

Appendix C

EPA ProUCL Calculations



	0		1	2
	Pre-Removal	Arsenic	D_Arsenic	
1	EB-01-00"	1.5		1
2	EB-02-00"	1.7		1
3	EB-03-00"	3.3		1
4	EB-04-00"	3		1
5	EB-05-00"	2.5		1
6	EB-06-00"	3.4		1
7	EB-07-00"	0.5		1
8	EB-08-00"	0.4		0
9	EB-09-00"	0.4		0
10	EB-10-00"	1.7		1
11	EB-11-00"	3.2		1
12	EB-12-00"	2.4		1
13	EB-13-00"	1.7		1
14	EB-14-00"/DUP-03-00	0.62		1
15	EB-15-00"	0.81		1
16	EB-16-00"	0.53		1
17	EB-17-00"	0.96		1
18	EB-18-00"	0.4		0
19	EB-20-00"	1.8		1
20	EB-24-00"	8.7		1
21	EB-24-2'S-00	5.3		1
22	EB-24-3'E-00	3.5		1
23	EB-24-2'N-00	3		1
24	EB-26-00"	0.4		0
25	EB-27-00"/DUP-02-00	0.59		1
26	EB-30-00"	8		1
27	EB-31-00"	1.9		1
28	EB-32-00"/DUP-01-00	6.4		1
29	EB-33-00"	1.2		1
30	EB-34-00"	1.1		1
31	EB-35-00"/DUP-04-00	34		1
32	EB-35-06"	1.7		1
33	EB-35-2'N-00	15		1
34	EB-35-2'N-06	1.9		1
35	EB-35-4'S-00	5.3		1
36	EB-35-10'SE-00	17		1
37	EB-36-00	7.4		1
38	EB-37-00	9.1		1
39	EB-38-00	6.4		1
40	EB-39-00	4		1
41	EB-40-00	5.4		1
42	EB-41-00	5.8		1
43	EB-42-00	7.6		1

	A	B	C	D	E	F	G	H	I	J	K	L
1	Gamma UCL Statistics for Data Sets with Non-Detects											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.19/19/2016 3:24:11 PM								
5	From File			WorkSheet.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10	Arsenic											
11												
12	General Statistics											
13	Total Number of Observations				43		Number of Distinct Observations				33	
14	Number of Detects				39		Number of Non-Detects				4	
15	Number of Distinct Detects				32		Number of Distinct Non-Detects				1	
16	Minimum Detect				0.5		Minimum Non-Detect				0.4	
17	Maximum Detect				34		Maximum Non-Detect				0.4	
18	Variance Detects				36.89		Percent Non-Detects				9.302%	
19	Mean Detects				4.869		SD Detects				6.074	
20	Median Detects				3		CV Detects				1.247	
21	Skewness Detects				3.33		Kurtosis Detects				13.87	
22	Mean of Logged Detects				1.086		SD of Logged Detects				0.999	
23												
24	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs											
25	KM Mean				4.454		KM Standard Error of Mean				0.905	
26	KM SD				5.856		95% KM (BCA) UCL				6.032	
27	95% KM (t) UCL				5.975		95% KM (Percentile Bootstrap) UCL				6.07	
28	95% KM (z) UCL				5.942		95% KM Bootstrap t UCL				6.989	
29	90% KM Chebyshev UCL				7.168		95% KM Chebyshev UCL				8.397	
30	97.5% KM Chebyshev UCL				10.1		99% KM Chebyshev UCL				13.45	
31												
32	Gamma GOF Tests on Detected Observations Only											
33	A-D Test Statistic				0.667		Anderson-Darling GOF Test					
34	5% A-D Critical Value				0.775		Detected data appear Gamma Distributed at 5% Significance Level					
35	K-S Test Statistic				0.12		Kolmogorov-Smirnov GOF					
36	5% K-S Critical Value				0.145		Detected data appear Gamma Distributed at 5% Significance Level					
37	Detected data appear Gamma Distributed at 5% Significance Level											
38												
39	Gamma Statistics on Detected Data Only											
40	k hat (MLE)				1.143		k star (bias corrected MLE)				1.072	
41	Theta hat (MLE)				4.259		Theta star (bias corrected MLE)				4.541	
42	nu hat (MLE)				89.17		nu star (bias corrected)				83.65	
43	Mean (detects)				4.869							
44												
45	Gamma ROS Statistics using Imputed Non-Detects											
46	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
47	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)											
48	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
49	This is especially true when the sample size is small.											
50	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
51	Minimum				0.01		Mean				4.417	
52	Maximum				34		Median				2.5	
53	SD				5.951		CV				1.347	

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	0		1	2
	Post-Removal		Arsenic	D_Arsenic
1	EB-01-00"		1.5	1
2	EB-02-00"		1.7	1
3	EB-03-00"		3.3	1
4	EB-04-00"		3	1
5	EB-05-00"		2.5	1
6	EB-06-00"		3.4	1
7	EB-07-00"		0.5	1
8	EB-08-00"		0.4	0
9	EB-09-00"		0.4	0
10	EB-10-00"		1.7	1
11	EB-11-00"		3.2	1
12	EB-12-00"		2.4	1
13	EB-13-00"		1.7	1
14	EB-14-00"/DUP-03-00		0.62	1
15	EB-15-00"		0.81	1
16	EB-16-00"		0.53	1
17	EB-17-00"		0.96	1
18	EB-18-00"		0.4	0
19	EB-20-00"		1.8	1
20	EB-24-2'S-00		5.3	1
21	EB-24-3'E-00		3.5	1
22	EB-26-00"		0.4	0
23	EB-27-00"/DUP-02-00		0.59	1
24	EB-30-00"		8	1
25	EB-31-00"		1.9	1
26	EB-32-00"/DUP-01-00		6.4	1
27	EB-33-00"		1.2	1
28	EB-34-00"		1.1	1
29	EB-35-06"		1.7	1
30	EB-35-2'N-06		1.9	1
31	EB-35-4'S-00		5.3	1
32	EB-36-00		7.4	1
33	EB-37-00		9.1	1
34	EB-38-00		6.4	1
35	EB-39-00		4	1
36	EB-40-00		5.4	1
37	EB-41-00		5.8	1
38	EB-42-00		7.6	1

	A	B	C	D	E	F	G	H	I	J	K	L
1	Gamma UCL Statistics for Data Sets with Non-Detects											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.19/19/2016 3:36:53 PM								
5	From File			WorkSheet.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10	Arsenic											
11												
12	General Statistics											
13	Total Number of Observations				38		Number of Distinct Observations				29	
14	Number of Detects				34		Number of Non-Detects				4	
15	Number of Distinct Detects				28		Number of Distinct Non-Detects				1	
16	Minimum Detect				0.5		Minimum Non-Detect				0.4	
17	Maximum Detect				9.1		Maximum Non-Detect				0.4	
18	Variance Detects				6.11		Percent Non-Detects				10.53%	
19	Mean Detects				3.3		SD Detects				2.472	
20	Median Detects				2.45		CV Detects				0.749	
21	Skewness Detects				0.821		Kurtosis Detects				-0.463	
22	Mean of Logged Detects				0.883		SD of Logged Detects				0.848	
23												
24	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs											
25	KM Mean				2.995		KM Standard Error of Mean				0.407	
26	KM SD				2.469		95% KM (BCA) UCL				3.634	
27	95% KM (t) UCL				3.681		95% KM (Percentile Bootstrap) UCL				3.664	
28	95% KM (z) UCL				3.664		95% KM Bootstrap t UCL				3.768	
29	90% KM Chebyshev UCL				4.215		95% KM Chebyshev UCL				4.767	
30	97.5% KM Chebyshev UCL				5.534		99% KM Chebyshev UCL				7.041	
31												
32	Gamma GOF Tests on Detected Observations Only											
33	A-D Test Statistic				0.457		Anderson-Darling GOF Test					
34	5% A-D Critical Value				0.763		Detected data appear Gamma Distributed at 5% Significance Level					
35	K-S Test Statistic				0.128		Kolmogorov-Smirnov GOF					
36	5% K-S Critical Value				0.153		Detected data appear Gamma Distributed at 5% Significance Level					
37	Detected data appear Gamma Distributed at 5% Significance Level											
38												
39	Gamma Statistics on Detected Data Only											
40	k hat (MLE)				1.754		k star (bias corrected MLE)				1.619	
41	Theta hat (MLE)				1.881		Theta star (bias corrected MLE)				2.038	
42	nu hat (MLE)				119.3		nu star (bias corrected)				110.1	
43	Mean (detects)				3.3							
44												
45	Gamma ROS Statistics using Imputed Non-Detects											
46	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
47	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)											
48	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
49	This is especially true when the sample size is small.											
50	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
51	Minimum				0.01		Mean				2.956	
52	Maximum				9.1		Median				1.9	
53	SD				2.547		CV				0.862	

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	0	1
	Pre-Removal	Lead
1	EB-01-00"	14
2	EB-02-00"	19
3	EB-03-00"	57
4	EB-04-00"	39
5	EB-05-00"	21
6	EB-06-00"	46
7	EB-07-00"	11
8	EB-08-00"	6.6
9	EB-09-00"	7.2
10	EB-10-00"	12
11	EB-11-00"	45
12	EB-12-00"	38
13	EB-13-00"	9.4
14	EB-14-00"/DUP-03-00	7.9
15	EB-15-00"	10
16	EB-16-00"	3.5
17	EB-17-00"	4.3
18	EB-18-00"	5
19	EB-19-00"	6
20	EB-20-00"	13
21	EB-21-00"	3.3
22	EB-22-00"	67
23	EB-24-00"	800
24	EB-24-06"	14
25	EB-24-2'S-00	54
26	EB-24-3'E-00	25
27	EB-24-2'N-00	160
28	EB-24-2'N-06	260
29	EB-24-2'N-12	95
30	EB-26-00"	5.5
31	EB-27-00"/DUP-02-00	9.5
32	EB-28-00"	11
33	EB-29-00"	19
34	EB-30-00"	29
35	EB-31-00"	32
36	EB-32-00"/DUP-01-00	26
37	EB-33-00"	24
38	EB-34-00"	14
39	EB-35-00"/DUP-04-00	170
40	EB-35-06"	13
41	EB-35-2'N-00	71
42	EB-35-4'S-00	24
43	EB-35-10'SE-00	72
44	EB-36-00	70

	A	B	C	D	E	F	G	H	I	J	K	L
1	Lognormal UCL Statistics for Uncensored Full Data Sets											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.19/19/2016 3:47:29 PM								
5	From File			WorkSheet.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10												
11	Lead											
12												
13	General Statistics											
14	Total Number of Observations				44		Number of Distinct Observations				38	
15							Number of Missing Observations				0	
16	Minimum				3.3		Mean				55.53	
17	Maximum				800		Median				20	
18	SD				125.4		Std. Error of Mean				18.9	
19	Coefficient of Variation				2.258		Skewness				5.213	
20												
21	Lognormal GOF Test											
22	Shapiro Wilk Test Statistic				0.963		Shapiro Wilk Lognormal GOF Test					
23	5% Shapiro Wilk Critical Value				0.944		Data appear Lognormal at 5% Significance Level					
24	Lilliefors Test Statistic				0.113		Lilliefors Lognormal GOF Test					
25	5% Lilliefors Critical Value				0.132		Data appear Lognormal at 5% Significance Level					
26	Data appear Lognormal at 5% Significance Level											
27												
28	Logged Statistics											
29	Minimum of Logged Data				1.194		Mean of logged Data				3.128	
30	Maximum of Logged Data				6.685		SD of logged Data				1.201	
31												
32	Lognormal Maximum likelihood Estimates (MLEs)											
33	MLE Mean				46.96		MLE Standard Deviation				84.4	
34	MLE Median				22.83		MLE Skewness				11.2	
35	MLE Coefficient of Variation				1.797		80% MLE Quantile				62.73	
36	90% MLE Quantile				106.4		95% MLE Quantile				164.6	
37	99% MLE Quantile				373.1							
38												
39	Lognormal Minimum Variance Unbiased Estimates (MVUEs)											
40	MVUE Mean				45.7		MVUE SD				74.22	
41	MVUE Median				22.46		MVUE SEM				10.16	
42												
43	Assuming Lognormal Distribution											
44	95% H-UCL				75.61		90% Chebyshev (MVUE) UCL				76.19	
45	95% Chebyshev (MVUE) UCL				90		97.5% Chebyshev (MVUE) UCL				109.2	
46	99% Chebyshev (MVUE) UCL				146.8							
47												
48	Nonparametric Distribution Free UCLs											
49	95% CLT UCL				86.61		95% Jackknife UCL				87.3	
50	95% Standard Bootstrap UCL				85.38		95% Bootstrap-t UCL				140.4	
51	95% Hall's Bootstrap UCL				198.6		95% Percentile Bootstrap UCL				91.25	
52	95% BCA Bootstrap UCL				109.2							
53	90% Chebyshev(Mean, Sd) UCL				112.2		95% Chebyshev(Mean, Sd) UCL				137.9	

	A	B	C	D	E	F	G	H	I	J	K	L
54	97.5% Chebyshev(Mean, Sd) UCL					173.5	99% Chebyshev(Mean, Sd) UCL					243.6
55												
56	Suggested UCL to Use											
57	95% H-UCL					75.61						
58												
59	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
60	Recommendations are based upon data size, data distribution, and skewness.											
61	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
62	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
63												
64	ProUCL computes and outputs H-statistic based UCLs for historical reasons only.											
65	H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.											
66	It is therefore recommended to avoid the use of H-statistic based 95% UCLs.											
67	Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.											
68												

	0		1
	Post-Removal		Lead
1	EB-01-00"		14
2	EB-02-00"		19
3	EB-03-00"		57
4	EB-04-00"		39
5	EB-05-00"		21
6	EB-06-00"		46
7	EB-07-00"		11
8	EB-08-00"		6.6
9	EB-09-00"		7.2
10	EB-10-00"		12
11	EB-11-00"		45
12	EB-12-00"		38
13	EB-13-00"		9.4
14	EB-14-00"/DUP-03-00		7.9
15	EB-15-00"		10
16	EB-16-00"		3.5
17	EB-17-00"		4.3
18	EB-18-00"		5
19	EB-19-00"		6
20	EB-20-00"		13
21	EB-21-00"		3.3
22	EB-22-00"		67
23	EB-24-06"		14
24	EB-24-2'S-00		54
25	EB-24-3'E-00		25
26	EB-26-00"		5.5
27	EB-27-00"/DUP-02-00		9.5
28	EB-28-00"		11
29	EB-29-00"		19
30	EB-30-00"		29
31	EB-31-00"		32
32	EB-32-00"/DUP-01-00		26
33	EB-33-00"		24
34	EB-34-00"		14
35	EB-35-06"		13
36	EB-35-4'S-00		24
37	EB-36-00		70

	A	B	C	D	E	F	G	H	I	J	K	L
1	Gamma UCL Statistics for Uncensored Full Data Sets											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.19/19/2016 3:54:42 PM								
5	From File			WorkSheet.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10												
11	Lead											
12												
13	General Statistics											
14	Total Number of Observations				37		Number of Distinct Observations				31	
15							Number of Missing Observations				0	
16	Minimum				3.3		Mean				22.03	
17	Maximum				70		Median				14	
18	SD				18.3		SD of logged Data				0.849	
19	Coefficient of Variation				0.831		Skewness				1.238	
20												
21	Gamma GOF Test											
22	A-D Test Statistic				0.481		Anderson-Darling Gamma GOF Test					
23	5% A-D Critical Value				0.764		Data appear Gamma Distributed at 5% Significance Level					
24	K-S Test Statistic				0.147		Kolmogorov-Smirnov Gamma GOF Test					
25	5% K-S Critical Value				0.147		Data appear Gamma Distributed at 5% Significance Level					
26	Data appear Gamma Distributed at 5% Significance Level											
27												
28	Gamma Statistics											
29	k hat (MLE)				1.646		k star (bias corrected MLE)				1.531	
30	Theta hat (MLE)				13.38		Theta star (bias corrected MLE)				14.39	
31	nu hat (MLE)				121.8		nu star (bias corrected)				113.3	
32	MLE Mean (bias corrected)				22.03		MLE Sd (bias corrected)				17.81	
33							Approximate Chi Square Value (0.05)				89.7	
34	Adjusted Level of Significance				0.0431		Adjusted Chi Square Value				88.79	
35												
36	Assuming Gamma Distribution											
37	95% Approximate Gamma UCL (use when n>=50)				27.82		95% Adjusted Gamma UCL (use when n<50)				28.11	
38												
39	Suggested UCL to Use											
40	95% Adjusted Gamma UCL				28.11							
41												
42	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
43	Recommendations are based upon data size, data distribution, and skewness.											
44	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
45	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
46												