Appendix P
ProUCL Input - Groundwater - Trichloroethene
Remedial Investigation, Former Forbes Atlas Missile Site S-5
Lyon County, Kansas

Trichloroethene	D_Trichloroethene
0.92	1
0.5	0
0.62	0
0.62	0
0.5	0
0.62	0
0.5	0
100	1
82	1
0.5	0
65	1
77	1
80	1
95	1
96	1
120	1

Appendix P
ProUCL Output - Groundwater - Trichloroethene
Remedial Investigation, Former Forbes Atlas Missile Site S-5
Lyon County, Kansas

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.12/26/2018 10:26:40 AM
From File	ProUCL input TCE_updated.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Trichloroethene

General Statistics

Total Number of Observations	16	Number of Distinct Observations	11
Number of Detects	9	Number of Non-Detects	7
Number of Distinct Detects	9	Number of Distinct Non-Detects	2
Minimum Detect	0.92	Minimum Non-Detect	0.5
Maximum Detect	120	Maximum Non-Detect	0.62
Variance Detects	1121	Percent Non-Detects	43.75%
Mean Detects	79.55	SD Detects	33.49
Median Detects	82	CV Detects	0.421
Skewness Detects	-1.739	Kurtosis Detects	4.215
Mean of Logged Detects	3.97	SD of Logged Detects	1.53

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.837	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.247	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.274	Detected Data appear Normal at 5% Significance Level

Detected Data appear Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	44.96	KM Standard Error of Mean	12.15
KM SD	45.81	95% KM (BCA) UCL	65.56
95% KM (t) UCL	66.26	95% KM (Percentile Bootstrap) UCL	63.69
95% KM (z) UCL	64.94	95% KM Bootstrap t UCL	65.04
90% KM Chebyshev UCL	81.4	95% KM Chebyshev UCL	97.91
97.5% KM Chebyshev UCL	120.8	99% KM Chebyshev UCL	165.8

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.874	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.737	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.414	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.285	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.375	k star (bias corrected MLE)	0.991
Theta hat (MLE)	57.86	Theta star (bias corrected MLE)	80.3
nu hat (MLE)	24.75	nu star (bias corrected)	17.83
Mean (detects)	79.55		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)
For such situations, GROS method may yield incorrect values of UCLs and BTVs
This is especially true when the sample size is small.
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.92	Mean	58.78
Maximum	120	Median	52.6
SD	34.71	CV	0.591
k hat (MLE)	1.661	k star (bias corrected MLE)	1.391

Theta hat (MLE)	35.39	Theta star (bias corrected MLE)	42.25
nu hat (MLE)	53.15	nu star (bias corrected)	44.52
Adjusted Level of Significance (β)	0.0335		
Approximate Chi Square Value (44.52, α)	30.22	Adjusted Chi Square Value (44.52, β)	28.88
95% Gamma Approximate UCL (use when n>=50)	86.61	95% Gamma Adjusted UCL (use when n<50)	90.62

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	44.96	SD (KM)	45.81
Variance (KM)	2098	SE of Mean (KM)	12.15
k hat (KM)	0.963	k star (KM)	0.824
nu hat (KM)	30.83	nu star (KM)	26.38
theta hat (KM)	46.67	theta star (KM)	54.53
80% gamma percentile (KM)	73.36	90% gamma percentile (KM)	108.5
95% gamma percentile (KM)	144.3	99% gamma percentile (KM)	228.5

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (26.38, α)	15.68	Adjusted Chi Square Value (26.38, β)	14.74
95% Gamma Approximate KM-UCL (use when n>=50)	75.68	95% Gamma Adjusted KM-UCL (use when n<50)	80.48

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.502	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.829	Detected Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.442	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.274	Detected Data Not Lognormal at 5% Significance Level	

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	47.06	Mean in Log Scale	2.896
SD in Original Scale	45.26	SD in Log Scale	1.728
95% t UCL (assumes normality of ROS data)	66.9	95% Percentile Bootstrap UCL	64.66
95% BCA Bootstrap UCL	64.59	95% Bootstrap t UCL	67.62
95% H-UCL (Log ROS)	470.8		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	1.93	KM Geo Mean	6.891
KM SD (logged)	2.554	95% Critical H Value (KM-Log)	5.541
KM Standard Error of Mean (logged)	0.677	95% H-UCL (KM -Log)	6946
KM SD (logged)	2.554	95% Critical H Value (KM-Log)	5.541
KM Standard Error of Mean (logged)	0.677		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	44.87	Mean in Log Scale	1.667
SD in Original Scale	47.41	SD in Log Scale	2.921
95% t UCL (Assumes normality)	65.64	95% H-Stat UCL	42434

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	66.26

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.