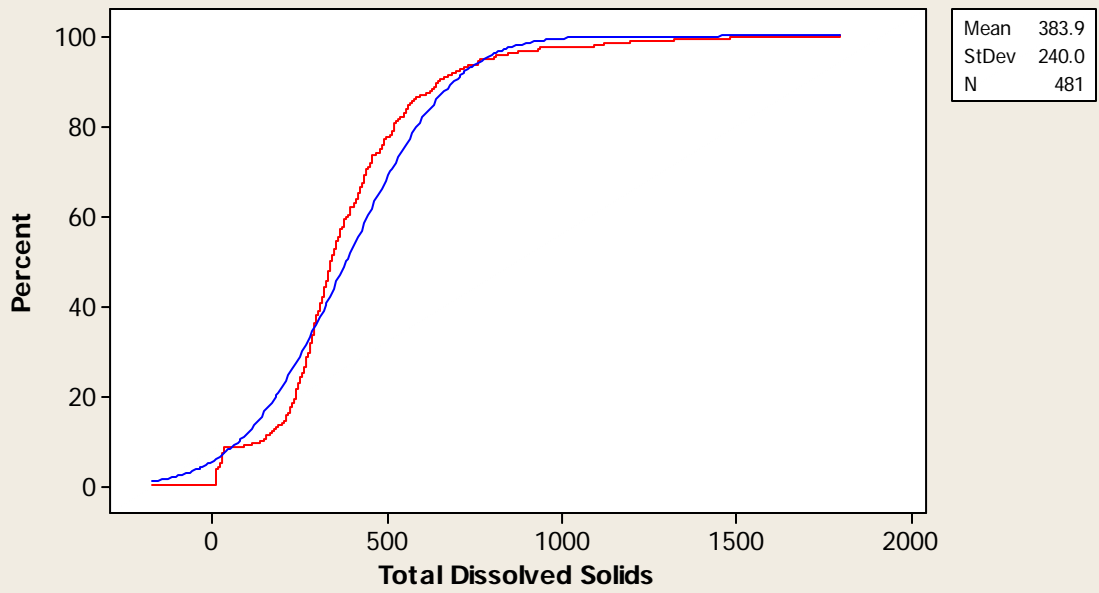
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Probability Plot of Total Dissolved Solids



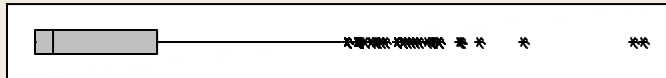
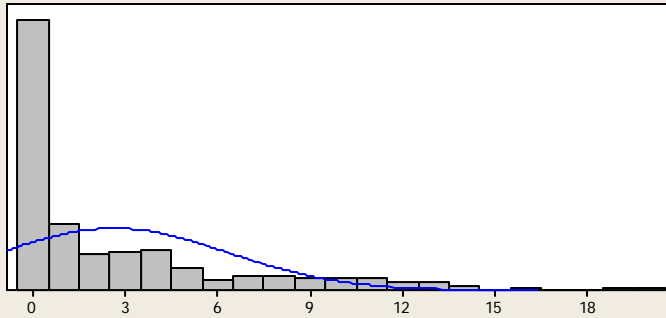
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Empirical CDF of Total Dissolved Solids Normal

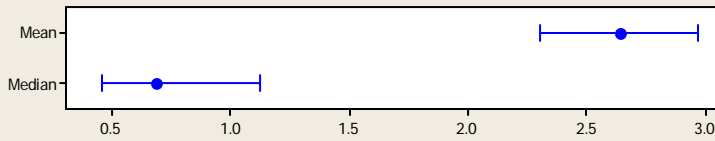


Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Summary for Nitrate (as N)



95% Confidence Intervals



Anderson-Darling Normality Test

A-Squared 46.66
P-Value < 0.005

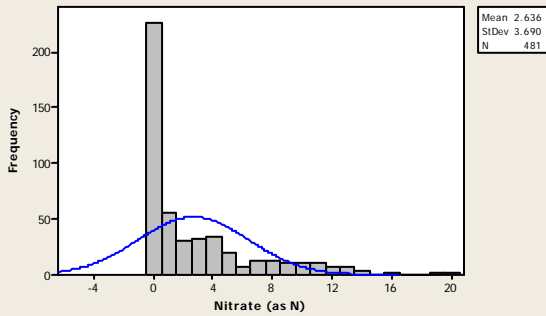
Mean 2.6358
StDev 3.6902
Variance 13.6173
Skewness 1.73582
Kurtosis 2.65788
N 481

Minimum 0.0500
1st Quartile 0.0500
Median 0.6900
3rd Quartile 4.0600
Maximum 19.8000

95% Confidence Interval for Mean
2.3052 2.9664
95% Confidence Interval for Median
0.4600 1.1247
95% Confidence Interval for StDev
3.4708 3.9394

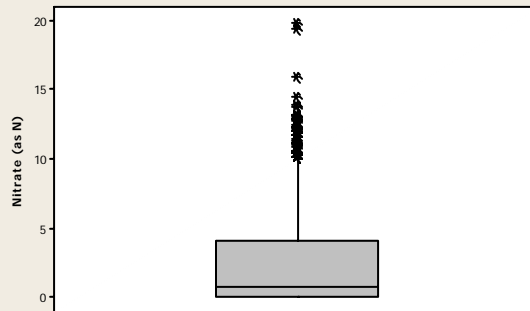
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of Nitrate (as N)



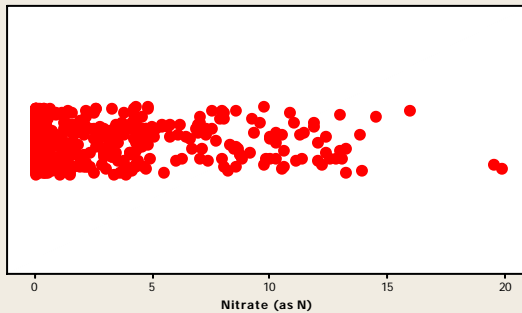
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Nitrate (as N)



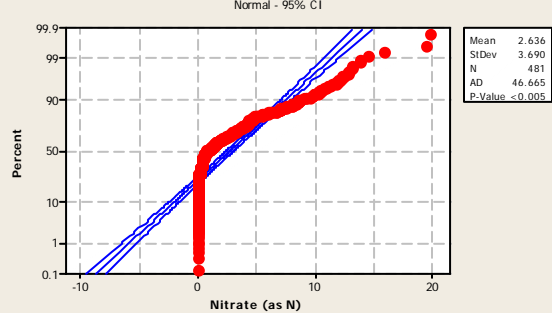
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of Nitrate (as N)



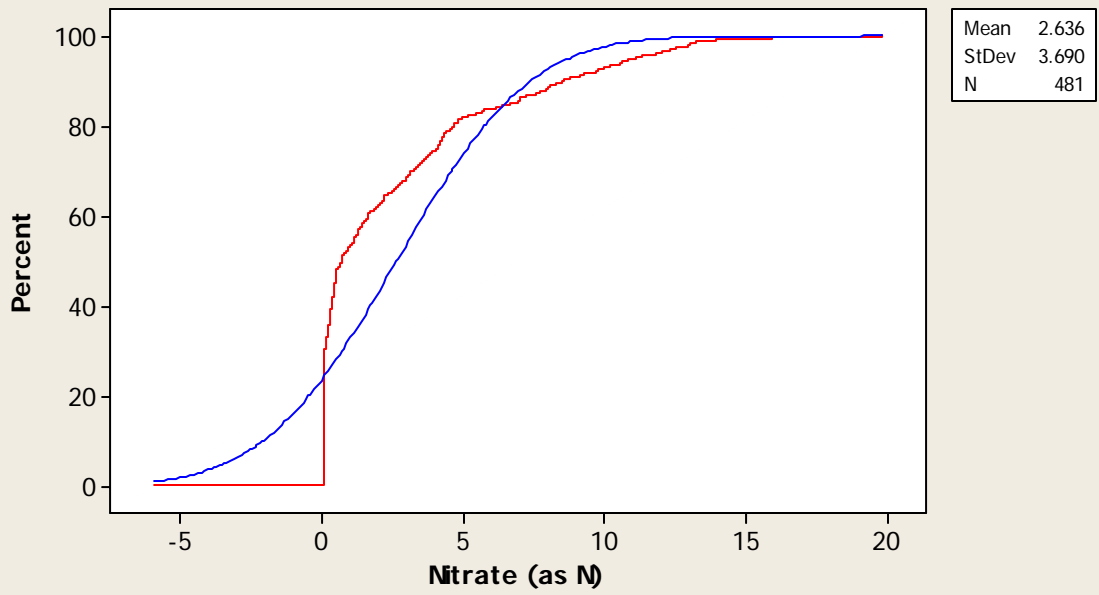
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Probability Plot of Nitrate (as N)



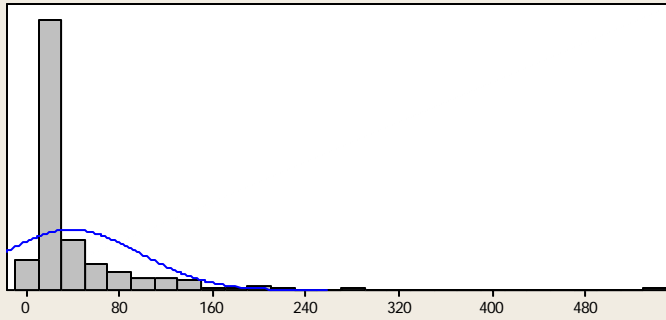
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Empirical CDF of Nitrate (as N) Normal

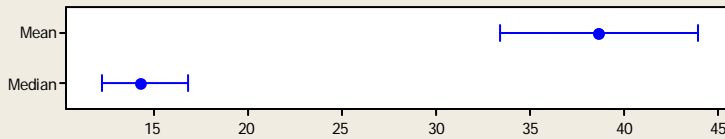


Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Summary for Chloride



95% Confidence Intervals



Anderson-Darling Normality Test

A-Squared 65.80
P-Value < 0.005

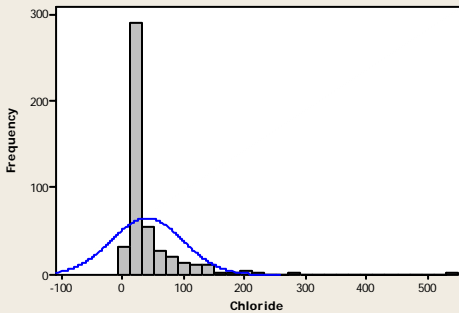
Mean 38.621
StDev 58.948
Variance 3474.886
Skewness 4.4278
Kurtosis 28.3884
N 481

Minimum 5.000
1st Quartile 10.000
Median 14.300
3rd Quartile 42.300
Maximum 537.000

95% Confidence Interval for Mean	
33.340	43.903
95% Confidence Interval for Median	
12.253	16.800
95% Confidence Interval for StDev	
55.444	62.929

Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

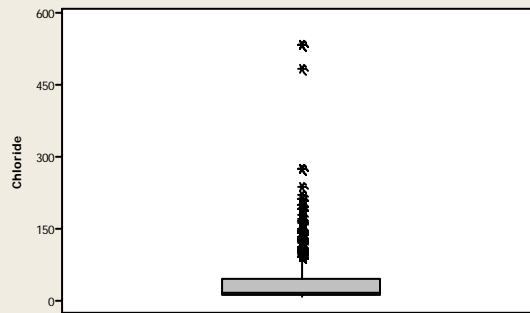
Histogram (with Normal Curve) of Chloride



Mean 38.62
StDev 58.95
N 481

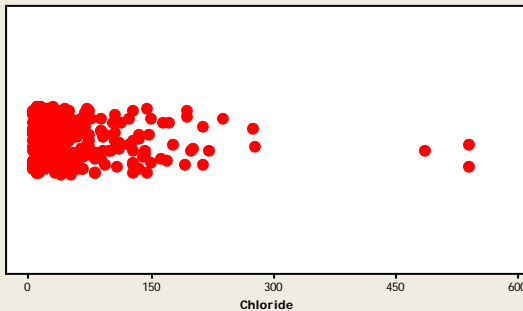
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Chloride



Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

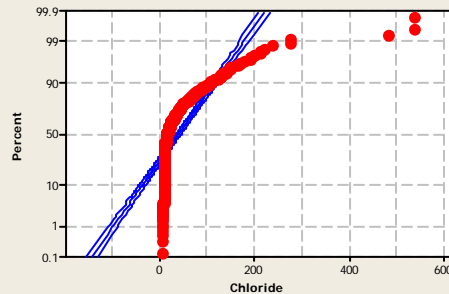
Individual Value Plot of Chloride



Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

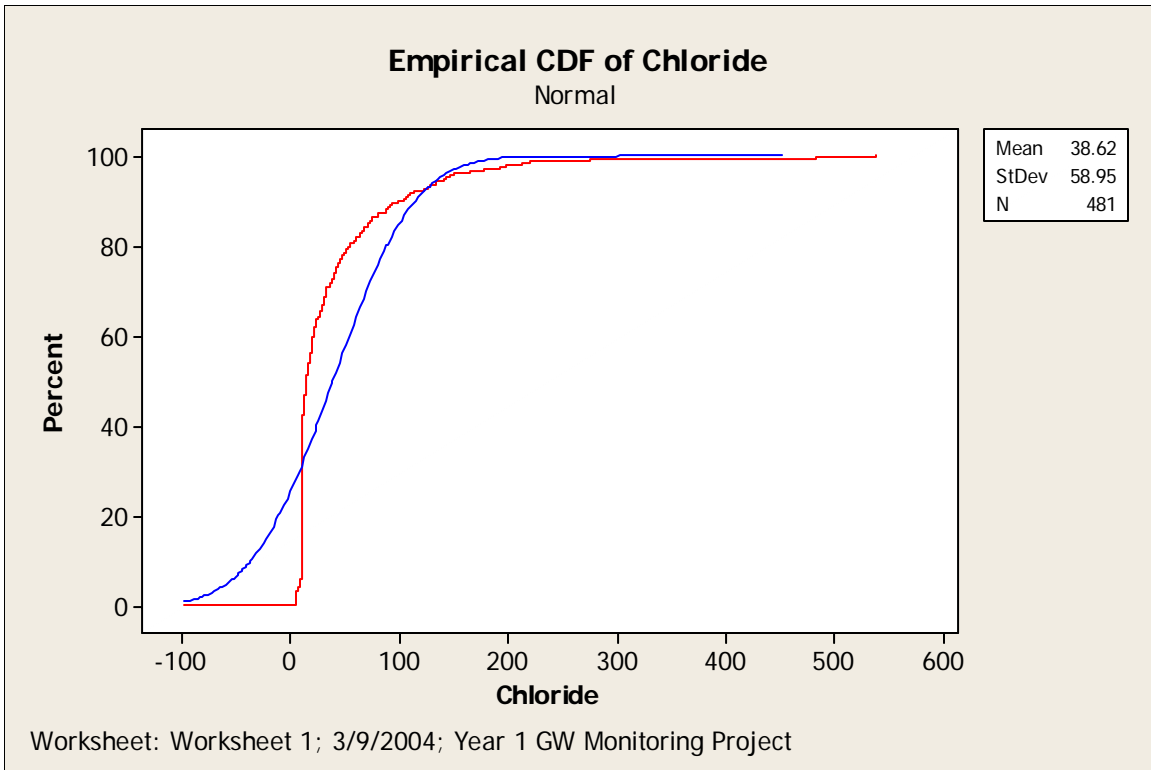
Probability Plot of Chloride

Normal - 95% CI

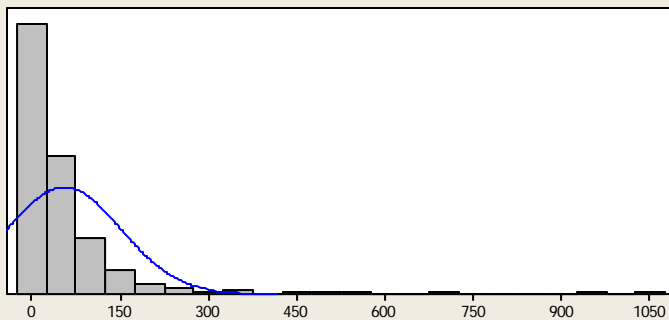


Mean 38.62
StDev 58.95
N 481
AD 65.799
P-Value <0.005

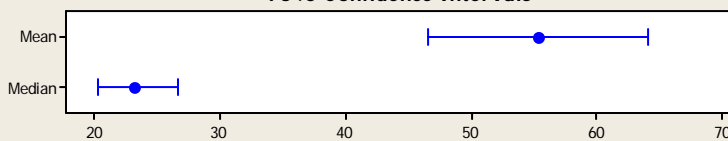
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project



Summary for Sulfate



95% Confidence Intervals



Anderson-Darling Normality Test

A-Squared 68.47
P-Value < 0.005

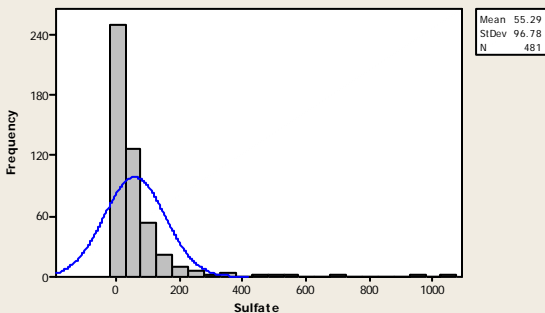
Mean 55.29
StDev 96.78
Variance 9367.13
Skewness 5.6687
Kurtosis 43.8497
N 481

Minimum 5.00
1st Quartile 10.35
Median 23.20
3rd Quartile 57.70
Maximum 1030.00

95% Confidence Interval for Mean
46.62 63.96
95% Confidence Interval for Median
20.40 26.75
95% Confidence Interval for StDev
91.03 103.32

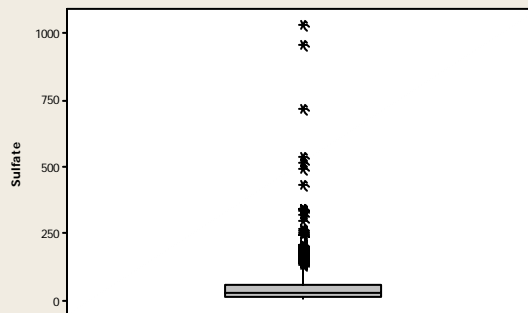
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of Sulfate



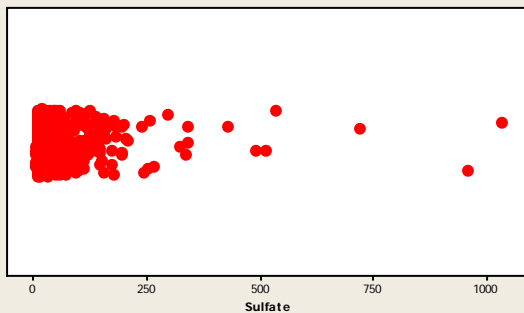
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Sulfate



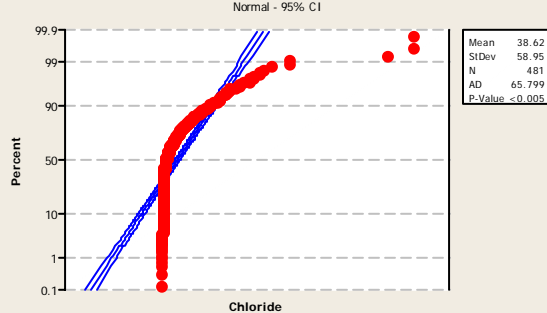
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of Sulfate

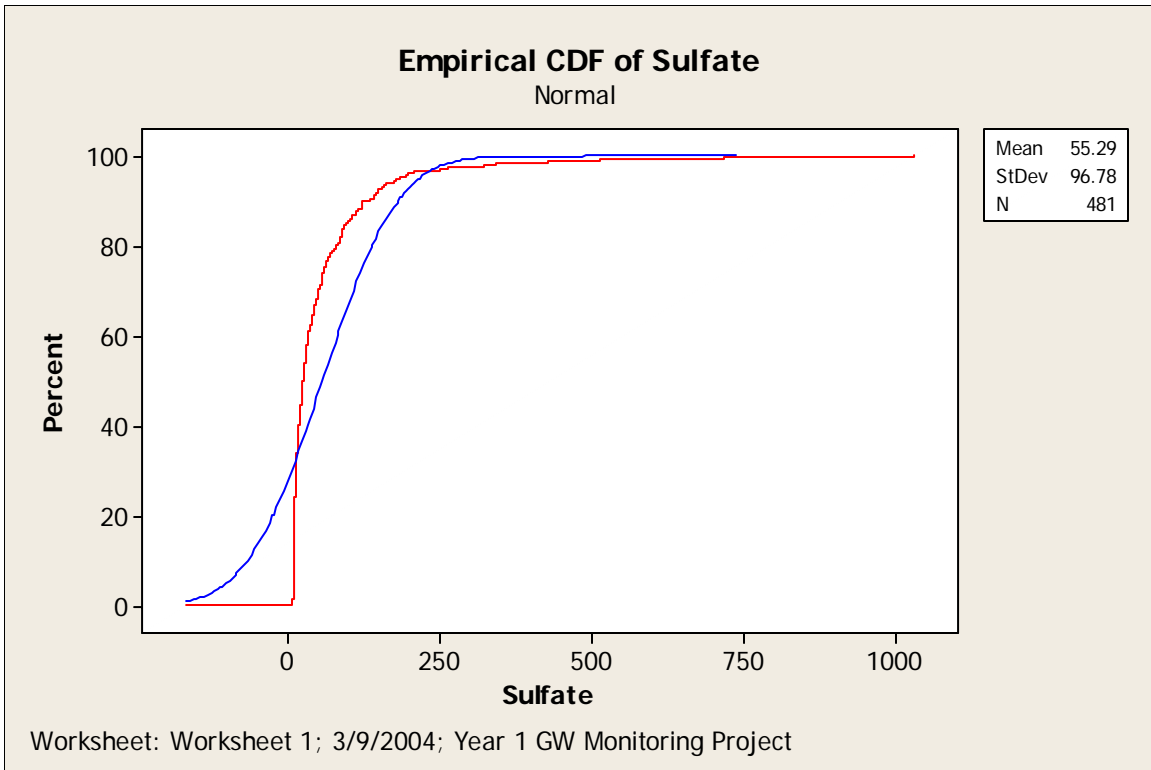


Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

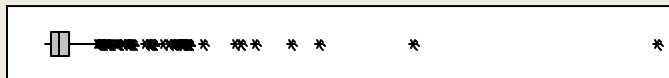
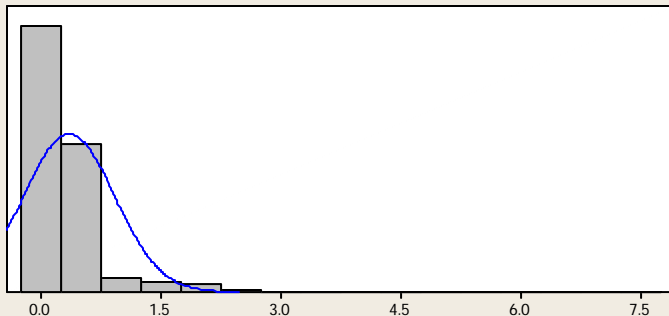
Probability Plot of Chloride



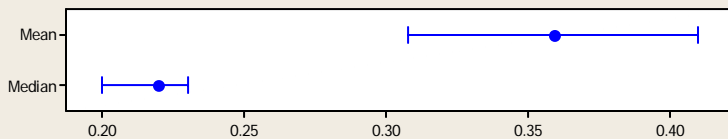
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project



Summary for Total Fluoride



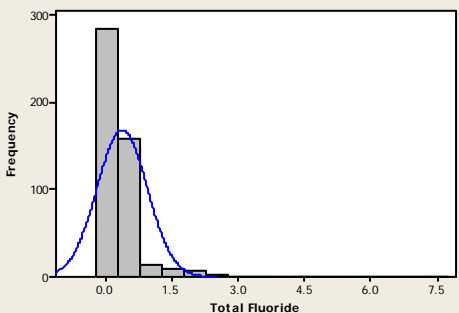
95% Confidence Intervals



Anderson-Darling Normality Test	
A-Squared	78.77
P-Value <	0.005
Mean	0.35846
StDev	0.56919
Variance	0.32398
Skewness	6.8100
Kurtosis	67.9148
N	481
Minimum	0.05000
1st Quartile	0.13000
Median	0.22000
3rd Quartile	0.35500
Maximum	7.70000
95% Confidence Interval for Mean	
	0.30747 0.40946
95% Confidence Interval for Median	
	0.20000 0.23000
95% Confidence Interval for StDev	
	0.53536 0.60764

Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

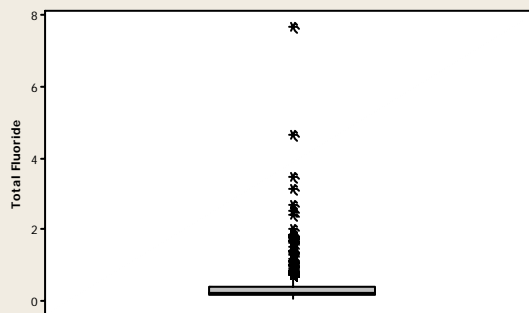
Histogram (with Normal Curve) of Total Fluoride



Mean 0.3585
StDev 0.5692
N 481

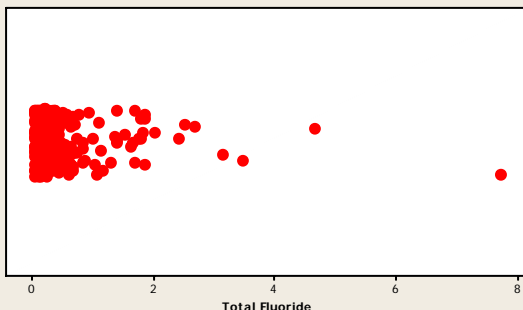
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Total Fluoride



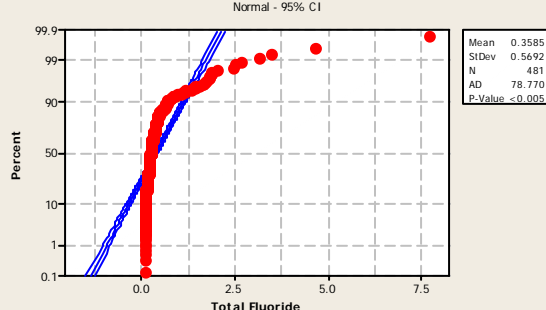
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of Total Fluoride



Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Probability Plot of Total Fluoride

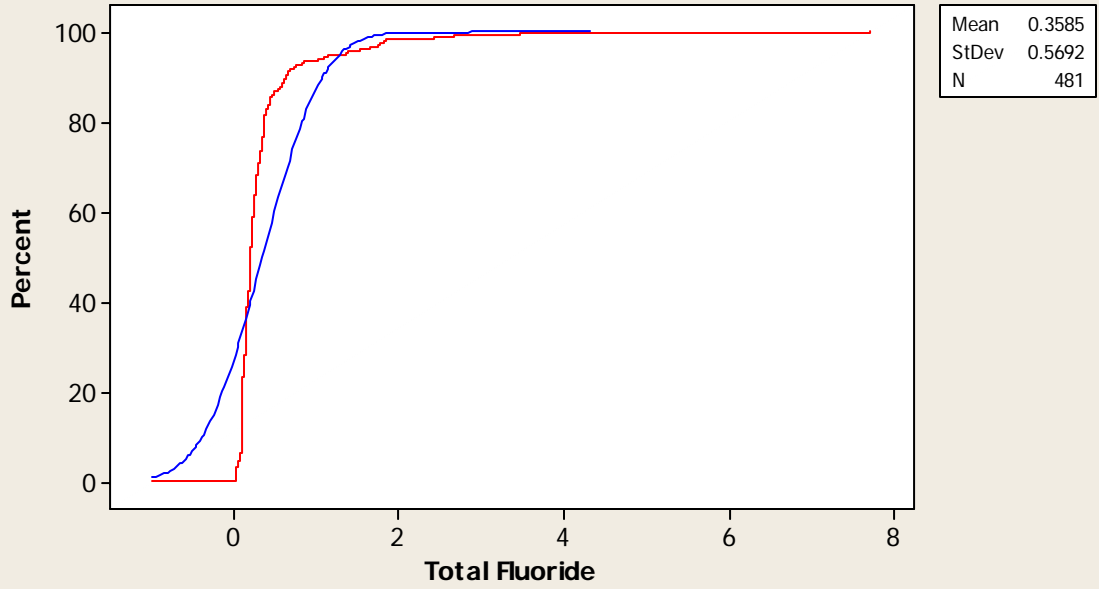


Mean 0.3585
StDev 0.5692
N 481
AD 78.770
P-Value <0.005

Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

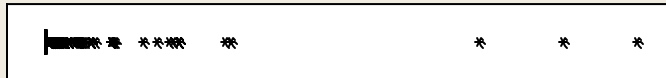
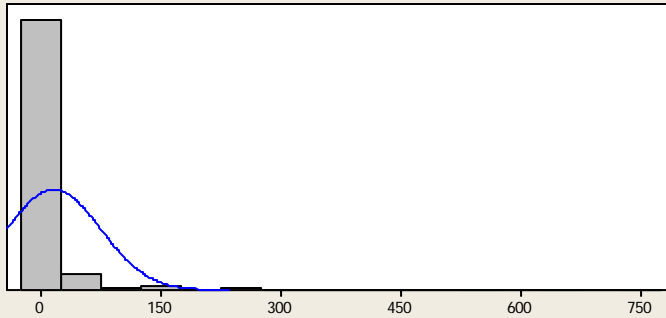
Empirical CDF of Total Fluoride

Normal

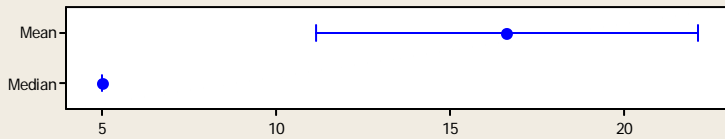


Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Summary for Total Copper



95 % Confidence Intervals



Anderson-Darling Normality Test

A-Squared 127.27
P-Value < 0.005

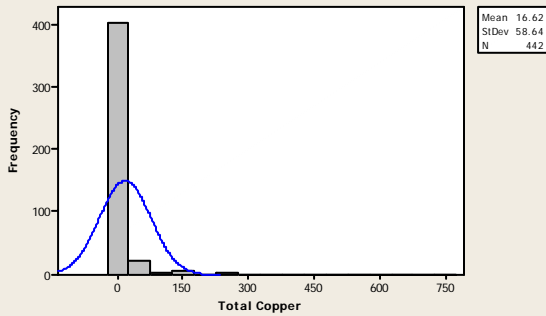
Mean 16.618
StDev 58.642
Variance 3438.899
Skewness 9.3561
Kurtosis 99.5270
N 442

Minimum 5.000
1st Quartile 5.000
Median 5.000
3rd Quartile 7.000
Maximum 744.000

95% Confidence Interval for Mean
11.136 22.100
95% Confidence Interval for Median
5.000 5.000
95% Confidence Interval for StDev
55.014 62.786

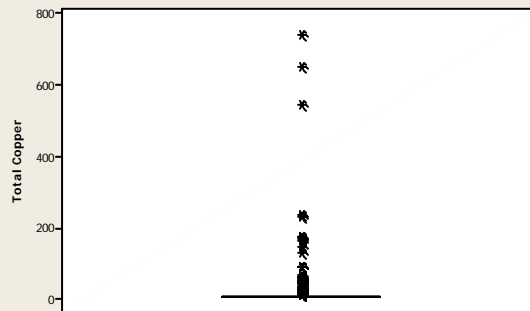
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of Total Copper



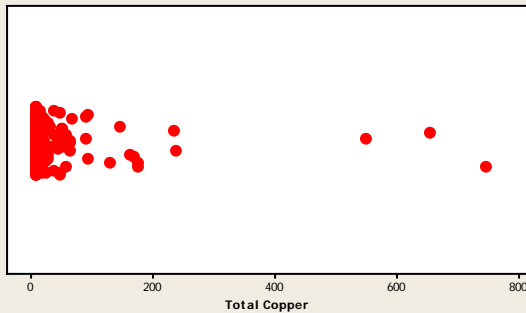
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Total Copper



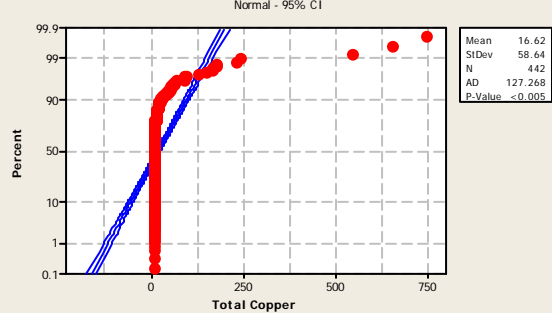
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of Total Copper

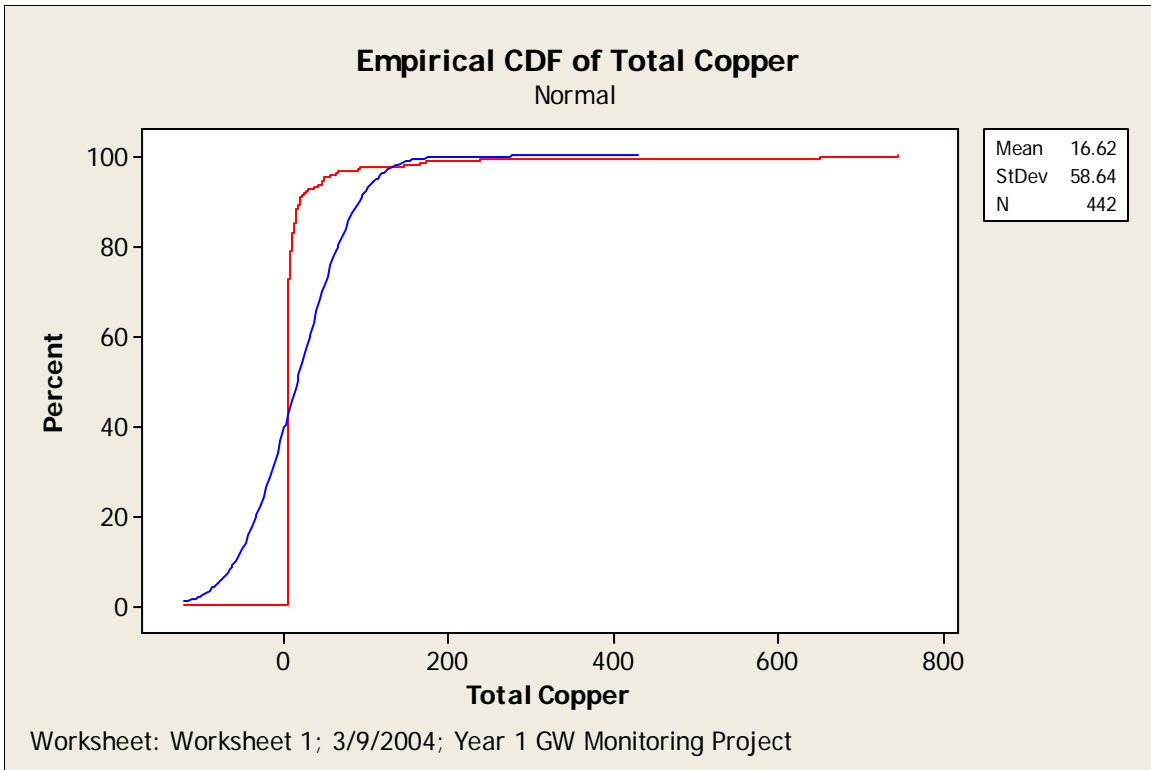


Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

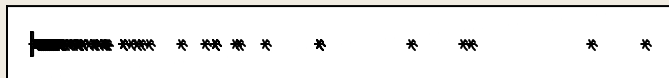
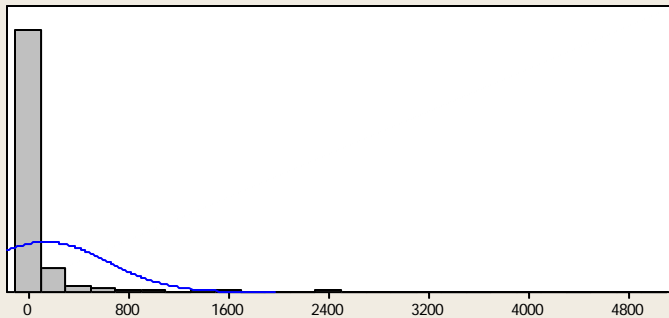
Probability Plot of Total Copper



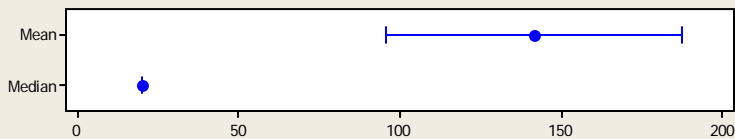
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project



Summary for Total Iron



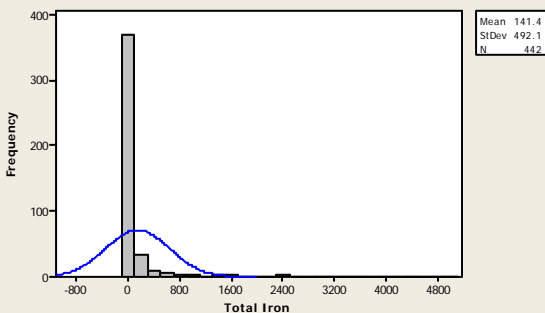
95% Confidence Intervals



Anderson-Darling Normality Test	
A-Squared	122.93
P-Value <	0.005
Mean	141.41
StDev	492.07
Variance	242133.78
Skewness	6.4495
Kurtosis	47.7099
N	442
Minimum	5.00
1st Quartile	20.00
Median	20.00
3rd Quartile	37.50
Maximum	4934.00
95% Confidence Interval for Mean	
95.41	187.41
95% Confidence Interval for Median	
20.00	20.00
95% Confidence Interval for StDev	
461.63	526.84

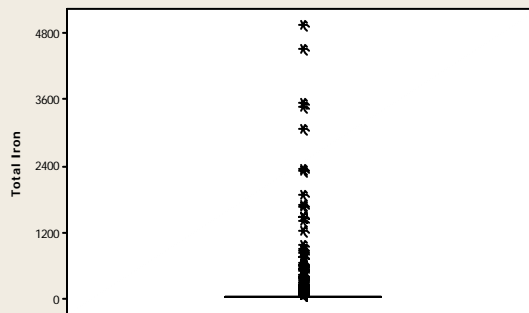
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of Total Iron



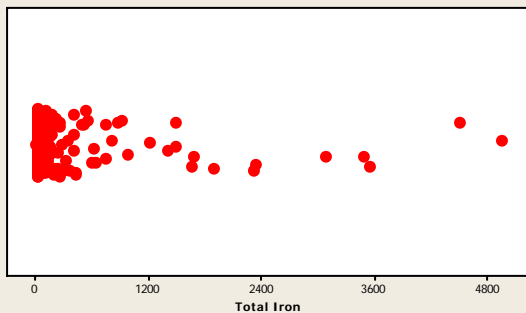
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Total Iron



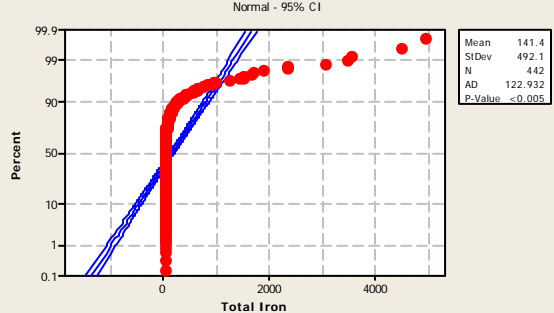
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of Total Iron



Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

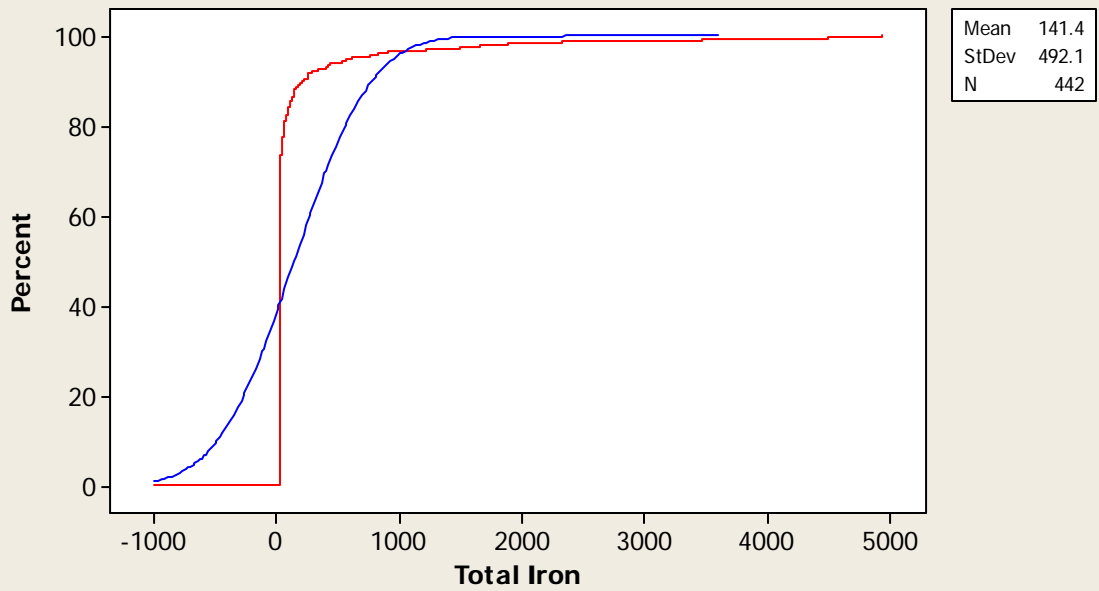
Probability Plot of Total Iron



Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

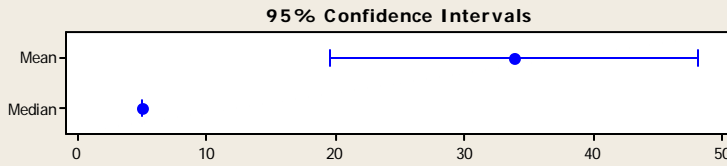
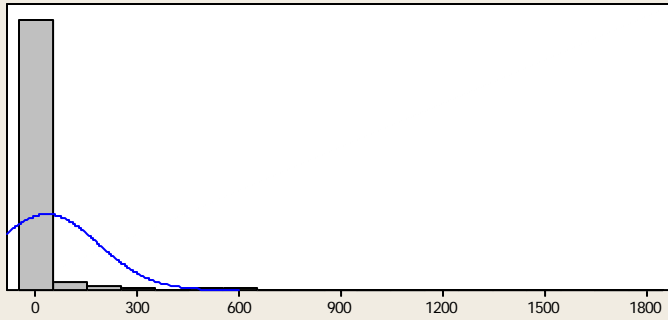
Empirical CDF of Total Iron

Normal



Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

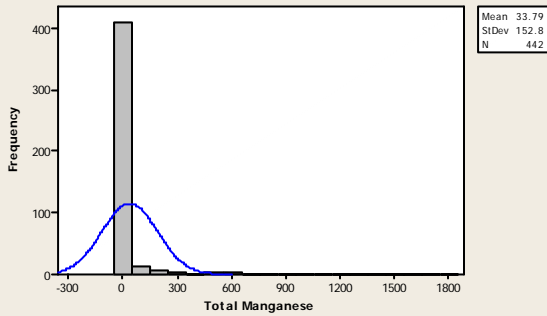
Summary for Total Manganese



Anderson-Darling Normality Test	
A-Squared	139.87
P-Value <	0.005
Mean	33.79
StDev	152.82
Variance	23353.89
Skewness	8.0701
Kurtosis	75.3732
N	442
Minimum	5.00
1st Quartile	5.00
Median	5.00
3rd Quartile	5.00
Maximum	1760.00
95% Confidence Interval for Mean	
	19.51 48.08
95% Confidence Interval for Median	
	5.00 5.00
95% Confidence Interval for StDev	
	143.37 163.62

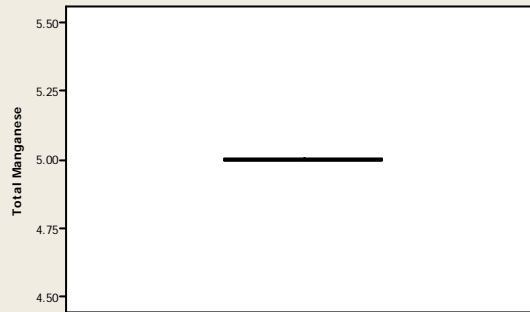
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of Total Manganese



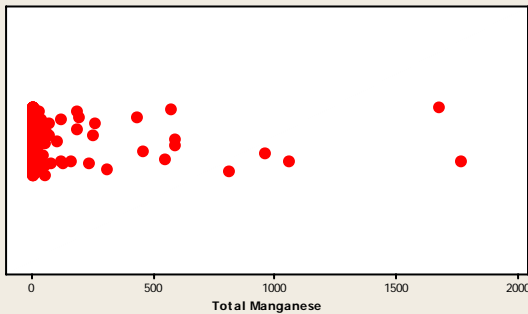
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Total Manganese



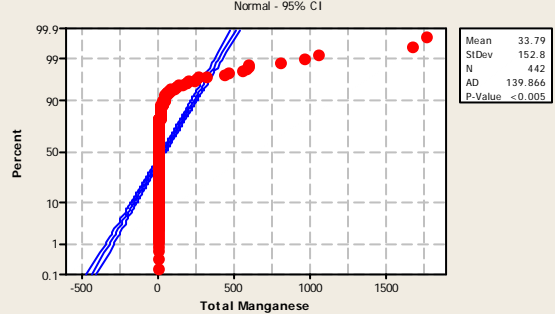
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of Total Manganese

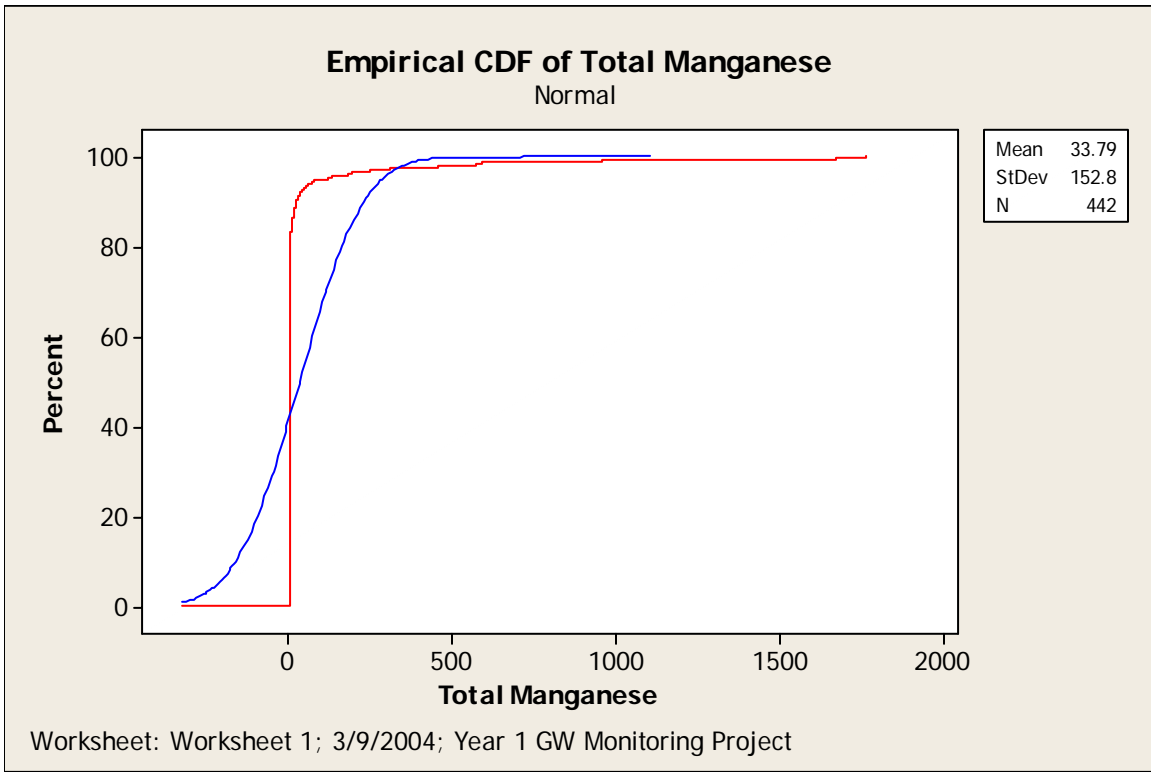


Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

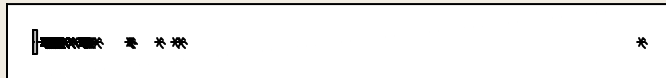
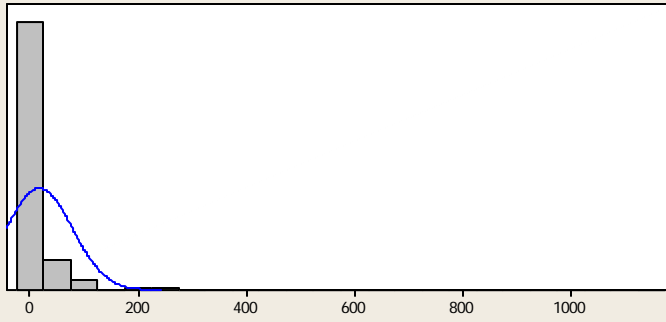
Probability Plot of Total Manganese



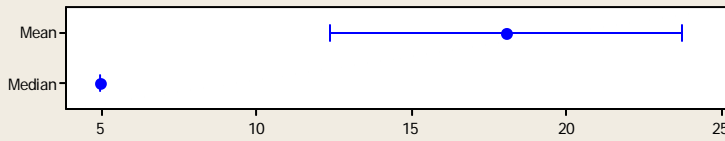
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project



Summary for Total Zinc



95 % Confidence Intervals



Anderson-Darling Normality Test

A-Squared 111.42
P-Value < 0.005

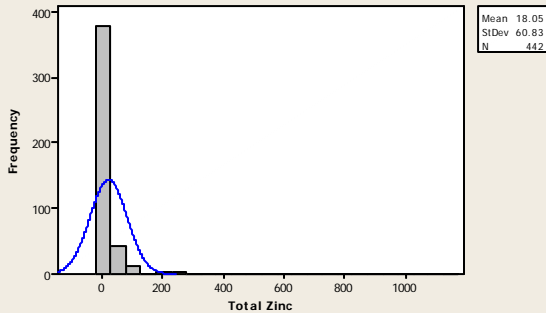
Mean 18.05
StDev 60.83
Variance 3699.69
Skewness 14.534
Kurtosis 255.945
N 442

Minimum 5.00
1st Quartile 5.00
Median 5.00
3rd Quartile 12.00
Maximum 1130.00

95% Confidence Interval for Mean
12.36 23.73
95% Confidence Interval for Median
5.00 5.00
95% Confidence Interval for StDev
57.06 65.12

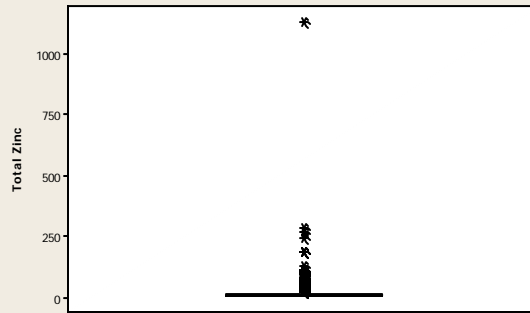
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of Total Zinc



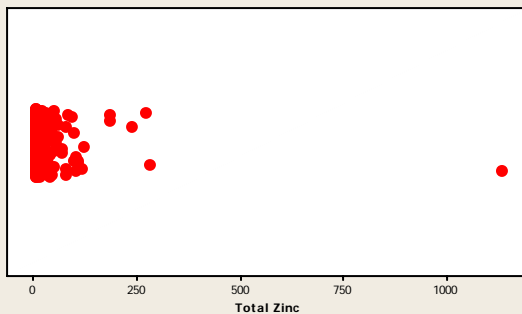
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Total Zinc



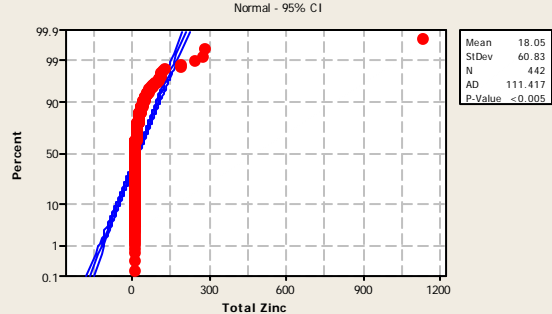
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of Total Zinc

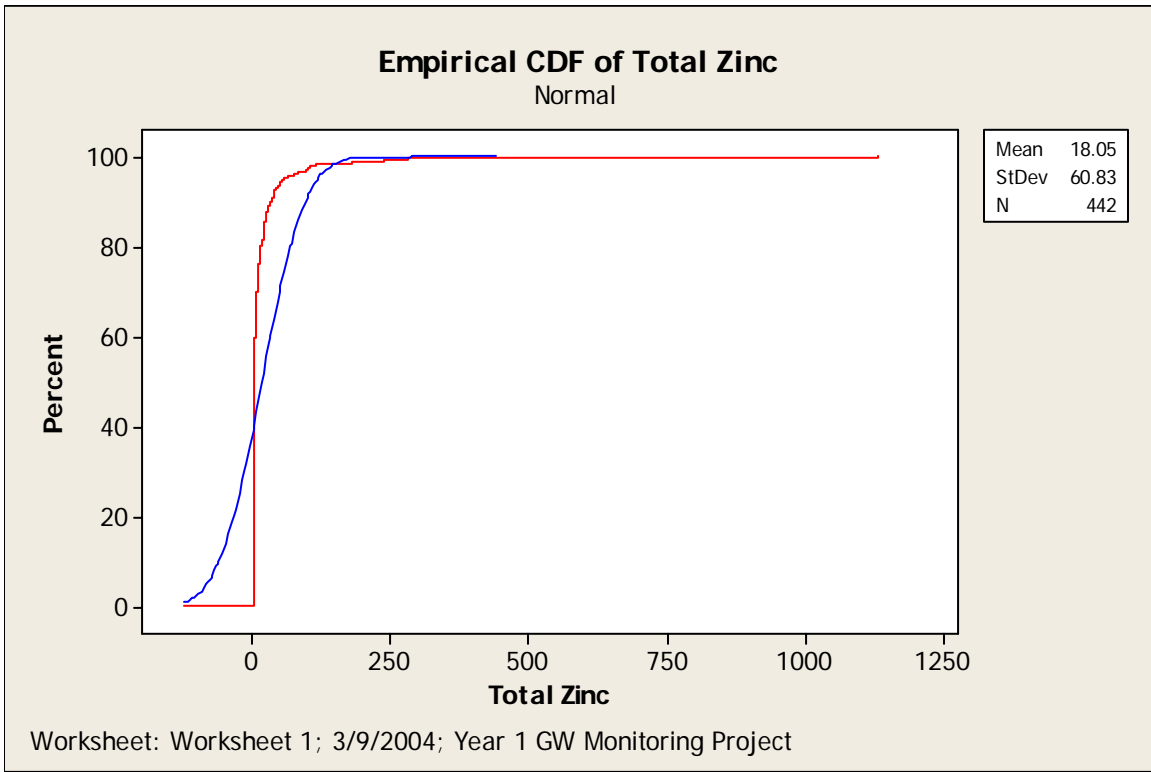


Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

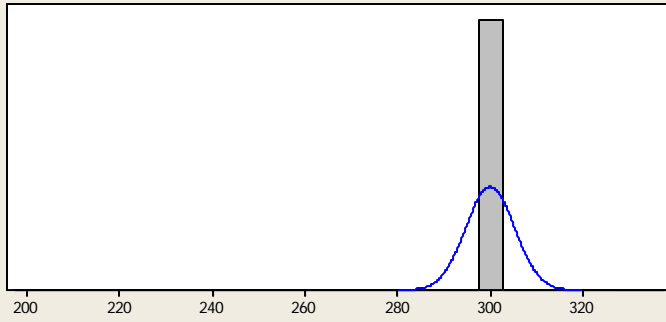
Probability Plot of Total Zinc



Worksheet: Worksheet 1; 3/23/2004; Year 1 GW Monitoring Project



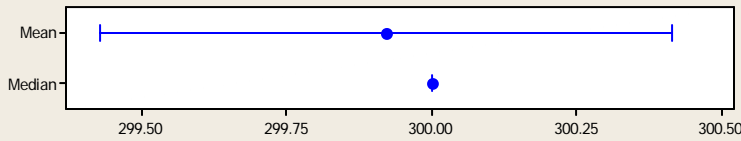
Summary for Total Aluminum



Anderson-Darling Normality Test	
A-Squared	167.27
P-Value <	0.005
Mean	299.92
StDev	5.25
Variance	27.55
Skewness	-14.562
Kurtosis	306.444
N	442
Minimum	200.00
1st Quartile	300.00
Median	300.00
3rd Quartile	300.00
Maximum	337.00
95% Confidence Interval for Mean	
	299.43 300.41
95% Confidence Interval for Median	
	300.00 300.00
95% Confidence Interval for StDev	
	4.92 5.62

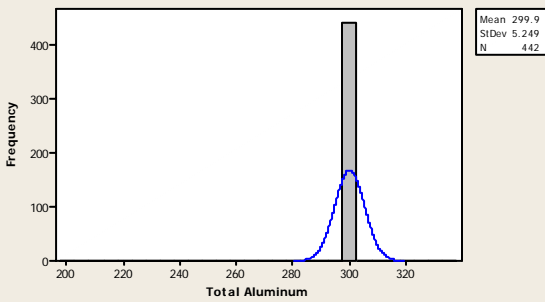


95% Confidence Intervals



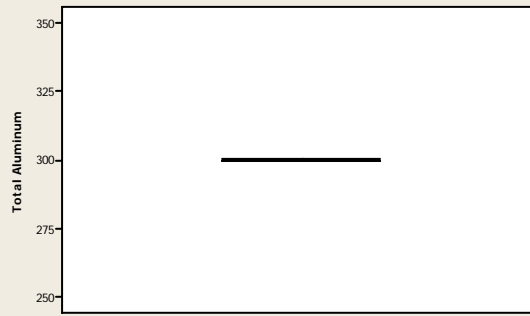
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram of Total Aluminum



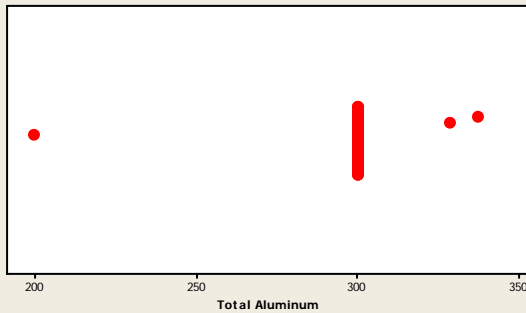
Worksheet: Worksheet 1; 3/23/2004; Year 1 GW Monitoring Project

Boxplot of Total Aluminum



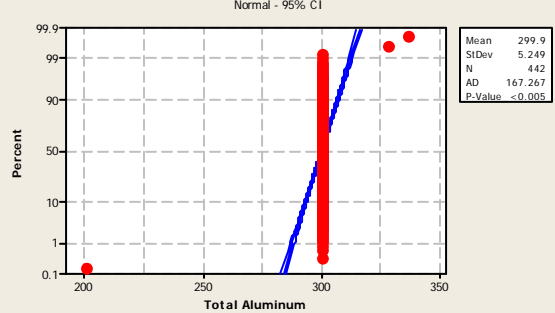
Worksheet: Worksheet 1; 3/23/2004; Year 1 GW Monitoring Project

Individual Value Plot of Total Aluminum



Worksheet: Worksheet 1; 3/23/2004; Year 1 GW Monitoring Project

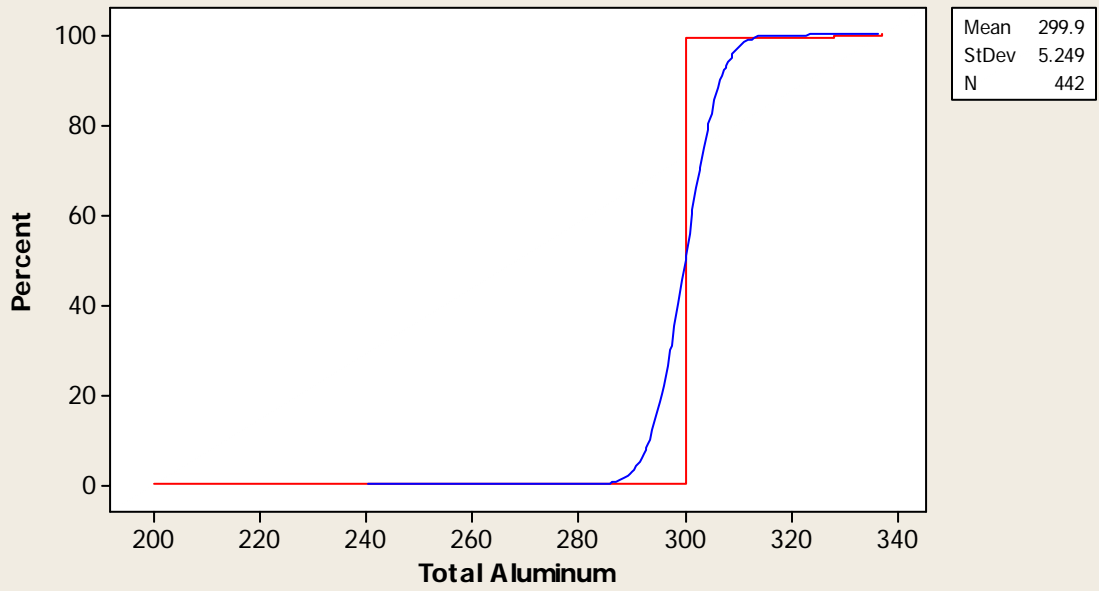
Probability Plot of Total Aluminum



Worksheet: Worksheet 1; 3/23/2004; Year 1 GW Monitoring Project

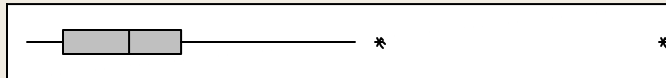
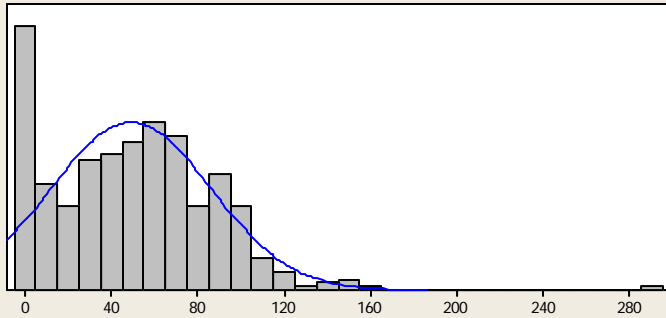
Empirical CDF of Total Aluminum

Normal

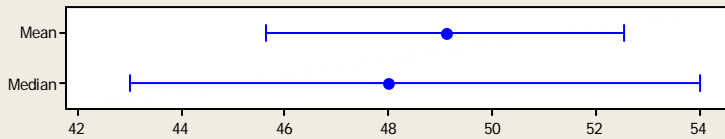


Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Summary for Total Calcium



95% Confidence Intervals



Anderson-Darling Normality Test

A-Squared 4.14
P-Value < 0.005

Mean 49.095
StDev 36.911
Variance 1362.395
Skewness 0.94199
Kurtosis 3.55935
N 442

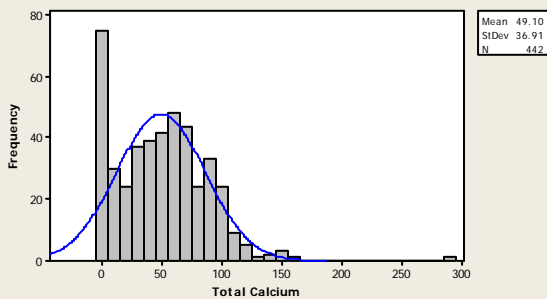
Minimum 1.000
1st Quartile 17.750
Median 48.000
3rd Quartile 72.000
Maximum 295.000

95% Confidence Interval for Mean
45.645 52.546
95% Confidence Interval for Median
43.000 54.000
95% Confidence Interval for StDev
34.627 39.519

Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

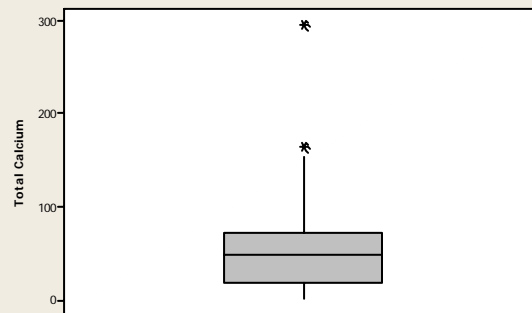
Histogram of Total Calcium

Normal



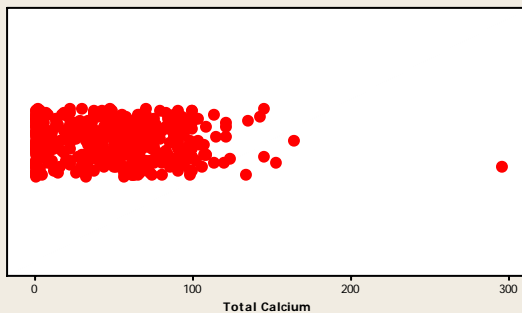
Worksheet: Worksheet 1; 3/23/2004; Year 1 GW Monitoring Project

Boxplot of Total Calcium



Worksheet: Worksheet 1; 3/23/2004; Year 1 GW Monitoring Project

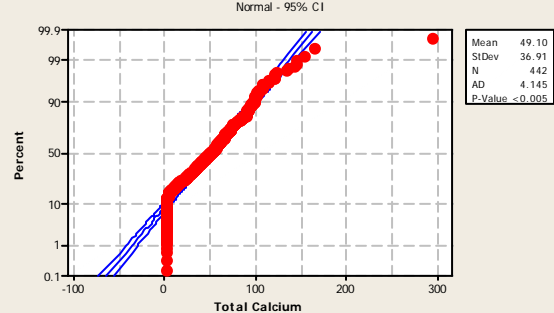
Individual Value Plot of Total Calcium



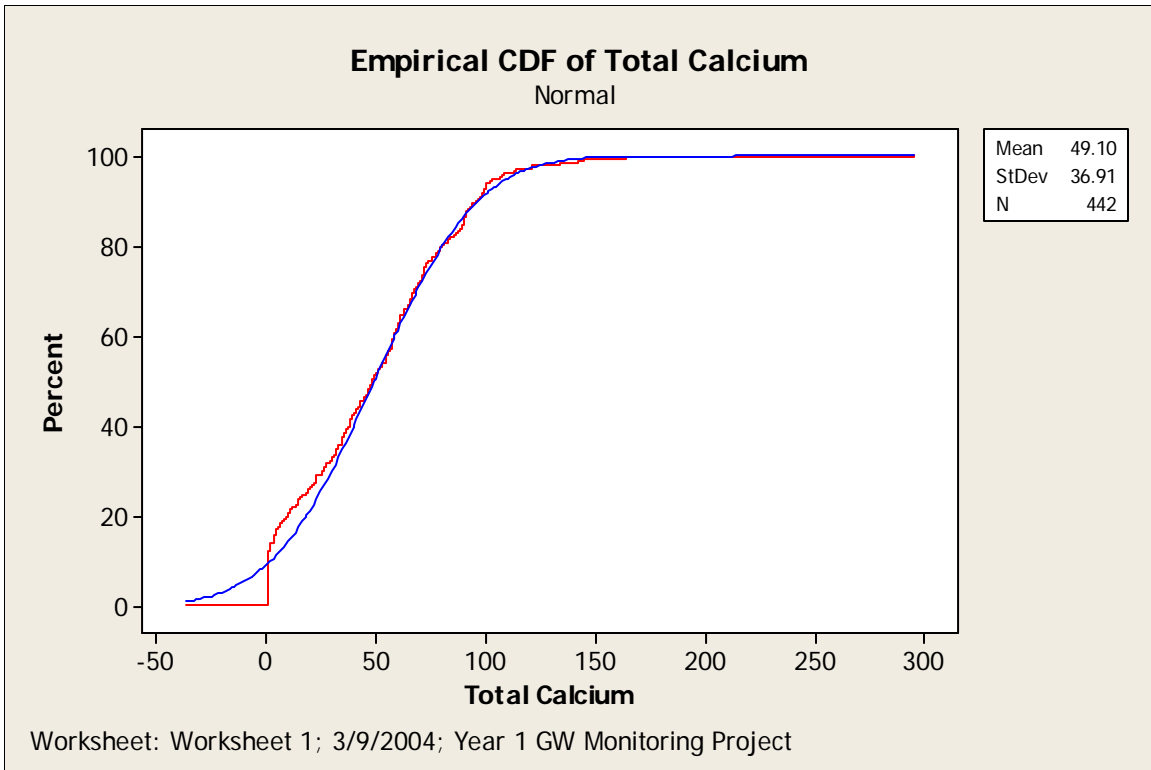
Worksheet: Worksheet 1; 3/23/2004; Year 1 GW Monitoring Project

Probability Plot of Total Calcium

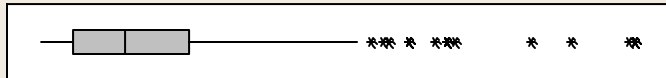
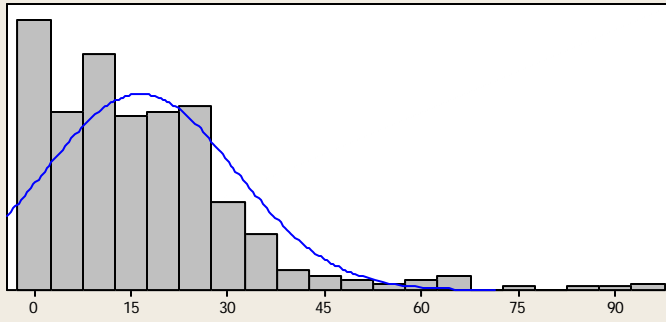
Normal - 95% CI



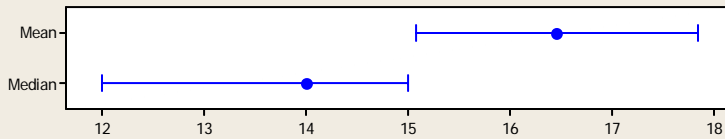
Worksheet: Worksheet 1; 3/23/2004; Year 1 GW Monitoring Project



Summary for Total Magnesium

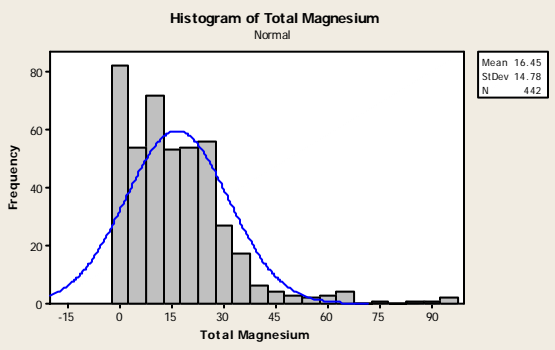


95% Confidence Intervals

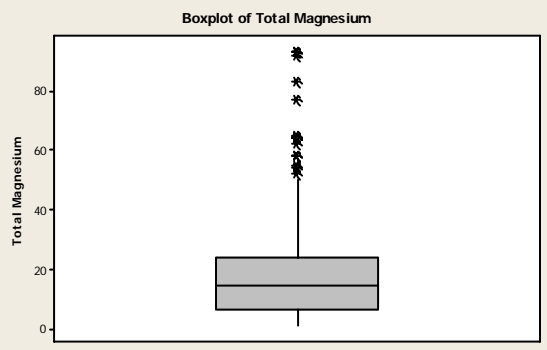


Anderson-Darling Normality Test	
A-Squared	11.90
P-Value <	0.005
Mean	16.452
StDev	14.784
Variance	218.561
Skewness	1.89915
Kurtosis	5.91397
N	442
Minimum	1.000
1st Quartile	6.000
Median	14.000
3rd Quartile	24.000
Maximum	93.000
95% Confidence Interval for Mean	
	15.070 17.835
95% Confidence Interval for Median	
	12.000 15.000
95% Confidence Interval for StDev	
	13.869 15.828

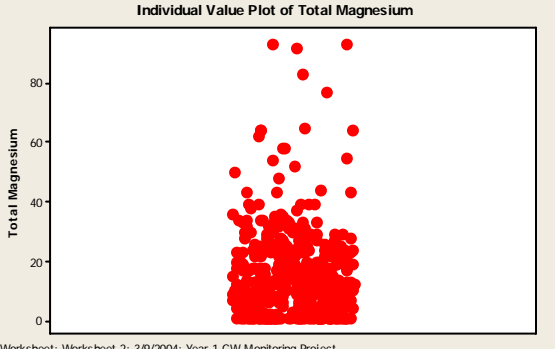
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project



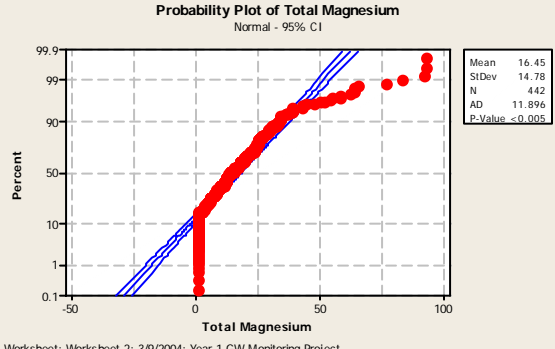
Worksheet: Worksheet 2; 3/9/2004; Year 1 GW Monitoring Project



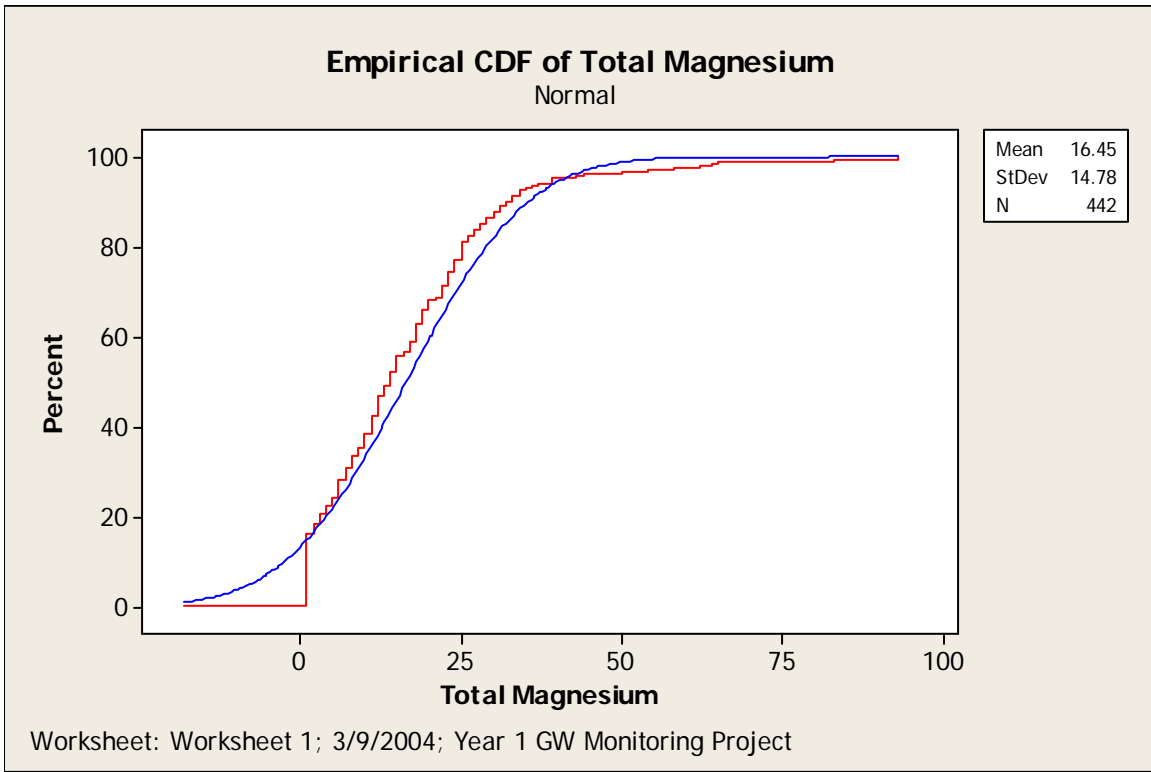
Worksheet: Worksheet 2; 3/9/2004; Year 1 GW Monitoring Project



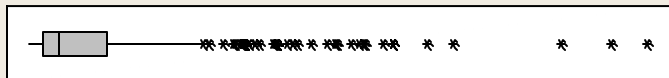
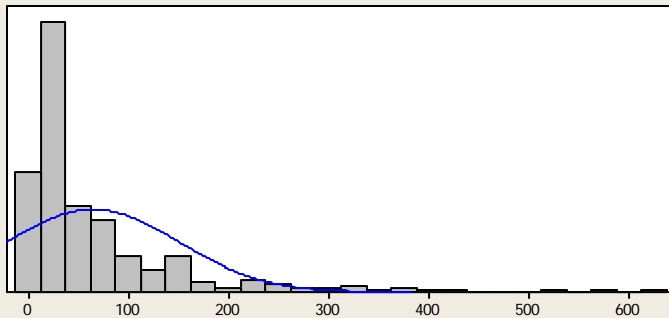
Worksheet: Worksheet 2; 3/9/2004; Year 1 GW Monitoring Project



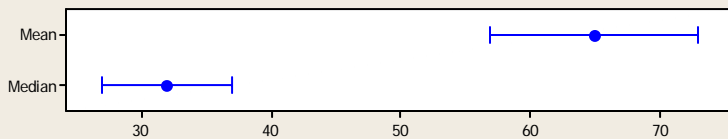
Worksheet: Worksheet 2; 3/9/2004; Year 1 GW Monitoring Project



Summary for Total Sodium



95% Confidence Intervals



Anderson-Darling Normality Test

A-Squared 40.96
P-Value < 0.005

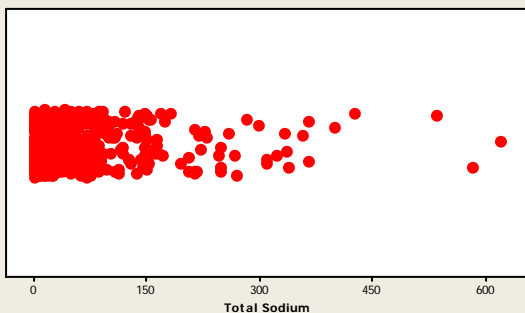
Mean 64.860
StDev 85.244
Variance 7266.593
Skewness 2.8539
Kurtosis 10.7194
N 442

Minimum 1.000
1st Quartile 16.000
Median 32.000
3rd Quartile 78.250
Maximum 618.000

95% Confidence Interval for Mean
56.891 72.829
95% Confidence Interval for Median
27.000 37.000
95% Confidence Interval for StDev
79.971 91.268

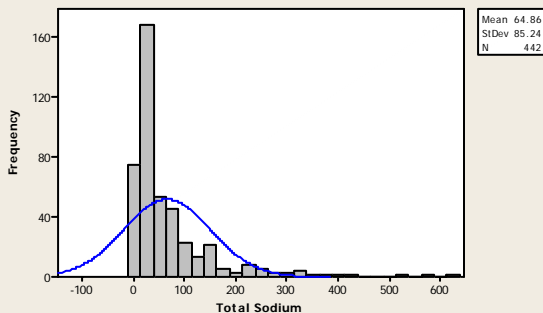
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Individual Value Plot of Total Sodium



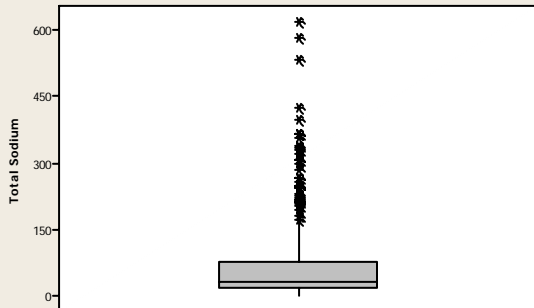
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of Total Sodium



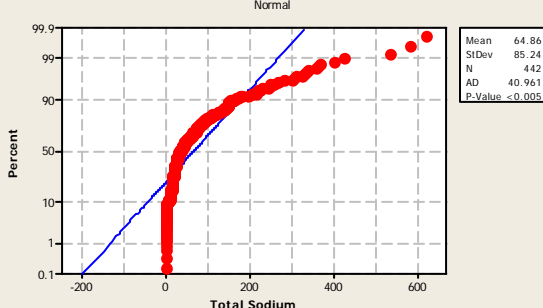
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Total Sodium

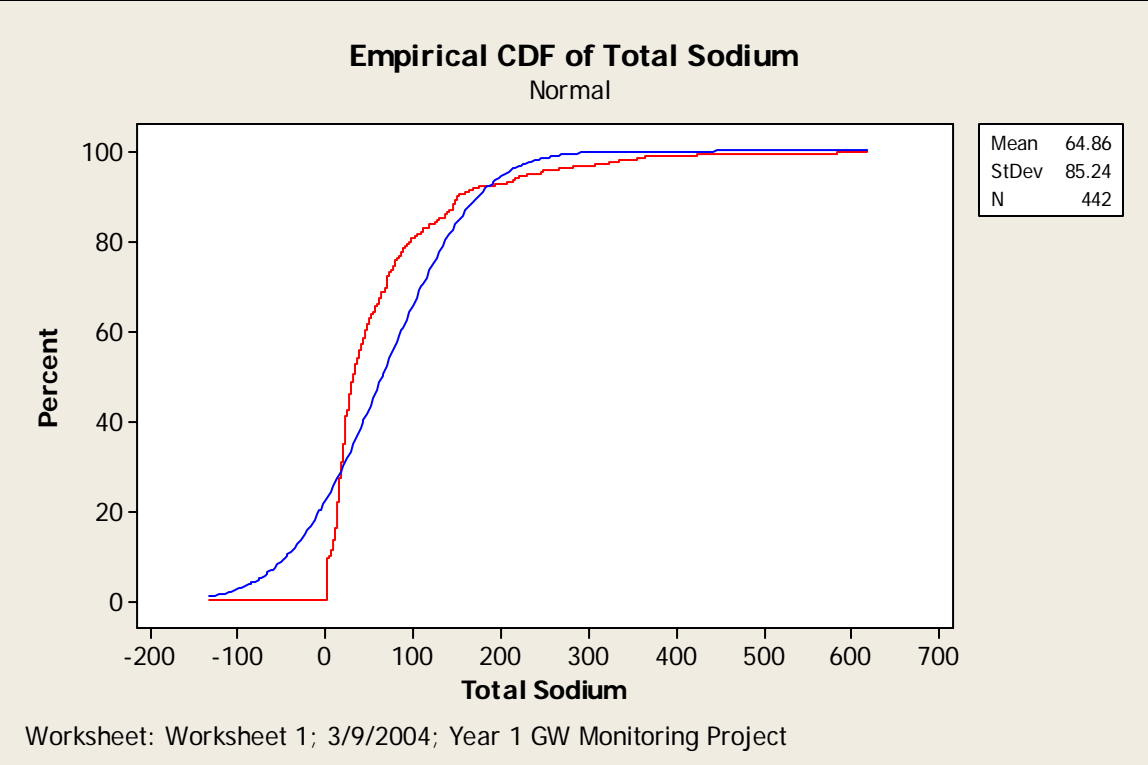


Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

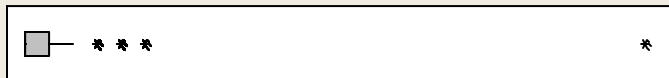
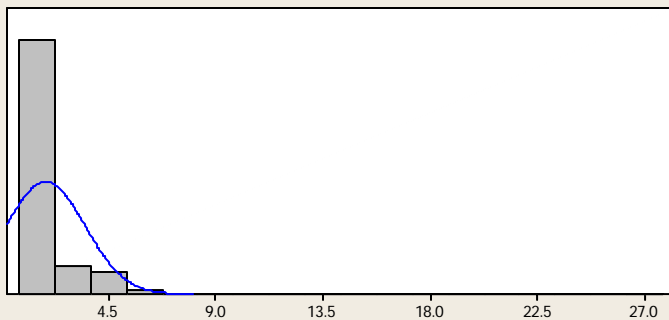
Probability Plot of Total Sodium



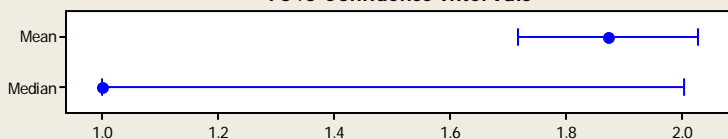
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project



Summary for Total Potassium



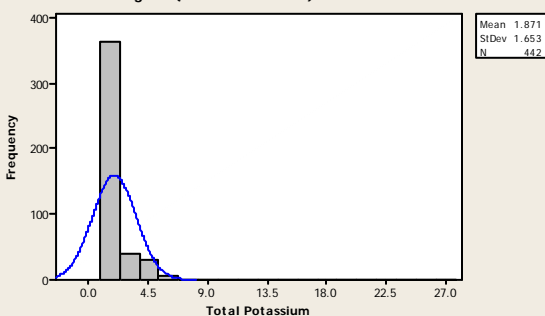
95% Confidence Intervals



Anderson-Darling Normality Test	
A-Squared	50.70
P-Value <	0.005
Mean	1.8710
StDev	1.6535
Variance	2.7339
Skewness	8.518
Kurtosis	120.850
N	442
Minimum	1.0000
1st Quartile	1.0000
Median	1.0000
3rd Quartile	2.0000
Maximum	27.0000
95% Confidence Interval for Mean	
	1.7165 2.0256
95% Confidence Interval for Median	
	1.0000 2.0000
95% Confidence Interval for StDev	
	1.5512 1.7703

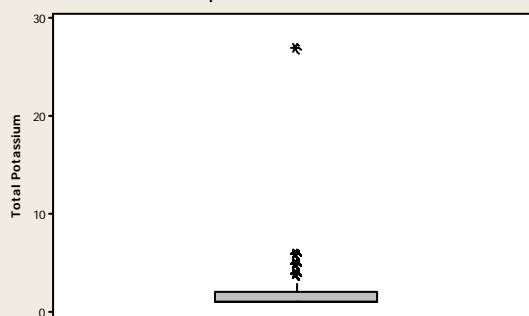
Worksheet: Worksheet 1; 3/9/2004; Year 1 GW Monitoring Project

Histogram (with Normal Curve) of Total Potassium



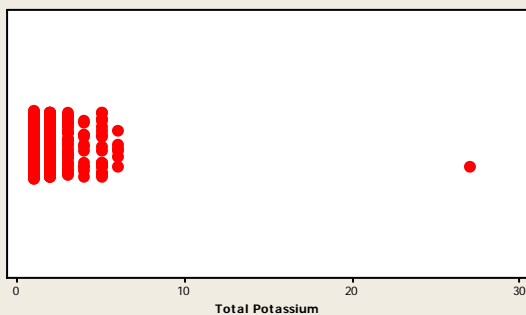
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Boxplot of Total Potassium



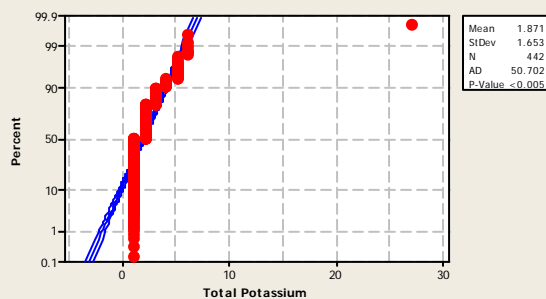
Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Individual Value Plot of Total Potassium

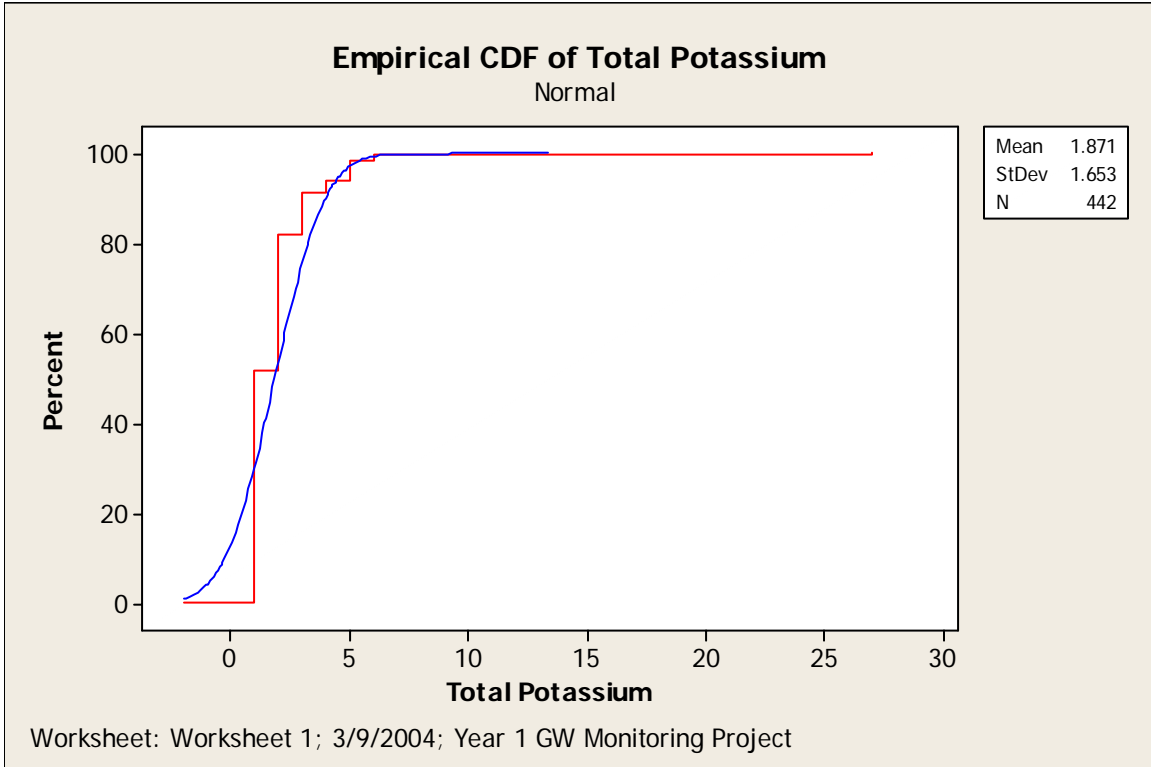


Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project

Normal - 95% CI



Worksheet: Worksheet 1; 2/26/2004; Year 1 GW Monitoring Project



Results and Conclusions

The data analyses indicate that none of the parameters are normally distributed. Most of these data are skewed because of data outliers from wells that have a problem with one or more parameters. Because of the skewed data, the mean is not representative of the true middle of the data distribution. Some skewness is due to lower detection limits imposed by instrument capability. A more appropriate measure for central tendency in this set of water quality data is the median.

Page one of the data set is a Graphical Summary of the data and additional clarifying plots including the Normal Probability Plot. Page two has the Cumulative Distribution Function Graph. These pages include all the elements described in the objectives section needed to better understand the range, variance and distribution of the data except Temporal Plots. There will not be sufficient data to do Temporal plots for several more years.

The null hypothesis for this project was that the mean of water quality samples collected in Oklahoma would fall below the Primary Drinking Water Standard. Aluminum was the only parameter that did not fail to reject the null hypothesis however, the laboratory detection limit for aluminum was 300 ug/L, which is above the secondary standard of 0.2 mg/L.

Chart of Means

Chemical Parameter	Mean	Drinking Water Standard
pH	7.5125	6.5-8.5
Total Alkalinity	213.76	no std.
Total Dissolved Solids	383.89mg/L	500mg/L
Nitrate	2.6358mg/L	10mg/L
Chloride	38.621mg/L	250mg/L
Sulfate	55.29mg/L	250mg/L
Fluoride	0.35846mg/L	2mg/L
Copper	16.618ug/L	1mg/L
Iron	141.41ug/L	0.3mg/L
Manganese	33.79ug/L	0.05mg/L
Zinc	18.05ug/L	5mg/L
Aluminum	299.92ug/L	0.05-2mg/L
Calcium	49.095mg/L	no std.
Magnesium	16.45mg/L	no std.
Sodium	64.86mg/L	no std.
Potassium	1.87mg/L	no std.