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MEMORANDUM

To: Dean Tagliaferro, USEPA
Darrell Moore, CENAE

From: Joel Lindsay

Date: February 6, 2003

Subject: 1.5 Mile Removal Action-Phase II PCB Data Evaluation for Limits of
Excavation Upstream of the Elm Street Bridge
DCN: GE-020603-ABLE

This memorandum has been prepared to present analytical results for soil samples collected along the riverbanks from Transect 98 to the Elm Street bridge as a part of the investigation stage of the 2nd Phase of the 1.5 Mile Reach Removal Action of the Housatonic River in Pittsfield, Massachusetts. Field sampling activities associated with this investigation were conducted on November 7 through November 9, 2001. Included in this memorandum is an analysis and UCL evaluation of the new bank sample data. The results of the data analysis and UCL evaluation are used to confirm, and in some cases modify excavation limits that were originally provided in the EE/CA for the 1.5 Mile Reach Removal Action. This memorandum includes the following sections:

- Purpose and Objectives
- Field Sampling Procedures
- Laboratory Analytical Procedures
- Analytical Results
- Data Analysis
- Removal Recommendations

The activities described in this memorandum were conducted in accordance with project-wide and area specific planning documents. These planning documents include the following:

- Project Field Sampling Plan (00-0334)
- Project Health and Safety Plan (HASP) (00-0313)
- Project Quality Assurance Project Plan and Addendum (QAPP) (00-0305)
- Site Specific Health and Safety Plan (00-0475)

Purpose and Objectives

The purpose of this investigation was to supplement existing riverbank soil data for the Phase II area of the 1.5 Mile Reach from transect 92 to the Elm Street bridge (transect 106) in order to finalize the vertical and horizontal excavation limits. Supplemental sampling and data evaluation for the remainder of Phase II (i.e., from the Elm Street bridge to transect 168) will be the subject of a separate report. This investigation and subsequent data assessment had specific objectives that are described in the paragraphs below:

West Bank

The sampling performed during the engineering evaluation/cost analysis (EE/CA) was generally limited to lower bank samples (e.g., elevation 975 feet above mean sea level (AMSL) and below). Based on this sampling, the EE/CA concluded that a three-foot excavation to the top of the riverbank was required to meet cleanup levels. General Electric (GE), in its written comments on the EE/CA, stated that additional sampling should be performed between existing sample locations and the actual “top of bank” (proposed excavation limit) where there was a significant difference between these two points. EPA generally concurred (see EPA Responsiveness Summary—November 2000). For the west bank from transect 98 to 106, the “top of the bank”, as agreed upon between EPA and GE, ranges from 980 feet AMSL to approximately 990 feet AMSL. Since this top elevation of sampling varied significantly from the elevation of the “top of bank”, EPA concluded that additional sampling for PCBs was warranted to determine if the limit of excavation could be lowered from the location proposed in the EE/CA.

East Bank

Additional investigation and assessment activities were required on the east bank for the following reasons:

1. To further sample and assess the upper bank for transects 92 to 102. The sampling performed in the EE/CA was generally limited to the lower bank (e.g., elevations 977 feet AMSL and below). The top of bank ranges from 985 to 990 feet AMSL). See the rationale for the west bank provided above.
2. To further assess PCB concentrations at depths greater than three feet on residential parcel I8-23-1. Parcel I8-23-1 encompasses transects 104 and 106. The cleanup level for depths greater than three feet on residential properties specified in the EE/CA and Action Memorandum include a “not-to-exceed” PCB concentration of 50 ppm and an average concentration of PCBs of less than 10 ppm in bank soils from 3 to 15 feet deep. Since the EE/CA contained only one sampling location with a depth greater than three feet on this property, additional sampling was warranted.

3. To sample parcel I8-23-1 at elevation 980 feet AMSL for PCBs to fill in this data gap. The riverbank on this residential parcel was previously sampled to the top of the bank (approximate elevation of 990 feet AMSL), however, sampling at elevation 980 AMSL was not performed.
4. To reassess the data evaluation performed in the EE/CA. The EE/CA contained the following errors or omissions: It evaluated parcel I8-23-4 as a residential parcel, which is incorrect; it omitted the results of over 19 sampling locations for parcel I8-23-1; it incorrectly concluded that only a one foot excavation was necessary to meet the residential cleanup criteria for parcels I8-23-1 and I8-23-4 while the report concluded that the 95% UCL for these properties for the 0 to 3 foot depth was 18.1 ppm (a 95% UCL was not calculated for the 1 – 3 foot depth); it concluded, based solely on eight depth samples collected from the lower bank, that parcels I8-23-2, I8-23-3, and I8 23-6 required only a one-foot excavation. Revised data evaluations were performed as part of this investigation to consider the appropriate use classification (i.e., residential vs. recreational) and all PCB analytical data collected to date.

Sampling Locations

A total of twenty-five sample locations were established to further characterize the PCB concentrations in the riverbanks from Transect 98 to the Elm Street bridge. Figure 1 depicts the locations of these samples collected as part of this effort.

Sample locations BS000173 – BS000182 are located at elevations ranging from 978 to 985 on the west bank. These locations were selected to correspond to existing transects 98 -106 where previous sampling did not extend to the top of bank (EPA limit of excavation). Sample locations BS000191 – BS000197 are located at elevations ranging from 980 to 989.5 (at the approximate EPA limit of excavation) on the east bank. These locations were selected to correspond to existing transects 98 -102 where previous sampling did not extend to the top of bank. Sample locations BS000183 – BS000190 are located on parcel I8-23-1 on the east bank at elevations 977 and 980. All locations were surveyed and staked at the appropriate elevation prior to the field sampling effort.

Field Sampling and Analytical Procedures

Soil sampling was conducted at each of the pre-determined locations as depicted in Figure 1. Seventeen sample locations were sampled along existing transects 98 – 106 on both the east and west riverbank and sampled to a depth of three feet (with sample depths including 0-1, 1-2, and 2-3 feet). At total of eight additional locations were sampled on parcel I8-23-1. Three of these eight locations on parcel I8-23-1 were sampled at elevation 980, and sampled at depth intervals of 0-1, 1-2, and 2-3 feet. The other five locations on parcel I8-23-1 were spaced at 25-foot intervals along the bank of the parcel at elevation

977 (approximately mid-bank) to assess PCB concentrations at depths between 3 and 6 feet (with sample depths of 3-4, 4-5, and 5-6 feet).

Sampling protocols were conducted in accordance with the WESTON Field Sampling Plan (30 July 2001) for soil sampling (C.32). Refusal was encountered before the design depth could be achieved at several locations including seven of the supplemental transect sample locations and all five of the 3 to 6 foot residential sample locations. Locations where refusal was met before the design depth could be achieved are depicted on the attached figure. For these locations no result is shown on the figure for depths where refusal was met.

All samples were analyzed for PCBs at a fixed, off site laboratory approved by CENAE. QA/QC samples were obtained in accordance with the requirements outlined in the project QAPP and Addendum (00-03-05). WESTON conducted data management and data validation of sample analyses in accordance with the procedures outlined in the project QAPP. All analyses were found to meet the Level III data quality objectives as outlined in the project QAPP.

Analytical Results and Data Analysis

A total of 72 samples were analyzed for Aroclors and Total PCBs. Table 1 shows the validated analytical results for all samples associated with this investigation. The data was evaluated using the EPA guidance documents entitled *Calculating Upper Confidence Limits for Exposure Point Concentrations as Hazardous Waste Sites* (December 2002). The EPA approved *PRO UCL* software package (Version 2.1, June 2002) was used to calculate various UCLs. A summary of the UCL calculations is provided in Table 2. Printouts from the *PRO UCL* software package are included in the attached Appendix.

Surficial Evaluation: 0 – 3 Feet

West Bank

EPA determined that on the west bank, the averaging area would be defined as the entire riverbank located on Parcel I8-24-1. This is due to the similar physical characteristics of the riverbank and also to include the entire riverbank for this property in one averaging area. This extends the subreach evaluation performed in the EE/CA to include transects 90 and 92. It also extends the subreach to the Elm Street bridge. The EE/CA terminated the subreach (or averaging area) at transect 106, which is approximately 15 feet upstream of the Elm Street bridge.

The data evaluation on the west bank consisted solely of evaluating the upper bank data. There was no re-evaluation of the three-foot excavation depth on the lower bank. This area is a commercial (recreational) property that has an apparent trend in the data where PCB concentrations decrease with an increase in elevation. Therefore, the following averaging areas were based on elevation.

Area A consists of nine sample locations including 27 total samples on the west bank of the river between transects 90 and 106 at elevation 980. This includes samples from depths of 0 to 3 feet. For this area, the average PCB concentration was 3.3 ppm and maximum concentration was 34 ppm. The UCL software package determined that the data was log-normal and the recommended UCL was 9.0 ppm. The 9.0 ppm UCL meets the 10 ppm 0-3 foot cleanup levels specified in the Action Memorandum for recreational properties.

Area B consists of four sample locations including 11 total samples on the west bank of the river between transects 90 and 106 at elevation greater than 980. This includes samples from depths of 0 to 3 feet. For this area, the average PCB concentration was 0.14 ppm and the maximum concentration was 0.54 ppm. The UCL software package determined that the data was log-normal and the recommended UCL was 0.37 ppm. The 0.37 UCL meets 10 ppm 0-3 foot cleanup levels specified in the Action Memorandum for recreational properties.

East Bank

The banks in this stretch of river were evaluated as two distinct areas based on geographic distribution of the sample locations and observed characteristics of the soil types in these areas. The first area includes the bank from transect 92 to transect 98 on the east side of the river. The second area includes the bank from transect 100 to transect 106 on the east side of the river.

Transects 92 – 98 (Parcel I8-23-6)

The first overall area consists of transects 92 through 98 and terminates at the property line of parcel I8-23-6. This area consists of one commercial (recreational) property and there is evidence of fill material on the entire riverbank. There is no obvious trend of PCB data with regard to depth or elevation. Due to these factors and others cited above, the remediation limits for the entire bank were re-evaluated for this area. In an attempt to minimize the required remediation, this area was divided into the following two averaging areas, 0-1 foot depth and 1-3 foot depth.

Area C consists of nineteen sample locations including 19 total samples on the east bank of the river between transects 92 and 98. This includes samples from the depth of 0 to 1 feet only. For this area, the average PCB concentration was 30.64 ppm and the maximum was 150 ppm. The UCL software package determined that the data was log-normal and the recommended UCL was 81.91 ppm. The 81.91 ppm UCL exceeds the 10 ppm cleanup levels specified in the Action Memorandum for recreational properties.

Area D consists of thirteen sample locations including 20 total samples on the east bank of the river between transects 92 and 98. This includes samples from depths of 1 to 3 feet. For this area, the average PCB concentration was 10.16 ppm and the maximum was

43 ppm. The UCL software package determined that the data was log-normal and the recommended UCL was 35.16 ppm. The 35.16 ppm UCL exceeds the 10 ppm cleanup levels specified in the Action Memorandum for recreational properties.

Transects 100 through 106 (parcels I8-23-1, I8-23-2, I8-23-3 and I8-23-4)

The second area includes both a commercial (recreational) and residential property with an apparent trend in the data where PCB concentrations decrease with an increase in elevation. Furthermore, the banks have not been observed to contain fill material. Therefore, the data was evaluated both by elevation and depth. In attempt to minimize excavation volumes, various elevation and depth-based sub areas were evaluated. After the UCLs were calculated for this area, the data was compared to the cleanup levels based on the use of each parcel (i.e., recreational standards for I8-23-2, I8-23-3 and I8-23-4 and residential standards for I8-23-1).

Area E consists of six sample locations including 17 total samples on the east bank of the river between transects 100 and 106 at elevation 980. This includes samples from depths of 0 to 3 feet. For this area, the average PCB concentration was 0.25 ppm and the maximum concentration was 1.4 ppm. The UCL software package determined that the data was log-normal and the recommended UCL was 0.68 ppm. The 0.68 UCL meets 10 ppm 0-3 foot cleanup level for recreational properties and the 2 ppm 0-3 foot cleanup level for residential properties specified in the Action Memorandum

Area F consists of fifteen sample locations including 50 total samples on the east bank of the river between transects 100 and 106 at elevation greater than 980. This includes samples from depths of 0 to 3 feet. For this area, the average PCB concentration was 0.28 ppm and the maximum concentration was 0.9 ppm. The UCL software package determined that the data distribution was not log-normal and not normal. All non-parametric UCLs calculated by the software package were below 1 ppm. Therefore, both the recreational and residential cleanup levels specified in the Action Memorandum are met in this area.

Based on the analysis for areas E and F, cleanup levels for both residential and recreational properties are currently met on parcels I8-23-1, I8-23-2, I8-23-3 and I8-23-4 at elevation 980 and above. Therefore, no remediation above elevation 980 is required on any of these parcels.

An analysis was performed to determine the required bank remediation at elevations below 980 as described in the paragraphs below:

Area G consists of twelve sample locations including 34 total samples on the east bank of the river between transects 100 and 106 at elevations less than 976. This includes samples from depths of 0 to 3 feet. For this area, the average PCB concentration was 8.37 ppm and the maximum concentration was 50 ppm. The UCL software package determined that the data distribution was not log-normal and not normal. All non-parametric UCLs calculated by the software package ranged from 11.62 ppm to 17.17

ppm. Therefore, this area does not currently meet either the residential or recreational cleanup levels specified in the Action Memorandum.

Area H consists of twelve sample locations including 12 total samples on the east bank of the river between transects 100 and 106 at elevation less than 976. This includes samples from depths of 0 to 1 feet. For this area, the average PCB concentration was 11.1 ppm and the maximum concentration was 50 ppm. The UCL software package determined that the data was log-normal and the recommended UCL was 33.9 ppm. The 33.9 ppm UCL exceeds both the 10 ppm cleanup level for recreational properties and the 2 ppm cleanup level for residential properties.

Area I consists of eleven sample locations including 22 total samples on the east bank of the river between transects 100 and 106 at elevation less than 976. This includes samples from depths of 1 to 3 feet. For this area, the average PCB concentration was 6.87 ppm and the maximum concentration was 38.7 ppm. The UCL software package determined that the data distribution was not log-normal and not normal. All non-parametric UCLs calculated by the software package ranged from 10.3 ppm to 16.1 ppm. Therefore, this area does not currently meet either the residential or recreational cleanup levels specified in the Action Memorandum.

Based on the analysis for subareas G, H, I, cleanup levels for both residential and recreational areas are not met at elevations below 976 for the 0-1, 1-3 and 0-3 depth ranges. Therefore, remediation is required on parcels I8-23-1, I8-23-2, I8-23-3 and I8-23-4 from 0-3 feet at elevation 976 and below.

The remaining area to be evaluated on parcels I8-23-1, I8-23-2, I8-23-3 and I8-23-4 is from elevation 976 to 980. Again, three separate calculations were performed and are described in the paragraphs below:

Area J consists of six sample locations including 18 total samples on the east bank of the river between transects 100 and 106 at elevations between 976 and 980. This includes samples from depths of 0 to 3 feet. For this area, the average PCB concentration was 7.5 ppm and the maximum concentration was 74 ppm. The UCL software package determined that the data was log-normal and the recommended UCL was 67 ppm. The 67 ppm UCL exceeds both the 10 ppm cleanup level for recreational properties and the 2 ppm cleanup level for residential properties.

Area K consists of six sample locations including 6 total samples on the east bank of the river between transects 100 and 106 at elevations between 976 and 980. This includes samples from depths of 0 to 1 feet. For this area, the average PCB concentration was 4.39 ppm and the maximum concentration was 14 ppm. The UCL software package determined that the data was log-normal and the recommended UCL was 29.7 ppm. The 29.7 ppm UCL (and the maximum concentration of 14 ppm) exceeds both the 10 ppm cleanup level for recreational properties and the 2 ppm cleanup level for residential properties.

Area L consists of six sample locations including 12 total samples on the east bank of the river between transects 100 and 106 at elevations between 976 and 980. This includes samples from depths of 1 to 3 feet. For this area, the average PCB concentration was 9.12 ppm and the maximum concentration was 74 ppm. The UCL software package determined that the data was log-normal and the recommended UCL was 99 ppm. The 99 ppm UCL (and the maximum concentration of 74 ppm) exceeds both the 10 ppm cleanup level for recreational properties and the 2 ppm cleanup level for residential properties.

Based on the analysis for subareas J, K and L, cleanup levels for both residential and recreational areas are not met at elevations between 976 and 980 for the 0-1, 1-3 and 0-3 depth ranges. Therefore, remediation is required on parcels I8-23-1, I8-23-2, I8-23-3 and I8-23-4 from 0-3 feet from elevation 976 to 980.

In summary, for parcels I8-23-1, I8-23-2, I8-23-3 and I8-23-4, no remediation is required above elevation 980. Remediation is required on all four parcels from 0 to 3 feet at elevations below 980.

Residential Property Evaluation: 3 – 6 Feet

To meet the additional cleanup level set for residential properties, an evaluation of PCB concentrations from samples obtained at depth (3 to 6 feet) was completed for Parcel I8-23-1. Two requirements have been established for the removal action associated with PCB concentrations in bank soils below three feet on residential parcels. First, a not to exceed (NTE) level of 50 ppm for PCBs has been instituted. Therefore, soil at locations and depths where PCB concentrations greater than 50 ppm were detected in samples must be removed. Secondly, residential parcels must have an average PCB concentration in soil from the 3 –15 foot depth of less than 10 ppm (excluding areas below the groundwater table).

The analysis performed below evaluated all PCB results from samples obtained below three feet in the proposed bank remediation area on parcel I8-23-1. To perform this evaluation, the bank was divided into six separate averaging areas. For each averaging area one sample location that had sample depth intervals greater than three feet (including sample locations BS000132, BS000183, BS000184, BS000186, BS000188, and BS000190) was utilized in the analysis. Therefore, the PCB concentrations for each sample location would represent riverbank soils from the perpendicular bi-sector between each sample location, extending from the edge of river to the limit of excavation. The following table depicts the PCB concentrations for each sample location by depth for each averaging area.

Averaging Areas for Parcel I8-23-1: Existing Conditions

Depth Interval (ft)	Areas					
	BS000190	BS000132	BS000188	BS000186	BS000184	BS000183
	1	2	3	4	5	6
3 - 4	8.9	26.8	59	1.2	0.5	0.018
4 - 5	1.9	90.2	48		0.22	0.018
5 - 6	4.5	9.52			0.2	0.018

Sample intervals where duplicate samples were collected have been averaged. This table also shows samples with PCB concentrations greater than the 50 ppm NTE level.

The following table depicts the same samples assuming that the depth intervals with PCB concentrations greater than the 50 ppm NTE level are removed. In addition, an average PCB concentration for each averaging area and the overall bank average is presented at the bottom of the table.

Averaging Areas for Parcel I8-23-1: NTE Intervals Removed

Depth Interval (ft)	Areas					
	BS000190	BS000132	BS000188	BS000186	BS000184	BS000183
	1	2	3	4	5	6
3 - 4	8.9	0.009	0.009	1.2	0.5	0.009
4 - 5	1.9	0.009	48		0.22	0.009
5 - 6	4.5	9.52			0.2	0.009
Averages	5.1	3.2	24.0	1.2	0.31	0.009
Overall Average=						5.6

All samples above depth intervals where PCB concentrations exceeded the 50-ppm NTE level are presumed to be excavated and replaced with clean fill and were assigned a PCB concentration of half the detection level of 0.018 ppm. The overall average PCB concentration for the riverbank area subject to remediation is less than 10 ppm. Therefore, no additional bank excavation is required.

Based on the table above, the deeper PCB data (3-6 feet) on this parcel require excavation from the river to the limit of excavation to a depth of 5 feet in Area 2, and 4 feet in Area 3. All other areas below elevation 980 required remediation from 0 to 3 feet.

Summary and Recommendations

Additional bank sampling was conducted between Transects 98 and 106 within the 1.5 Mile Reach of the Housatonic River. This additional data was gathered to further characterize concentrations of PCBs in the upper banks on these transects and to determine if modifications in the limit of excavation established in the EE/CA would be

appropriate. Based on these new results and supplemental data evaluation, the following conclusions and modifications to remediation limits from the EE/CA were made:

- **West Bank transects 90 to 106 (parcel I8-24-1).** The EE/CA required remediation from 0 to 3 feet for the entire riverbank down to transect 106. The evaluation of the riverbank data on the west side of the river from transect 90 to 106, incorporating the new sampling results, indicates that the existing PCB concentrations are less than the cleanup goal of 10 ppm from elevation 980 to the top of the riverbank. Therefore, the remediation in this area will consist of the top three feet of the riverbank up to elevation 980. No remediation above elevation 980 is required. This remediation will encompass the entire west riverbank for parcel I8-24-1, including transects 90 and 92 and extending to the Elm Street bridge (i.e., approximately 15 feet beyond transect 106).
- **East Bank transects 92 to 98 (parcel I8-23-6).** The EE/CA required remediation from only the 0-1 foot depth to the top of the riverbank in this area. The re-evaluation of the riverbank soil data on the east side of the river from transect 92 to 98, incorporating the new sampling results, indicates that the PCB concentrations exceed the cleanup goal of 10 ppm at the 0-1 foot depth and 1-3 foot depths to the top of the riverbank. Based on this re-evaluation of the data, remediation is required from 0-3 feet to the top of the riverbank in this area. The 0-3 foot remediation is required down to the property line between parcels I8-23-6 and I8-23-4.
- **East bank transects 100 to 106 (parcels I8-23-1, I8-23-2, I8-23-3 and I8-23-4).** The EE/CA required remediation from only the 0-1 foot depth to the top of the riverbank in this area. The re-evaluation of the riverbank soil data on the east side of the river from transect 100 to 106, incorporating the new sampling results, indicates that the PCB concentrations are currently less than both cleanup levels of 10 ppm and 2 ppm from elevation 980 and greater but exceed both the 10 ppm and 2 ppm cleanup levels at elevations less than 980. Therefore, remediation on these parcels (extending all the way to the Elm Street bridge) is required from 0 to 3 feet up to elevation 980. No remediation above elevation 980 is required.
- **Residential Parcel I8-23-1.** The EE/CA did not consider the additional cleanup level of 10 ppm for the 3 to 15 foot depth interval on residential parcels. Based on the evaluation of sample results at depth (3 – 6 feet), it is necessary to remove additional soil at depths greater than the proposed three feet in averaging areas 2 and 3 (see above). In averaging area 2, the total depth of excavation will need to be adjusted to 5 feet while in averaging area 3, the total depth of excavation will need to be adjusted to 4 feet.

Table 1: Sample Results

Location ID	Depth (ft)	PCB Total Result (ppm)	Result Flag
BS000173	0 - 1	0.23	
BS000173	1 - 2	0.1	
BS000173	2 - 3	0.021	U
BS000174	0 - 1	0.5	J
BS000174	1 - 2	1.7	
BS000174	2 - 3	1.7	
BS000175	0 - 1	0.16	
BS000175	1 - 2	0.036	
BS000175	2 - 3	0.022	
BS000176	0 - 1	1.4	
BS000176	1 - 2	0.27	
BS000176	2 - 3	0.13	
BS000177	0 - 1	0.12	
BS000177	1 - 2	0.12	
BS000178	0 - 1	5.1	
BS000178	1 - 2	34	
BS000178	2 - 3	26	
BS000178	0 - 1	5.7	
BS000179	0 - 1	100	
BS000179	1 - 2	14	
BS000179	2 - 3	13	
BS000180	0 - 1	0.54	J
BS000180	1 - 2	0.047	J
BS000180	2 - 2.5	0.13	J
BS000181	0 - 1	2.4	J
BS000181	1 - 2	0.079	J
BS000181	2 - 3	0.24	J
BS000182	0 - 1	0.6	J
BS000182	1 - 2	0.098	J
BS000182	2 - 2.6	0.031	J
BS000183	3 - 4	0.018	U
BS000183	4 - 5	0.018	U
BS000183	5 - 5.7	0.018	U
BS000183	4 - 5	0.018	U
BS000184	3 - 4	0.5	J
BS000184	4 - 5	0.22	J
BS000184	5 - 5.6	0.2	J
BS000185	0 - 1	0.17	J
BS000185	1 - 2	0.018	J
BS000185	2 - 2.6	0.017	U
BS000186	3 - 3.9	1.2	
BS000187	0 - 1	1.4	
BS000187	1 - 2	0.086	
BS000187	2 - 2.2	0.15	
BS000188	3 - 4	59	
BS000188	4 - 5	48	J
BS000189	0 - 1	0.32	
BS000189	1 - 2	0.05	J
BS000189	2 - 3	0.068	J
BS000189	0 - 1	0.32	

Location ID	Depth (ft)	PCB Total Result (ppm)	Result Flag
BS000190	3 - 4	8.9	
BS000190	4 - 5	1.9	
BS000190	5 - 5.6	4.5	
BS000191	0 - 1	0.13	
BS000191	1 - 2	0.064	
BS000191	2 - 3	0.019	
BS000192	0 - 1	0.12	
BS000192	1 - 2	0.15	
BS000193	0 - 1	0.2	
BS000193	1 - 2	0.16	
BS000193	2 - 3	0.36	J
BS000194	0 - 1	0.44	
BS000194	1 - 2	0.28	
BS000194	2 - 3	0.2	
BS000195	0 - 1	120	
BS000195	1 - 2	8.3	
BS000195	2 - 3	3.5	
BS000196	0 - 1	2.7	
BS000196	1 - 1.5	0.65	
BS000197	0 - 1	4.4	
BS000197	1 - 2	0.33	
BS000197	2 - 3	0.78	

Table 2: UCL Results

Data Set	UCL Information			Data Set Characteristics				Sample Set Rationale
	Data Distribution	UCL	UCL Method	Bank	Transects	Sample Depths (ft)	Elevation (ft)	
A	Lognormal	9.01068	95% Chebyshev (MVUE)	West	90 - 106	0 - 3	≈ 980	Commercial property with apparent pattern in data where concentrations decrease with increase in elevation, therefore, data set based on elevation. Commercial property with no apparent pattern in data, predominantly fill material. Commercial/Residential property considered as one averaging area based on lack of fill material in the banks, minimum area covered, and apparent pattern in data where concentrations decrease with increase in elevation, therefore, data set based on elevation.
B	Lognormal	0.372193	95% Chebyshev (MVUE)	West	90 - 106	0 - 3	> 980	
C	Lognormal	81.91109	95% Chebyshev (MVUE)	East	92 - 98	0 - 1	N/A	
D	Lognormal	35.1626	95% Chebyshev (MVUE)	East	92 - 98	1 - 3	N/A	
E	Lognormal	0.684744	95% Chebyshev (MVUE)	East	100 - 106	0 - 3	≈ 980	
F	Non-Parametric	0.314644 -	95% CLT	East	100 - 106	0 - 3	> 980	
		0.367285 ¹	95% Chebyshev (Mean, Std)					
G	Non-Parametric	11.6176 -	95% Standard Bootstrap	East	100 - 106	0 - 3	< 976	
		17.16729 ¹	95% Chebyshev (Mean, Std)					
H	Lognormal	33.85708	95% Chebyshev (MVUE)	East	100 - 106	0 - 1	< 976	
I	Non-Parametric	10.27153 -	95% Standard Bootstrap	East	100 - 106	1 - 3	< 976	
		16.07112 ¹	95% Chebyshev (Mean, Std)					
J	Lognormal	67.70872	99% Chebyshev (MVUE)	East	100 - 106	0 - 3	> 976, < 980	
K	Lognormal	14*	99% Chebyshev (MVUE)	East	100 - 106	0 - 1	> 976, < 980	
L	Lognormal	74*	99% Chebyshev (MVUE)	East	100 - 106	1 - 3	> 976, < 980	

* The maximum Total PCB concentration is presented when the calculated UCL is greater than the maximum.

¹ The minimum and maximum of five separate non parametric UCL calculations is presented

APPENDIX

Pro UCL Software Printouts

Summary Statistics for	A	
Number of Samples		27
Minimum		0.024
Maximum		34
Mean		3.347296
Median		0.5
Standard Deviation		7.918231
Variance		62.69838
Coefficient of Variation		2.36556
Skewness		3.341992

Shapiro-Wilk Test Statistic 0.449159
Shapiro-Wilk 5% Critical Value 0.923
Data not Normal at 5% Significance Level
Data are Lognormal: Try Lognormal UCLs

95 % UCL (Assuming Normal Data)

Student's-t 5.946426

95 % UCL (Adjusted for Skewness)

Adjusted-CLT 6.901079
Modified-t 6.109776

95 % Non-parametric UCL

CLT 5.85383
Jackknife 5.946426
Standard Bootstrap 5.838936
Bootstrap-t 15.21436
Chebyshev (Mean, Std) 9.989666

Pro UCL Software Printouts

Summary Statistics for	A
Number of Samples	27
Minimum	0.024
Maximum	34
Mean	3.347296
Median	0.5
Standard Deviation	7.918231
Variance	62.69838
Coefficient of Variation	2.36556
Skewness	3.341992

95 % UCL (Assuming Normal Data)	
Student's-t	5.946426

95 % UCL (Adjusted for Skewness)	
Adjusted-CLT	6.901079
Modified-t	6.109776

95 % Non-parametric UCL	
CLT	5.85383
Jackknife	5.946426
Standard Bootstrap	5.824646
Bootstrap-t	14.85002
Chebyshev (Mean, Std)	9.989666

Summary Statistics for	ln(A)
Minimum	-3.729701
Maximum	3.526361
Mean	-0.437029
Standard Deviation	1.834343
Variance	3.364814
Shapiro-Wilk Test Statistic	0.973439
Shapiro-Wilk 5% Critical Value	0.923

Data are Lognormal at 5% Significance Level

Estimates Assuming Lognormal Distribution	
MLE Mean	3.474248
MLE Standard Deviation	18.36038
MLE Coefficient of Variation	5.284706
MLE Skewness	163.446
MLE Median	0.645953
MLE 80% Quantile	3.043448
MLE 90% Quantile	6.821653
MLE 95% Quantile	13.20328
MLE 99% Quantile	46.04655

MVU Estimate of Median	0.606846
MVU Estimate of Mean	3.006245
MVU Estimate of Std. Dev.	9.661731
MVU Estimate of SE of Mean	1.377512

UCL Assuming Lognormal Distribution	
95% H-UCL	13.06067
95% Chebyshev (MVUE) UCL	9.01068
99% Chebyshev (MVUE) UCL	16.71232

Recommended UCL to use:
95 % Chebyshev (MVUE) UCL

Pro UCL Software Printouts

Summary Statistics for	B	
Number of Samples		11
Minimum		0.0105
Maximum		0.54
Mean		0.137773
Median		0.12
Standard Deviation		0.148696
Variance		0.02211
Coefficient of Variation		1.079284
Skewness		2.244992

Shapiro-Wilk Test Statistic 0.748451
Shapiro-Wilk 5% Critical Value 0.85
Data not Normal at 5% Significance Level
Data are Lognormal: Try Lognormal UCLs

95 % UCL (Assuming Normal Data)
Student's-t 0.219032

95 % UCL (Adjusted for Skewness)
Adjusted-CLT 0.243944
Modified-t 0.22409

95 % Non-parametric UCL
CLT 0.211517
Jackknife 0.219032
Standard Bootstrap 0.207456
Bootstrap-t 0.299893
Chebyshev (Mean, Std) 0.333197

Pro UCL Software Printouts

Summary Statistics for	B
Number of Samples	11
Minimum	0.0105
Maximum	0.54
Mean	0.137773
Median	0.12
Standard Deviation	0.148696
Variance	0.02211
Coefficient of Variation	1.079284
Skewness	2.244992

95 % UCL (Assuming Normal Data)
Student's-t 0.219032

95 % UCL (Adjusted for Skewness)
Adjusted-CLT 0.243944
Modified-t 0.22409

95 % Non-parametric UCL
CLT 0.211517
Jackknife 0.219032
Standard Bootstrap 0.207614
Bootstrap-t 0.300277
Chebyshev (Mean, Std) 0.333197

Summary Statistics for	ln(B)
Minimum	-4.55638
Maximum	-0.616186
Mean	-2.477883
Standard Deviation	1.119905
Variance	1.254188
Shapiro-Wilk Test Statistic	0.965661
Shapiro-Wilk 5% Critical Value	0.85

Data are Lognormal at 5% Significance Level

Estimates Assuming Lognormal Distribution
MLE Mean 0.157113
MLE Standard Deviation 0.248666
MLE Coefficient of Variation 1.582717
MLE Skewness 8.712841
MLE Median 0.083921
MLE 80% Quantile 0.216197
MLE 90% Quantile 0.353877
MLE 95% Quantile 0.529597
MLE 99% Quantile 1.135436

MVU Estimate of Median 0.079249
MVU Estimate of Mean 0.144816
MVU Estimate of Std. Dev. 0.179614
MVU Estimate of SE of Mean 0.052164

UCL Assuming Lognormal Distribution
95% H-UCL 0.49587
95% Chebyshev (MVUE) UCL 0.372193
99% Chebyshev (MVUE) UCL 0.66384
Recommended UCL to use:
95 % Chebyshev (MVUE) UCL

Pro UCL Software Printouts

Summary Statistics for	C	
Number of Samples		19
Minimum		1.34
Maximum		150
Mean		30.64316
Median		18.2
Standard Deviation		39.49899
Variance		1560.17
Coefficient of Variation		1.288999
Skewness		2.31608

Shapiro-Wilk Test Statistic		0.676472
Shapiro-Wilk 5% Critical Value		0.901

Data not Normal at 5% Significance Level
Data are Lognormal: Try Lognormal UCLs

95 % UCL (Assuming Normal Data)

Student's-t		46.3567
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95 % UCL (Adjusted for Skewness)

Adjusted-CLT		50.69309
Modified-t		47.15918

95 % Non-parametric UCL

CLT		45.54831
Jackknife		46.3567
Standard Bootstrap		45.37294
Bootstrap-t		71.31358
Chebyshev (Mean, Std)		70.14215

Pro UCL Software Printouts

Summary Statistics for	C
Number of Samples	19
Minimum	1.34
Maximum	150
Mean	30.64316
Median	18.2
Standard Deviation	39.49899
Variance	1560.17
Coefficient of Variation	1.288999
Skewness	2.31608

Summary Statistics for	ln(C)
Minimum	0.29267
Maximum	5.010635
Mean	2.744252
Standard Deviation	1.282147
Variance	1.6439
Shapiro-Wilk Test Statistic	0.958284
Shapiro-Wilk 5% Critical Value	0.901
Data are Lognormal at 5% Significance Level	

95 % UCL (Assuming Normal Data)	
Student's-t	46.3567

95 % UCL (Adjusted for Skewness)	
Adjusted-CLT	50.69309
Modified-t	47.15918

95 % Non-parametric UCL	
CLT	45.54831
Jackknife	46.3567
Standard Bootstrap	45.02426
Bootstrap-t	69.22947
Chebyshev (Mean, Std)	70.14215

Estimates Assuming Lognormal Distribution	
MLE Mean	35.38198
MLE Standard Deviation	72.29808
MLE Coefficient of Variation	2.043359
MLE Skewness	14.66174
MLE Median	15.55298
MLE 80% Quantile	45.95518
MLE 90% Quantile	80.78659
MLE 95% Quantile	128.1734
MLE 99% Quantile	306.9012

MVU Estimate of Median	14.8931
MVU Estimate of Mean	32.95603
MVU Estimate of Std. Dev.	53.28524
MVU Estimate of SE of Mean	11.23106

UCL Assuming Lognormal Distribution	
95% H-UCL	89.04082
95% Chebyshev (MVUE) UCL	81.91109
99% Chebyshev (MVUE) UCL	144.7037
Recommended UCL to use:	
95 % Chebyshev (MVUE) UCL	

Pro UCL Software Printouts

Summary Statistics for	D	
Number of Samples		20
Minimum		0.284
Maximum		43
Mean		10.1628
Median		6.03
Standard Deviation		11.70812
Variance		137.08
Coefficient of Variation		1.152056
Skewness		1.542804

Shapiro-Wilk Test Statistic	0.808758
Shapiro-Wilk 5% Critical Value	0.905

Data not Normal at 5% Significance Level
Data are Lognormal: Try Lognormal UCLs

95 % UCL (Assuming Normal Data)

Student's-t	14.68969
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95 % UCL (Adjusted for Skewness)

Adjusted-CLT	15.4341
Modified-t	14.84022

95 % Non-parametric UCL

CLT	14.46905
Jackknife	14.68969
Standard Bootstrap	14.18428
Bootstrap-t	15.76195
Chebyshev (Mean, Std)	21.57446

Pro UCL Software Printouts

Summary Statistics for	D
Number of Samples	20
Minimum	0.284
Maximum	43
Mean	10.1628
Median	6.03
Standard Deviation	11.70812
Variance	137.08
Coefficient of Variation	1.152056
Skewness	1.542804

Summary Statistics for	ln(D)
Minimum	-1.258781
Maximum	3.7612
Mean	1.496055
Standard Deviation	1.518334
Variance	2.305338
Shapiro-Wilk Test Statistic	0.949298
Shapiro-Wilk 5% Critical Value	0.905

Data are Lognormal at 5% Significance Level

95 % UCL (Assuming Normal Data)	
Student's-t	14.68969

95 % UCL (Adjusted for Skewness)	
Adjusted-CLT	15.4341
Modified-t	14.84022

95 % Non-parametric UCL	
CLT	14.46905
Jackknife	14.68969
Standard Bootstrap	14.29063
Bootstrap-t	16.17313
Chebyshev (Mean, Std)	21.57446

Estimates Assuming Lognormal Distribution	
MLE Mean	14.13599
MLE Standard Deviation	42.47285
MLE Coefficient of Variation	3.00459
MLE Skewness	36.1379
MLE Median	4.464044
MLE 80% Quantile	16.10367
MLE 90% Quantile	31.40961
MLE 95% Quantile	54.25604
MLE 99% Quantile	152.5816
MVU Estimate of Median	4.213368
MVU Estimate of Mean	12.68244
MVU Estimate of Std. Dev.	26.72566
MVU Estimate of SE of Mean	5.157303

UCL Assuming Lognormal Distribution	
95% H-UCL	46.06085
95% Chebyshev (MVUE) UCL	35.1626
99% Chebyshev (MVUE) UCL	63.99696

Recommended UCL to use:
95 % Chebyshev (MVUE) UCL

Pro UCL Software Printouts

Summary Statistics for	E	
Number of Samples		17
Minimum		0.0085
Maximum		1.4
Mean		0.253559
Median		0.17
Standard Deviation		0.3189
Variance		0.101697
Coefficient of Variation		1.257695
Skewness		3.191291

Shapiro-Wilk Test Statistic 0.618908
Shapiro-Wilk 5% Critical Value 0.892
Data not Normal at 5% Significance Level
Data are Lognormal: Try Lognormal UCLs

95 % UCL (Assuming Normal Data)

Student's-t 0.388593

95 % UCL (Adjusted for Skewness)

Adjusted-CLT 0.444746

Modified-t 0.398571

95 % Non-parametric UCL

CLT 0.380779

Jackknife 0.388593

Standard Bootstrap 0.376024

Bootstrap-t 0.555135

Chebyshev (Mean, Std) 0.590696

Pro UCL Software Printouts

Summary Statistics for	E
Number of Samples	17
Minimum	0.0085
Maximum	1.4
Mean	0.253559
Median	0.17
Standard Deviation	0.3189
Variance	0.101697
Coefficient of Variation	1.257695
Skewness	3.191291

95 % UCL (Assuming Normal Data)	
Student's-t	0.388593

95 % UCL (Adjusted for Skewness)	
Adjusted-CLT	0.444746
Modified-t	0.398571

95 % Non-parametric UCL	
CLT	0.380779
Jackknife	0.388593
Standard Bootstrap	0.37674
Bootstrap-t	0.539919
Chebyshev (Mean, Std)	0.590696

Summary Statistics for	ln(E)
Minimum	-4.767689
Maximum	0.336472
Mean	-1.935853
Standard Deviation	1.207611
Variance	1.458325
Shapiro-Wilk Test Statistic	0.938778
Shapiro-Wilk 5% Critical Value	0.892
Data are Lognormal at 5% Significance Level	

Estimates Assuming Lognormal Distribution	
MLE Mean	0.299186
MLE Standard Deviation	0.543395
MLE Coefficient of Variation	1.816247
MLE Skewness	11.44009
MLE Median	0.144301
MLE 80% Quantile	0.400348
MLE 90% Quantile	0.681082
MLE 95% Quantile	1.051973
MLE 99% Quantile	2.394204

MVU Estimate of Median	0.138228
MVU Estimate of Mean	0.279821
MVU Estimate of Std. Dev.	0.408957
MVU Estimate of SE of Mean	0.092896

UCL Assuming Lognormal Distribution	
95% H-UCL	0.742836
95% Chebyshev (MVUE) UCL	0.684744
99% Chebyshev (MVUE) UCL	1.204121
Recommended UCL to use:	
95 % Chebyshev (MVUE) UCL	

Pro UCL Software Printouts

Summary Statistics for	F	
Number of Samples		50
Minimum		0.019
Maximum		0.9
Mean		0.28274
Median		0.3
Standard Deviation		0.13715
Variance		0.01881
Coefficient of Variation		0.485076
Skewness		2.014036
Shapiro-Wilk Test Statistic		0.745881
Shapiro-Wilk 5% Critical Value		0.947
Data not Normal at 5% Significance Level		
Data not Lognormal: Try Non-parametric UCL		
95 % UCL (Assuming Normal Data)		
Student's-t		0.315258
95 % UCL (Adjusted for Skewness)		
Adjusted-CLT		0.320547
Modified-t		0.316179
95 % Non-parametric UCL		
CLT		0.314644
Jackknife		0.315258
Standard Bootstrap		0.314371
Bootstrap-t		0.322321
Chebyshev (Mean, Std)		0.367285

Pro UCL Software Printouts

Summary Statistics for	F
Number of Samples	50
Minimum	0.019
Maximum	0.9
Mean	0.28274
Median	0.3
Standard Deviation	0.13715
Variance	0.01881
Coefficient of Variation	0.485076
Skewness	2.014036

95 % UCL (Assuming Normal Data)

Student's-t	0.315258
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95 % UCL (Adjusted for Skewness)

Adjusted-CLT	0.320547
Modified-t	0.316179

95 % Non-parametric UCL

CLT	0.314644
Jackknife	0.315258
Standard Bootstrap	0.314814
Bootstrap-t	0.324517
Chebyshev (Mean, Std)	0.367285

Summary Statistics for	ln(F)
Minimum	-3.963316
Maximum	-0.105361
Mean	-1.408915
Standard Deviation	0.649566
Variance	0.421937
Shapiro-Wilk Test Statistic	0.707102
Shapiro-Wilk 5% Critical Value	0.947
Data not Lognormal at 5% Significance Level	
Data not Normal: Try Non-parametric UCL	

Estimates Assuming Lognormal Distribution

MLE Mean	0.301813
MLE Standard Deviation	0.218666
MLE Coefficient of Variation	0.724508
MLE Skewness	2.553826
MLE Median	0.244408
MLE 80% Quantile	0.423149
MLE 90% Quantile	0.563143
MLE 95% Quantile	0.711501
MLE 99% Quantile	1.107358

MVU Estimate of Median	0.243379
MVU Estimate of Mean	0.300293
MVU Estimate of Std. Dev.	0.213421
MVU Estimate of SE of Mean	0.029854

UCL Assuming Lognormal Distribution

95% H-UCL	0.362942
95% Chebyshev (MVUE) UCL	0.430426
99% Chebyshev (MVUE) UCL	0.59734

Pro UCL Software Printouts

Summary Statistics for	G	
Number of Samples		34
Minimum		0.2765
Maximum		50
Mean		8.373294
Median		3.2275
Standard Deviation		11.76383
Variance		138.3877
Coefficient of Variation		1.404923
Skewness		2.063558
Shapiro-Wilk Test Statistic		0.717064
Shapiro-Wilk 5% Critical Value		0.933
Data not Normal at 5% Significance Level		
Data not Lognormal: Try Non-parametric UCL		
95 % UCL (Assuming Normal Data)		
Student's-t		11.7876
95 % UCL (Adjusted for Skewness)		
Adjusted-CLT		12.45465
Modified-t		11.90659
95 % Non-parametric-UCL		
CLT		11.69175
Jackknife		11.7876
Standard Bootstrap		11.6176
Bootstrap-t		12.76148
Chebyshev (Mean, Std)		17.16729

Pro UCL Software Printouts

Summary Statistics for	G
Number of Samples	34
Minimum	0.2765
Maximum	50
Mean	8.373294
Median	3.2275
Standard Deviation	11.76383
Variance	138.3877
Coefficient of Variation	1.404923
Skewness	2.063558

95 % UCL (Assuming Normal Data)

Student's-t	11.7876
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95 % UCL (Adjusted for Skewness)

Adjusted-CLT	12.45465
Modified-t	11.90659

95 % Non-parametric UCL

CLT	11.69175
Jackknife	11.7876
Standard Bootstrap	11.61002
Bootstrap-t	12.96598
Chebyshev (Mean, Std)	17.16729

Summary Statistics for	ln(G)
Minimum	-1.285544
Maximum	3.912023
Mean	1.029208
Standard Deviation	1.653171
Variance	2.732973

Shapiro-Wilk Test Statistic	0.908399
Shapiro-Wilk 5% Critical Value	0.933
Data not Lognormal at 5% Significance Level	
Data not Normal: Try Non-parametric UCL	

Estimates Assuming Lognormal Distribution

MLE Mean	10.97582
MLE Standard Deviation	41.61924
MLE Coefficient of Variation	3.791905
MLE Skewness	65.89777
MLE Median	2.798847
MLE 80% Quantile	11.31509
MLE 90% Quantile	23.41863
MLE 95% Quantile	42.46471
MLE 99% Quantile	130.9064

MVU Estimate of Median	2.688466
MVU Estimate of Mean	10.06948
MVU Estimate of Std. Dev.	27.94098
MVU Estimate of SE of Mean	3.748983

UCL Assuming Lognormal Distribution

95% H-UCL	28.06295
95% Chebyshev (MVUE) UCL	26.41092
99% Chebyshev (MVUE) UCL	47.37139

Pro UCL Software Printouts

Summary Statistics for	H	
Number of Samples		12
Minimum		0.53
Maximum		50
Mean		11.129
Median		4.305
Standard Deviation		14.67049
Variance		215.2232
Coefficient of Variation		1.318221
Skewness		2.03844

Shapiro-Wilk Test Statistic	0.724852
Shapiro-Wilk 5% Critical Value	0.859

Data not Normal at 5% Significance Level
Data are Lognormal: Try Lognormal UCLs

95 % UCL (Assuming Normal Data)

Student's-t	18.73458
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95 % UCL (Adjusted for Skewness)

Adjusted-CLT	20.75778
Modified-t	19.14993

95 % Non-parametric UCL

CLT	18.09496
Jackknife	18.73458
Standard Bootstrap	17.69717
Bootstrap-t	28.77827
Chebyshev (Mean, Std)	29.58896

Pro UCL Software Printouts

Summary Statistics for	H
Number of Samples	12
Minimum	0.53
Maximum	50
Mean	11.129
Median	4.305
Standard Deviation	14.67049
Variance	215.2232
Coefficient of Variation	1.318221
Skewness	2.03844

Summary Statistics for	ln(H)
Minimum	-0.634878
Maximum	3.912023
Mean	1.638091
Standard Deviation	1.379133
Variance	1.902008
Shapiro-Wilk Test Statistic	0.958476
Shapiro-Wilk 5% Critical Value	0.859

Data are Lognormal at 5% Significance Level

95 % UCL (Assuming Normal Data)	
Student's-t	18.73458

95 % UCL (Adjusted for Skewness)	
Adjusted-CLT	20.75778
Modified-t	19.14993

95 % Non-parametric UCL	
CLT	18.09496
Jackknife	18.73458
Standard Bootstrap	17.68046
Bootstrap-t	29.05058
Chebyshev (Mean, Std)	29.58896

Estimates Assuming Lognormal Distribution	
MLE Mean	13.31772
MLE Standard Deviation	31.79375
MLE Coefficient of Variation	2.387328
MLE Skewness	20.76816
MLE Median	5.145339
MLE 80% Quantile	16.50162
MLE 90% Quantile	30.27364
MLE 95% Quantile	49.7378
MLE 99% Quantile	127.2247
MVU Estimate of Median	4.75098
MVU Estimate of Mean	11.6928
MVU Estimate of Std. Dev.	19.04021
MVU Estimate of SE of Mean	5.084836

UCL Assuming Lognormal Distribution	
95% H-UCL	60.6735
95% Chebyshev (MVUE) UCL	33.85708
99% Chebyshev (MVUE) UCL	62.28628
Recommended UCL to use:	
95 % Chebyshev (MVUE) UCL	

Pro UCL Software Printouts

Summary Statistics for	I
Number of Samples	22
Minimum	0.2765
Maximum	38.7
Mean	6.870182
Median	1.625
Standard Deviation	9.900713
Variance	98.02413
Coefficient of Variation	1.441114
Skewness	1.882275

Shapiro-Wilk Test Statistic	0.710236
Shapiro-Wilk 5% Critical Value	0.911
Data not Normal at 5% Significance Level	
Data not Lognormal: Try Non-parametric UCL	

95 % UCL (Assuming Normal Data)

Student's-t	10.50239
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95 % UCL (Adjusted for Skewness)

Adjusted-CLT	11.24733
Modified-t	10.64357

95 % Non-parametric UCL

CLT	10.3422
Jackknife	10.50239
Standard Bootstrap	10.27153
Bootstrap-t	11.69761
Chebyshev (Mean, Std)	16.07112

Pro UCL Software Printouts

Summary Statistics for	l
Number of Samples	22
Minimum	0.2765
Maximum	38.7
Mean	6.870182
Median	1.625
Standard Deviation	9.900713
Variance	98.02413
Coefficient of Variation	1.441114
Skewness	1.882275

95 % UCL (Assuming Normal Data)
Student's-t 10.50239

95 % UCL (Adjusted for Skewness)
Adjusted-CLT 11.24733
Modified-t 10.64357

95 % Non-parametric UCL
CLT 10.3422
Jackknife 10.50239
Standard Bootstrap 10.30768
Bootstrap-t 12.13403
Chebyshev (Mean, Std) 16.07112

Summary Statistics for	ln(l)
Minimum	-1.285544
Maximum	3.65584
Mean	0.697089
Standard Deviation	1.723652
Variance	2.970976
Shapiro-Wilk Test Statistic	0.865417
Shapiro-Wilk 5% Critical Value	0.911
Data not Lognormal at 5% Significance Level	
Data not Normal: Try Non-parametric UCL	

Estimates Assuming Lognormal Distribution
MLE Mean 8.869136
MLE Standard Deviation 38.15889
MLE Coefficient of Variation 4.302436
MLE Skewness 92.54949
MLE Median 2.0079
MLE 80% Quantile 8.615607
MLE 90% Quantile 18.39322
MLE 95% Quantile 34.20928
MLE 99% Quantile 110.6424

MVU Estimate of Median 1.876423
MVU Estimate of Mean 7.680591
MVU Estimate of Std. Dev. 20.56609
MVU Estimate of SE of Mean 3.498899

UCL Assuming Lognormal Distribution
95% H-UCL 34.96915
95% Chebyshev (MVUE) UCL 22.93194
99% Chebyshev (MVUE) UCL 42.49419

Pro UCL Software Printouts

Summary Statistics for	J	
Number of Samples		18
Minimum		0.009
Maximum		74
Mean		7.54225
Median		1.225
Standard Deviation		17.20744
Variance		296.0959
Coefficient of Variation		2.281473
Skewness		3.766125

Shapiro-Wilk Test Statistic 0.455676
Shapiro-Wilk 5% Critical Value 0.897
Data not Normal at 5% Significance Level
Data are Lognormal: Try Lognormal UCLs

95 % UCL (Assuming Normal Data)

Student's-t 14.5978

95 % UCL (Adjusted for Skewness)

Adjusted-CLT 18.06047

Modified-t 15.19785

95 % Non-parametric UCL

CLT 14.2135

Jackknife 14.5978

Standard Bootstrap 13.88059

Bootstrap-t 29.58886

Chebyshev (Mean, Std) 25.22121

Pro UCL Software Printouts

Summary Statistics for	J
Number of Samples	18
Minimum	0.009
Maximum	74
Mean	7.54225
Median	1.225
Standard Deviation	17.20744
Variance	296.0959
Coefficient of Variation	2.281473
Skewness	3.766125

95 % UCL (Assuming Normal Data)	
Student's-t	14.5978

95 % UCL (Adjusted for Skewness)	
Adjusted-CLT	18.06047
Modified-t	15.19785

95 % Non-parametric UCL	
CLT	14.2135
Jackknife	14.5978
Standard Bootstrap	14.01981
Bootstrap-t	29.96044
Chebyshev (Mean, Std)	25.22121

99 % Non-parametric UCL	
Chebyshev (Mean, Std)	47.89726

Summary Statistics for	ln(J)
Minimum	-4.710531
Maximum	4.304065
Mean	0.274949
Standard Deviation	2.150693
Variance	4.625481
Shapiro-Wilk Test Statistic	0.940501
Shapiro-Wilk 5% Critical Value	0.897

Data are Lognormal at 5% Significance Level

Estimates Assuming Lognormal Distribution	
MLE Mean	13.29901
MLE Standard Deviation	133.6877
MLE Coefficient of Variation	10.05245
MLE Skewness	1045.976
MLE Median	1.316464
MLE 80% Quantile	8.10341
MLE 90% Quantile	20.87579
MLE 95% Quantile	45.27882
MLE 99% Quantile	195.872

MVU Estimate of Median	1.156711
MVU Estimate of Mean	9.580168
MVU Estimate of Std. Dev.	35.66459
MVU Estimate of SE of Mean	5.842139

UCL Assuming Lognormal Distribution	
95% H-UCL	148.803
95% Chebyshev (MVUE) UCL	35.04546
99% Chebyshev (MVUE) UCL	67.70872
Recommended UCL to use:	
99 % Chebyshev (MVUE) UCL	

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Summary Statistics for	K
Number of Samples	6
Minimum	0.2925
Maximum	14
Mean	4.389833
Median	1.225
Standard Deviation	5.775825
Variance	33.36015
Coefficient of Variation	1.315728
Skewness	1.242735

Shapiro-Wilk Test Statistic	0.764855
Shapiro-Wilk 5% Critical Value	0.788
Data not Normal at 5% Significance Level	
Data are Lognormal: Try Lognormal UCLs	

95 % UCL (Assuming Normal Data)

Student's-t	9.141258
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95 % UCL (Adjusted for Skewness)

Adjusted-CLT	9.546617
Modified-t	9.340641

95 % Non-parametric UCL

CLT	8.26835
Jackknife	9.141258
Standard Bootstrap	7.950189
Bootstrap-t	42.88908
Chebyshev (Mean, Std)	14.66799

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Summary Statistics for	K
Number of Samples	6
Minimum	0.2925
Maximum	14
Mean	4.389833
Median	1.225
Standard Deviation	5.775825
Variance	33.36015
Coefficient of Variation	1.315728
Skewness	1.242735

Summary Statistics for	ln(K)
Minimum	-1.229291
Maximum	2.639057
Mean	0.537559
Standard Deviation	1.572005
Variance	2.471199
Shapiro-Wilk Test Statistic	0.913254
Shapiro-Wilk 5% Critical Value	0.788
Data are Lognormal at 5% Significance Level	

95 % UCL (Assuming Normal Data)	
Student's-t	9.141258

95 % UCL (Adjusted for Skewness)	
Adjusted-CLT	9.546617
Modified-t	9.340641

95 % Non-parametric UCL	
CLT	8.26835
Jackknife	9.141258
Standard Bootstrap	7.983528
Bootstrap-t	45.39933
Chebyshev (Mean, Std)	14.66799

99 % Non-parametric UCL	
Chebyshev (Mean, Std)	27.85134

Estimates Assuming Lognormal Distribution	
MLE Mean	5.889425
MLE Standard Deviation	19.38742
MLE Coefficient of Variation	3.291903
MLE Skewness	45.54883
MLE Median	1.711823
MLE 80% Quantile	6.461768
MLE 90% Quantile	12.90461
MLE 95% Quantile	22.72593
MLE 99% Quantile	66.29018

MVU Estimate of Median	1.384263
MVU Estimate of Mean	4.261876
MVU Estimate of Std. Dev.	6.598429
MVU Estimate of SE of Mean	2.552199

UCL Assuming Lognormal Distribution	
95% H-UCL	539.1912
95% Chebyshev (MVUE) UCL	15.38665
99% Chebyshev (MVUE) UCL	29.65593
Recommended UCL to use:	
99 % Chebyshev (MVUE) UCL	

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Summary Statistics for	L	
Number of Samples		12
Minimum		0.009
Maximum		74
Mean		9.118458
Median		1.065
Standard Deviation		20.84006
Variance		434.3081
Coefficient of Variation		2.285481
Skewness		3.233683

Shapiro-Wilk Test Statistic		0.478417
Shapiro-Wilk 5% Critical Value		0.859

Data not Normal at 5% Significance Level
Data are Lognormal: Try Lognormal UCLs

95 % UCL (Assuming Normal Data)

Student's-t		19.92251
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95 % UCL (Adjusted for Skewness)

Adjusted-CLT		25.01452
Modified-t		20.85849

95 % Non-parametric UCL

CLT		19.01391
Jackknife		19.92251
Standard Bootstrap		18.55318
Bootstrap-t		51.44094
Chebyshev (Mean, Std)		35.34163

Pro UCL Software Printouts

Summary Statistics for	L
Number of Samples	12
Minimum	0.009
Maximum	74
Mean	9.118458
Median	1.065
Standard Deviation	20.84006
Variance	434.3081
Coefficient of Variation	2.285481
Skewness	3.233683

Summary Statistics for	ln(L)
Minimum	-4.710531
Maximum	4.304065
Mean	0.143645
Standard Deviation	2.443107
Variance	5.968773
Shapiro-Wilk Test Statistic	0.938774
Shapiro-Wilk 5% Critical Value	0.859
Data are Lognormal at 5% Significance Level	

95 % UCL (Assuming Normal Data)	
Student's-t	19.92251

Estimates Assuming Lognormal Distribution	
MLE Mean	22.82898
MLE Standard Deviation	450.851
MLE Coefficient of Variation	19.74906
MLE Skewness	7761.886
MLE Median	1.154474
MLE 80% Quantile	9.098141
MLE 90% Quantile	26.65661
MLE 95% Quantile	64.23549
MLE 99% Quantile	339.1057

95 % UCL (Adjusted for Skewness)	
Adjusted-CLT	25.01452
Modified-t	20.85849

95 % Non-parametric UCL	
CLT	19.01391
Jackknife	19.92251
Standard Bootstrap	18.49521
Bootstrap-t	52.80698
Chebyshev (Mean, Std)	35.34163

MVU Estimate of Median	0.895803
MVU Estimate of Mean	11.93681
MVU Estimate of Std. Dev.	43.747
MVU Estimate of SE of Mean	8.782161

99 % Non-parametric UCL	
Chebyshev (Mean, Std)	68.97697

UCL Assuming Lognormal Distribution	
95% H-UCL	1813.975
95% Chebyshev (MVUE) UCL	50.21736
99% Chebyshev (MVUE) UCL	99.31821
Recommended UCL to use:	
99 % Chebyshev (MVUE) UCL	

