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March 14, 2019

Mr. David Brownlee
Unit Coordinator
Response & Remediation Program
Land Protection Branch
Georgia Environmental Protection Division
2 Martin Luther King Jr. Drive, SE, Suite 1054
Atlanta, Georgia 30334

Re: Voluntary Remediation Program Twelfth Semi-Annual Status Update
CSX Transportation, Inc.
DePriest Signal Shop (HSI #10611)
641 East Liberty Street
Savannah, Chatham County, Georgia
Tax Parcel ID#2-0033-12-001

Dear Mr. Brownlee:

The following report is submitted in accordance with requirements of the Voluntary Remediation Program. This site was accepted into the program on March 15, 2013.

This semi-annual report includes a Corrective Action Plan (CAP) for the site as well as addressing other comments in your letter dated February 4, 2019. Some of these comments address questions regarding the development of risk reduction standards for the site. Clarifications are presented to address those questions and to propose appropriate standards for EPD approval. The CAP was prepared under the assumption that the risk reduction standards as proposed are acceptable.

As noted in the March 15, 2013, VRP approval letter, CSXT is required to submit a Compliance Status Report by March 15, 2018. CSXT is unable to complete the VRP requirements within this five-year timeframe due to delayed review and concurrence, but is prepared to proceed expeditiously when Georgia EPD approvals are obtained.

Professional hours charged to the project during this semi-annual period consist of 52 hours by the undersigned. Work has included site inspection and preparation of this document.

Please note that the address for Matt Adkins has been changed to that shown below.

Sincerely,

Ronald E. Holley, P.E.

Enclosures

cc: Matt Adkins, CSXT
1590 Marietta Blvd. NW
Atlanta, GA 30318

Professional Engineer Certification

I certify under penalty of law that this report and all attachments were prepared by me or under my direct supervision in accordance with the Voluntary Remediation Program Act (O.C.G.A. Section 12-8-101, et. seq.). I am a professional engineer who is registered with the Georgia State Board of Registration for Professional Engineers and I have the necessary experience and am in charge of the investigation and remediation of this release of regulated substances.

Furthermore, to document my direct oversight of the Voluntary Remediation Plan development, implementation of corrective action, and long term monitoring, I have included a monthly summary of hours invoiced and a description of services provided by me to the Voluntary Remediation Program participant since the previous submittal to the Georgia Environmental Protection Division.

The information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

March 14, 2019

Ronald E. Holley, P.E. Date
Georgia Registration 16507

Corrective Action Plan

DePriest Signal Shop VRP Site

Savannah, GA

March 2019

Prepared for

CSX Transportation, Inc.

Jacksonville, FL

Prepared by

Holley Consultants, Inc.

Roswell, GA

TABLE OF CONTENTS

Corrective Action Plan

DePriest Signal Shop VRP Site

Savannah, GA

1.0 Introduction

The following Corrective Action Plan (CAP) addresses the removal of impacted soil at the referenced site in compliance with the State of Georgia Voluntary Remediation Program (VRP). The approach and specific actions are proposed under the assumption that risk reductions standards proposed for the site in **Attachment A** to this document are approved by the Georgia Environmental Protection division (EPD).

2.0 Property Description

The DePriest Signal Shop Site (the Site) is part of the former Liberty Street Yard, which began operation in 1854. Several parcels were added to the property in subsequent years. Over several years, the railroad constructed a terminal facility, which included a depot, warehouses, and car and locomotive repair shops. Ownership of the property and facilities progressed through several companies. The current owner of the property that has remained in railroad ownership is CSXT, which maintains the DePriest Signal Shop for assembling and repairing railroad signals.

The Site is located in the northeast portion of Savannah, Georgia (see **Figure 1.1**). The area is located approximately 2/3 mile (3,500 feet) southwest of the Savannah River. Properties comprising the former Liberty Street Yard include: approximately 24 acres owned by CSXT, part of which is occupied by the DePriest Signal Shop; approximately 12.72 (9.15 + 3.57) acres owned by the Savannah-Chatham County Board of Education (East Broad Elementary School); approximately 7.7 acres owned by Chatham County and leased to the City of Savannah (Mathilda Park); and 2.75 acres owned by the Catholic Bishop of the Diocese of Savannah.

The Site topography is generally flat, with the highest elevation to the west. The total topographic relief on site varies from about 25 feet mean sea level (msl) in the west portion of the Site to about 15 feet msl along the eastern edge. Surface drainage flows to storm drains on the properties, eventually entering the city storm sewer system east of the Site.

The CSXT DePriest Signal Shop is currently engaged in production and storage of railroad signal equipment. The site includes several buildings and covered storage areas in the north

portion of the site, as well as paved parking lots and concrete pads. The southern fenced portion of the site is vacant land with gravel and grass cover and occasional concrete pads. Wooded and overgrown vacant land is located southeast and west of the fenced portion of the site.

3.0 Environmental History

Initial limited environmental sampling at the site by CSXT in the 1990's indicated the presence of two (2) Hazardous Site Response Act (HSRA) regulated substances at levels in excess of state mandated notification concentrations – lead and benzo(a)pyrene. A Release Notification was filed on May 29, 1998. EPD responded on February 12, 2002, with a letter requiring that a CSR be prepared.

Initial soil and ground water sampling was conducted between May and August 2002 in connection with CSR preparation. The initial CSR was submitted to EPD in August 2002. It noted that off-site sampling in an adjacent park and school was needed to complete delineations, but could not proceed until access was granted by current owners. When sampling was conducted in the off-site areas starting in July 2003, impacts were identified that prompted an expedited investigation and remediation of those properties. The off-site remediation was completed in September 2004.

Upon completion of the off-site activities, CSXT resumed additional sampling of the remainder of the DePriest Signal Shop site. Samples were collected from March-May 2005. The following regulated substances were detected in soil - arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, and multiple semi-volatile organic compounds (SVOC's). Those substances with levels greater than HSRA notification concentrations were identified, and an effort was made to delineate the extent to which these regulated substances exceeded background concentrations. All substances except SVOC's were delineated to their background concentrations within the site boundaries.

Ground water sampling was conducted in May 2002 and November 2003. Analysis revealed the presence of low levels of barium, and a delineation to background concentrations was performed. No other regulated substances were detected in ground water.

Type 3 and Type 4 minimum risk reduction standards (RRS) applicable to industrial sites were developed for substances found in soil at greater than background concentrations. All metals except mercury and selenium exceeded Type 3 standards in at least one location. Arsenic, barium, and lead were the only metals to exceed the Type 4 standards. Several SVOC's also exceeded Type 3 standards, but only benzo(a)pyrene exceeded the Type 4 standard. Barium did not exceed Type 3 risk reduction standards in ground water.

A CSR for the on-site areas was submitted in September 2005. An amendment was submitted in March 2008.

In 2012, CSXT submitted an application to include the DePriest Signal Shop Site in the Voluntary Remediation Program (VRP). The Site was accepted into the program on March 15, 2013. Since that time, eleven Semi-annual Status Update reports have been submitted to EPD. The ninth Semi-annual Status Update report submitted in September 2017 proposed alternative RRS based upon exposure averaging methodology. EPD responded to that update in February 2019 calling for preparation of a CAP.

4.0 Regulated Substances to be Remediated and Associated Risk Reduction Standards

The ninth Semi-annual Status Update report describes the process of calculating risk reduction standards for regulated substances observed at the Site. The Site was divided into four (4) exposure domains based upon potential exposure scenarios. Exposure factors appropriate to each area were assigned, and corresponding RRS were calculated using exposure averaging techniques. Based upon their review, EPD requested clarifications of the calculations and additional tables and figures. Reponses to the EPD comments are provided in **Attachment A**.

Risk-based calculations included the development of averaged exposure point concentrations (EPC) using all soil data. It was determined that only one regulated substance (arsenic) had RRS exceedances at the Site. (see **Table 3**). Exceedances were observed only in shallow soils (typically 0-2 feet). No exceedances were observed in deeper zones.

Determination of where remediation is needed to meet the arsenic RRS was conducted by removing soil sampling points (data points) with higher concentrations of arsenic from the calculations until the average EPC was below the applicable RRS. **Table 3** shows that the following points should be removed:

003-0-1	203/0-2	404/0-2	502/0-1	602/0-1
701/0-1	822/0-1	1332/0-1		

In addition, CSXT intends to voluntarily remove the area around sampling point 702 because it is a lead hot spot. (Note that on Table 3 the lead calculation changed when sample points were removed because lead in those areas will be removed although it does not exceed RRS.)

Outlines of the five (5) areas requiring remediation based upon the calculations are presented on **Figure 1**.

5.0 Evaluation of Corrective Action

The selected remedy to remove arsenic and lead impacted soil at the Site is excavation. It will be conducted in those areas shown on **Figure 1**, which encompass the sampling points with elevated levels as noted above. There are five (5) areas identified, as noted below:

Area Designation	Domain Location	Estimated Area (SF)
SW	West	1,700
W	West	8,700
S	South	16,600
E	East	1,600
NW	West	500
	Total rounded	30,000

The actual areal extent of the excavations will be established by soil analysis (see below). Excavation will be conducted to depths of approximately two feet in each area, corresponding with previous sample depth intervals. Impacted soils will be transported to a local non-hazardous landfill for disposal. Clean soil will be obtained from an off-site source and used to backfill the excavations to previous grade. Vegetation will be applied to complete the process.

Incidental to the remedial activity will be the maintenance of existing fences at the Site. CSXT may choose to expand fencing in some areas to discourage trespassing.

Based upon previous soil excavation at the site, cost of the remedial effort is estimated as follows:

Total volume of soil in tons = 30,000 SF * 2 feet deep / 27 CF/CY = 2,222 CY

2,200 CY * 1.5 tons/CY = 3,333 tons

Excavation and disposal cost @ $40/ton = 3,333 * $40 = $133,000

Backfill and placement @ $15/ton = 3,333 * $15 = $50,000

Vegetation and Miscellaneous = $40,000

Engineering and Oversight = $50,000

Estimated Total = $275,000

6.0 Corrective Action Activities

Several actions will be taken prior to excavation. First, limited clearing will be necessary in the west and east domain excavation areas, which are currently wooded. Existing fencing will be removed to facilitate access to the proposed excavation areas. A temporary track crossing may be required to access the east domain area.

A survey will also be conducted to confirm the locations of previous sampling points. Using these sample points as reference, the estimated excavation areas will be marked so that confirmation sampling activities may be conducted (see below). CSXT intends to conduct confirmation sampling prior to initiating excavation so that soil removal quantities may be confirmed before proceeding.

Contractor selection will proceed with a bid solicitation, pre-bid meeting, review of proposals, and contractor selection. Waste will be characterized in a profile, then negotiations will be conducted with local non-hazardous landfills, and an agreement completed for disposal. A source of backfill soil will be identified and testing will be conducted to confirm soil quality. It may be necessary to coordinate with the City of Savannah Traffic Department regarding hauling schedules.

The excavation and backfill operation will be conducted sequentially within designated areas. Soils will be removed and placed nearby for subsequent loading onto dump trucks, or may be loaded directly into trucks. It is anticipated that tandem dump trucks will be used for hauling. Clean backfill will be brought to the site and stockpiled nearby for introduction into the

excavations and compaction. After all areas are addressed, appropriate seed and fertilizer will be applied.

Waste soil hauling and disposal operations will be recorded on standard non-hazardous manifest forms to document weights of material for payment.

7.0 Confirmation Sampling

7.1 Sampling SOPs and Analytical Methods (incl screening)

With the exception of three discrete sample points that are considered lead hotspots, arsenic is the only regulated substance that exceeds applicable risk reduction standards at the site. Remediation efforts will be focused on reducing arsenic to its allowable EPC in shallow soils (0-2 feet). Samples of deeper soils at the site did not contain arsenic above the corresponding risk reduction standard. Lead-containing soils at these hotspots and other locations where arsenic removal is required will also be removed, but is not required to meet RRS. Therefore no lead analysis is proposed.

Confirmation sampling will be performed prior to excavation so that there will be no uncertainty as to the excavation limits of the project. Soil sampling will be conducted in accordance with USEPA document SESDPROC-300-R3, Soil Sampling. All sampling will be conducted under the oversight of a Georgia PE or PG.

Initial sampling will be conducted by first laying out proposed sidewall sampling points along the perimeters of the anticipated excavation areas. These points will be located generally along the lines identified on **Figure 1** and will be spaced at approximately 25-foot intervals.

The sampling will be conducted using a direct-push drill rig. A lined probe will be driven to a depth of two feet (after removal of any surface gravel or pavement). Recovered soil will be mixed in a bowl as noted in the referenced EPA guidance. The resulting sample may, at CSXT discretion, be analyzed with a field x-ray fluorescence meter (XRF) prior to containerization to indicate the general level of arsenic present. If the concentration appears to be within an appropriate value, the sample will be placed into a container provided by TestAmerica Laboratories, Savannah, GA. If not, another sample point will be selected further outside the

originally proposed perimeter. In some cases, CSX may choose to also collect samples outside the area and hold them until other sample analyses are completed. These contingency samples would then be analyzed only if other samples are not acceptable and additional samples are needed for delineation.

Samples will be placed into coolers at the Site, then hand delivered to the TestAmerica Laboratories location in Savannah, GA. Arsenic will be analyzed in the laboratory by EPA Method SW-846 6010.

7.2 Number of Samples and Distribution and Acceptance Criteria

Samples will be collected at approximately 25-foot intervals around the proposed perimeter of the excavation. Unless the perimeter is very limited (as in Area NW, with an estimated perimeter of 120 feet) an attempt will be made to collect at least eight (8) evenly spaced perimeter samples. (A minimum of eight samples is recommended for calculation of the UCL of the mean for arsenic.)

Upon receipt of sample results for arsenic, the results will be compared to the approved risk reduction standard of 44 mg/kg. If there are less than eight samples for a given area, the comparison will be made on a point-by-point basis. If there are at least eight samples for the area, the arsenic UCL value will be calculated using all sample point results. The methodology for UCL calculation is presented in EPA Publication "EPA/600/-07/041 ProUCL Version 4.00.05 Technical Guide". The calculated UCL will be compared to the risk reduction standard to determine whether acceptable margins have been achieved.

If acceptable margins are not achieved from this sampling event, additional sampling will be conducted until acceptable margins are achieved. Sampling during these events will be conducted by manual advancement of either a hand auger or a shovel as addressed in the previously referenced sampling guidance document. The samples may be field screened and, if selected, will be containerized and transported to the laboratory in the same manner as during the initial sampling event. Results will then be combined with other valid perimeter point data for comparison to the risk reduction standard. After finalization of the excavation perimeters, the areas will be delineated with paint.

No bottom confirmation samples are proposed at the Site. Review of **Table 3** reveals that the risk reduction standard for arsenic at depths greater than two feet is 210 mg/kg. No existing

subsurface samples exceed this value. Of the 91 surface arsenic soil samples from the Site, only three had an arsenic concentration greater than 210 mg/kg (sample locations 203, 404, and 602), and soil at these three points is being removed.

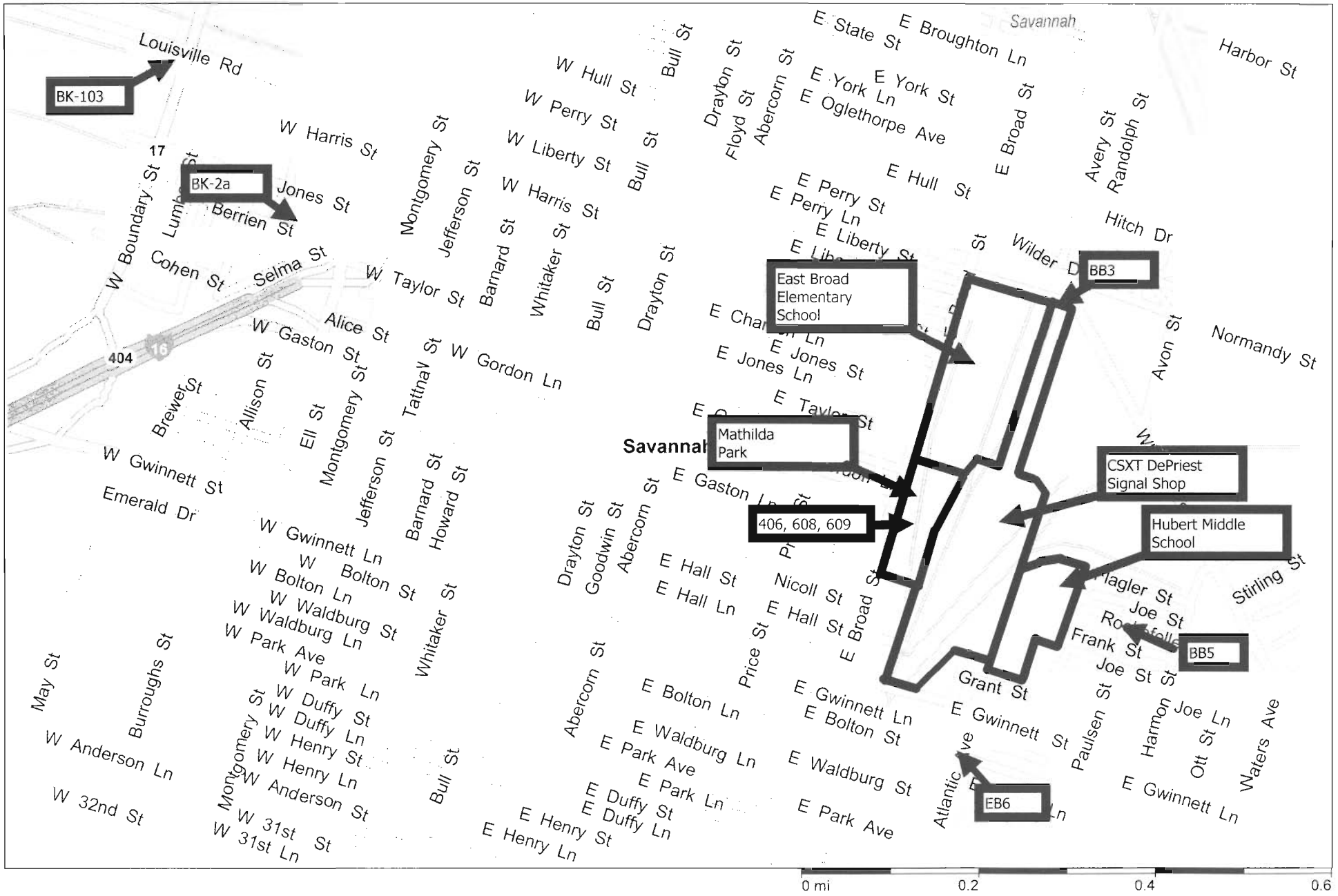
Based upon a sampling criteria of one approximately every 25 feet of sidewall, initial sampling is estimated to yield the following number of samples:

Excavation Area	Perimeter (ft)	No. of Samples
North	120	5
Northwest	700	28
Southwest	160	7
South	560	23
East	160	7
	Total	70

8.0 Reporting

After completion of the Site remedial action, a report will be prepared for submission to EPD. This report will be included in the final Site CSR. The report will address whether and how the project objectives were met, and will include laboratory reports, tables and figures showing sample points, areas removed, etc., and documentation that the CAP procedures were followed. The report will be signed and certified by a Georgia PE or PG.

Figure 1.1 Location Map



MAGNETIC

THE MASONIC BLDG. ASSOC.

ST. JAMES A.M.E. CHURCH

DOW ELECTRONICS, INC.

MAYOR & ALDERMEN CITY OF SAVANNAH

SHIPWATCH PARTNERS

MATHILDA PARK

SHIPWATCH PARTNERS

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

EAST BROAD STREET ELEMENTARY SCHOOL

BOARD OF EDUCA SAVANNAH & CHA

MATCH LINE SEE BELOW FOR CONTINUATION

WEST DOMAIN

SOUTH DOMAIN

NORTH DOMAIN

EAST DOMAIN

HUBERT MIDDLE SCHOOL

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

STEVENS OIL/SCRAP SITE

EASTLAWN STREET 24' R/W

AREA SW A=1,700 SF

AREA W A=8,700 SF

AREA S A=16,600 SF

AREA E A=1600 SF

AREA NW A=500 SF

MONITORING WELL 17 TOP CASING 19.54

MONITORING WELL 18 TOP 17.93 TOP PVC 17.53

MONITORING WELL 19 TOP17.68 TOP PVC 17.34

MONITORING WELL 12 TOP12.74 TOP CASING 15.55

MONITORING WELL 13 TOP13.44

GRAVEL ROAD

RAILROAD TRACK

CHAIN LINK FENCE

TELEPHONE POLE

POWER POLE

GUY WIRE

PIT

RUIN

CONC. WALL

FUEL AREA

SHELTER

VALVE TOP 18.67

STEEL POST

GUARD POST

LIGHT POLE

STEEL PLATE

PAVEMENT

ASPHALT PAVING

ASPHALT

SAN. SEWER MANHOLE TOP17.21

GRATE INLET TOP16.95

GRATE INLET TOP16.62

GRATE INLET TOP14.53

GRATE INLET TOP14.78

FIRE HYDRANT

WATER VALVE

SIGN POST

UNDERGROUND PEDESTAL

METAL BUILDING

BLOCK BUILDING

LOADING DOCK

POWER BOX

STORM JUNCTION BOX TOP15.22 I.E.7.14

SAN. MANHOLE TOP15.24 I.E.6.14

DRAIN INLET TOP14.97

DRAIN INLET TOP14.78

BENCHMARK RE-SET "B" T/P ELEV. 17.76 MSL (NGVD 1929)

CONCRETE

RAMP

GRAVEL

IPF

LEGEND

- Property Line
- RRS
- Background
- 30A — Sample Point
- Excavation Limit
- Domain ID

MATCH LINE

BUILDING

ASPHALT PAVEMENT

LIBERTY STREET

VICINITY MAP
N.T.S.

LIBERTY STREET

EAST BROAD STREET

WHEATON STREET

GWINNETT STREET

WATERS AVE.

SITE

GRAPHIC SCALE IN FEET

60 0 60 120 180 240

CSX TRANSPORTATION

HOLLEY CONSULTANTS

REVISIONS & DATE

FIGURE 1
EXCAVATION AND DOMAIN LIMITS
CSXT DEPRIEST SIGNAL SHOP
SAVANNAH, GA

DESIGNED BY	CHECKED BY	SCALE	DATE
–	REH	INDICATED	MAR 2019

Table 3. Statistical Summary of Metals in Soil
DePriest Signal Site - Savannah, GA

Exposure Domain	Surface Soil (SS) Detection Summary					ProUCL Recommended		Type 3-4 RRS	ProUCL Recommended		Data Points
NORTH	N_{Total}	N_{Detect}	FOD	Min	Max	UCL	Distribution	SS (2)	UCL(alt)	Distribution	Removed
Antimony	3	1	33%	11	11			930			
Arsenic	20	20	100%	1.1	17			44			
Barium	16	16	100%	23	480			100000 (3)			
Cadmium	19	11	58%	0.56	2			2300			
Chromium (III)	14	14	100%	4.2	1700			100000 (3)			
Lead	19	19	100%	24	1600			2600			
Mercury	19	19	100%	0.043	2.9			700			
Selenium	10	0	0%	--	--			12000			
Silver	10	0	0%	--	--			12000			

Exposure Domain	Subsurface Soil (SbS) Detection Summary					Type 3-4 RRS	
NORTH	(n-total)	(n-detect)	Freq	Min	Max	SbS	
Antimony	0	0	--	--	--	280	
Arsenic	3	0	0%	--	--	210	
Barium	1	1	100%	45	45	100000 (3)	
Cadmium	1	0	0%	--	--	700	
Chromium (III)	1	1	100%	2.4	2.4	100000 (3)	
Lead	1	1	100%	2.8	2.8	1200	
Mercury	1	1	100%	0.03	0.03	210	
Selenium	1	0	0%	--	--	3500	
Silver	1	0	0%	--	--	3500	

Exposure Domain	Surface Soil (SS) Detection Summary					ProUCL Recommended		Type 3-4 RRS	ProUCL Recommended		Removed
SOUTH	N_{Total}	N_{Detect}	FOD	Min	Max	UCL	Distribution	SS (4)	UCL(alt)	Distribution	Data Points
Antimony	0	0	--	--	--			930			
Arsenic	23	22	96%	5.3	300	**96**	95% KM (Chebyshev)	**44**	**36**	KM H-UCL	602 (0-1) & 701 (0-1)[+702(0-1)]
Barium	22	22	100%	10	2900			100000 (3)			
Cadmium	22	9	41%	0.088	70			2300			
Chromium (III)	24	24	100%	3.3	2300			100000 (3)			
Lead	29	29	100%	25	27000	1927	Mean (6)	2600	[892]	Mean (6)	702(0-2) Hotspot [+602 (0-1) & 701 (0-1)]
Mercury	22	22	100%	0.02	1.8			700			
Selenium	22	0	0%	--	--			12000			
Silver	22	3	14%	1.9	14			12000			

Exposure Domain	Subsurface Soil (SbS) Detection Summary					Type 3-4 RRS	
SOUTH	N_{Total}	N_{Detect}	FOD	Min	Max	SbS	
Antimony	0	0	--	--	--	280	
Arsenic	3	1	33%	15	15	210	
Barium	3	3	100%	3.7	81	100000 (3)	
Cadmium	3	1	33%	2	2	700	
Chromium (III)	3	3	100%	2	250	100000 (3)	
Lead	3	3	100%	3.1	2600	**1200**	[889] Mean
Mercury	2	1	50%	0.026	0.026	210	
Selenium	3	0	0%	--	--	3500	
Silver	3	0	0%	--	--	3500	

Exposure Domain	Surface Soil (SS) Detection Summary					ProUCL Recommended		Type 3-4 RRS	ProUCL Recommended		Removed
EAST	N_{Total}	N_{Detect}	FOD	Min	Max	UCL	Distribution	SS (5)	UCL(alt)	Distribution	Data Points
Antimony	7	3	43%	4.4	6.5			660			
Arsenic	22	22	100%	1.3	160	**58**	95% Chebyshev (m, sd)	**44**	38	95% Chebyshev (m, sd)	822 (0-1)
Barium	7	7	100%	38	250			100000 (3)			
Cadmium	15	6	40%	0.45	24			1600			
Chromium (III)	16	16	100%	3.2	38			100000 (3)			
Lead	21	21	100%	46	5400	764	Mean (6)	2600	[532]	Mean (6)	[822 (0-1)]
Mercury	12	12	100%	0.11	8.6			490			
Selenium	1	0	0%	--	--			8200			
Silver	1	0	0%	--	--			8200			

Exposure Domain	Subsurface Soil (SbS) Detection Summary					Type 3-4 RRS	
EAST	N_{Total}	N_{Detect}	FOD	Min	Max	SbS	
Antimony	1	0	0%	--	--	280	
Arsenic	1	0	0%	--	--	210	
Barium	0	0	--	--	--	100000 (3)	
Cadmium	1	0	0%	--	--	700	
Chromium (III)	1	1	100%	3.1	3.1	100000 (3)	
Lead	1	1	100%	3.5	3.5	1200	
Mercury	1	0	0%	--	--	210	
Selenium	0	0	--	--	--	3500	
Silver	0	0	--	--	--	3500	

Exposure Domain	Surface Soil (SS) Detection Summary					ProUCL Recommended		Type 3-4 RRS	ProUCL Recommended		Removed
WEST	N_{Total}	N_{Detect}	FOD	Min	Max	UCL	Distribution	SS (5)	UCL(alt)	Distribution	Data Points
Antimony	14	5	36%	2.9	14			660			
Arsenic	37	35	95%	2.2	380	**87**	Gamma Adjusted KM	**44**	41.0	95% KM Adjusted Gamma	203 (0-2), 404 (0-2), 003 (0-2), 1332 (0-1)
Barium	17	17	100%	11	290			100000 (3)			
Cadmium	36	16	44%	0.084	6.2			1600			
Chromium (III)	34	34	100%	2.8	23			100000 (3)			
Lead	31	31	100%	3.7	590			2600	[217]	Mean (6)	[203 (0-2), 404 (0-2), 003 (0-2), 1332 (0-1)]
Mercury	32	32	100%	0.056	1.3			490			
Selenium	19	5	26%	1.2	2.6			8200			
Silver	15	0	0%	--	--			8200			

Exposure Domain	Subsurface Soil (SbS) Detection Summary					Type 3-4 RRS	
WEST	N_{Total}	N_{Detect}	FOD	Min	Max	SbS	
Antimony	2	1	50%	12	12	280	
Arsenic	2	1	50%	51	51	210	
Barium	1	1	100%	19	19	100000 (3)	
Cadmium	2	1	50%	0.88	0.88	700	
Chromium (III)	2	2	100%	1.9	9.1	100000 (3)	
Lead	2	2	100%	12	350	1200	
Mercury	2	2	100%	0.025	0.18	210	
Selenium	2	0	0%	--	--	3500	
Silver	2	0	0%	--	--	3500	

Notes:

(1) Concentrations are in milligrams/kilogram (mg/kg).

(2) North Domain - Maximum of Type 3 surface soil RRS and Type 4 for industrial worker

(3) RRS limited to no greater than 100,000 mg/kg

(4) South Domain - Type 4 is lower of industrial worker and landscaper. Higher of selected Type 4 and Type 3 surface soil RRS.

(5) East and West Domains - Type 4 is lower of industrial worker and trespasser. Higher of selected Type 4 and Type 3 surface soil RRS.

(6) Per USEPA guidance, RRS for lead, which is based on Adult Lead Methodology, is compared to the domain mean concentration rather than the UCL.

UCL (upper confidence limit of arithmetic mean) is calculated with all points within domain.

UCL (alt) is calculated with listed points removed.

Points to be removed primarily because of arsenic exceedance of RRS.

[Points removed incidentally that also reduce mean concentration of lead or UCL of arsenic]

Revised by/date LMS 2/22/19
Checked by/date IMR 2/25/19

ATTACHMENT A
RESPONSE TO EPD COMMENTS IN FEBRUARY 4, 2019 LETTER

1.0 Introduction

The following attachment to the 12th Semi-Annual Status update includes response to EPD comments dated February 4, 2019, and includes updated risk reduction standards and discussion, a discussion of ground water sampling procedures, and revised drawings.

2.0 Response to EPD Comments

Response to EPD comments on Area Averaging:

Comment 1) Area Averaging

Although an area averaging approach to calculate an Exposure Point Concentration (EPC) is allowable under the VRP Act, the methods presented in the 9th VRP Semi-Annual Status Update will require additional work to be approved by EPD.

Response: A revised Table 3 is attached. Also, print-outs of the ProUCL outputs. In the comments below, EPD refers to Table 2, but the correct designation is Table 3. As a general response, per USEPA guidance for the Adult Lead Methodology, the exposure point concentration for each domain is the mean lead concentration rather than the upper confidence limit of the arithmetic mean (UCL):

"Under both current and future exposure scenarios, an arithmetic mean concentration should be estimated from sampling data within the exposure area that a worker would be expected to have access to on a regular basis (https://www.epa.gov/superfund/lead-superfund-sites-frequent-questions-risk-assessors-adult-lead-methodology#soil%20lead)."

For this reason, the mean lead concentration is listed on Table 3 as the exposure point concentration (EPC) for lead instead of the lead UCL.

Specifically:

a) EPD agrees with the choice of splitting the property into four Exposure Domains (ED). However, the ED boundaries are not indicated in any figure. Please provide a map/figure to present the boundaries of the EDs.

*Response: A figure showing the samples per domain is provided in attached **Figure 1**.*

b) In addition, it is unclear which Type 4 Risk Reduction Standard (RRS) is being applied for each ED. Attachment C presents a multitude of scenarios based on site-specific exposure assumptions, but the report is lacking a table that shows which RRS is being used to compare with the calculated EPC.

Response: Footnotes have been added to Table 3 to indicate which receptor groups were considered in the selection of the Type 4 RRS for each of the 4 domains. This information is also presented in the text. The lowest of the Type 4 RRS were selected and then compared to the Type 3 RRS. The RRS of each domain was the maximum of Type 3 and the selected Type 4 RRS. In summary, the following receptors are considered for the domains:

Domain	***Receptors Evaluated***
North (Inside Fence)	*Industrial Worker (Types 3 and 4)*
South (Inside Fence)	*Industrial Worker (Types 3 and 4) and Landscaper (Type 4)*
East and West (Outside Fence)	*Industrial Workers (Types 3 and 4) and Trespasser (Type 4)*
All domains for subsurface soil	*Type 3 Subsurface Soil and Construction Worker (Type 4)*

c) The Statistical Summary of Metals in Soil presented in Table 2 does not match the electronic data from ProUCL that was provided in the Excel spreadsheets. Specifically:

i) In Table 2, the North ED shows a 95% UCL of 9, but the Excel spreadsheet has a value of 10. The mean value of 504 mg/kg for lead does not match the 95% UCL of 659 mglkg that was presented in the Excel spreadsheet. EPD is also unsure why the Excel spreadsheet presented a UCL calculation for lead with points 903/0-1, 1003/0-5, and 1103/0-1 removed since the 95% UCL with all points for lead was below the Type 4 RRS.

Response: Because the maximum concentrations of arsenic, lead, and other detected metals are less than the RRS of the North domain, no samples need removal to bring the North Domain into compliance. Table 3 has been so edited. Supplemental calculations for a residential cleanup of lead have been removed.

ii) In Table 2, the South ED shows a mean value of 1927 mg/kg for lead. The Excel spreadsheet presents a 95% UCL value of 497.7 mg/kg after removing 15 samples greater than 710 mg/kg. The Excel spreadsheet also presents a value with all samples that gives a 95% UCL of 4822 mg/kg. It appears that additional evaluation is needed for this area to get an EPC that is under the Type 4 RRS. EPD ran the UCL calculations and found that removal of only one additional data point (702/0-1) beyond the two points removed for arsenic compliance (602/0-1 and 701/0-1) would provide a 95% UCL of 1118 mg/kg, which would be an acceptable EPC for a Type 4 RRS.

Response: Supplemental calculations for a residential cleanup of lead have been removed (i.e., calculation with 15 samples removed). The mean of all lead data in the South Domain is 1,927 mg/kg, which is less than the lead RRS of 2,600 mg/kg. However, location 702 (0-2) is a likely hotspot with a concentration of 27,000 mg/kg. Therefore, this location is proposed for removal. Two additional locations, 602 (0-1) and 701 (0-1), will be removed to reduce the exposure point concentration (EPC) for arsenic. Thus, the EPCs for both lead and arsenic will be reduced after removal of three locations to a lead mean of 892 mg/kg and arsenic UCL of 36 mg/kg.

iii) In Table 2, the East ED indicates a 95% UCL of for arsenic of 38 mg/kg after removal of data point 822(0-1). This was not presented in the Excel spreadsheet. EPD needs to see the ProUCL output for this calculation. In addition, a mean value of 764 mg/kg for lead is presented instead of the 95% UCL value of 1273 mg/kg. However, when EPD ran

the UCL calculations for lead with data point 822(0-1) removed, the 95% UCL was only 824 mg/kg.

Response: The spreadsheet showing the arsenic pre- and post-removal EPCs is provided. Removal of location 822 (0-1) is proposed to reduce the UCL for arsenic from 58 mg/kg to 38 mg/kg in the East Domain. At the same time, the mean concentration of lead will be incidentally reduced from a mean of 764 mg/kg to 532 mg/kg; both concentrations are less than the lead RRS of 2,600 mg/kg. Thus, lead is not a COC for the East Domain.

iv) In Table 2, the West ED indicates a mean value of 232 mg/kg for lead instead of using the recommended 95% UCL value of 278.5 mg/kg.

Response: Using all lead data, the mean lead concentration is 232 mg/kg for the West Domain, which is in compliance with the lead RRS. Four locations are recommended for removal in the West Domain to reduce the UCL of arsenic from 87 mg/kg to 41 mg/kg. Locations for removal include 203 (0-2), 404 (0-2), 003 (0-2), and 1332 (0-1). Removal of these locations will incidentally reduce the lead concentration to a mean of 217 mg/kg. Lead is not a COC for the West Domain.

d) A figure for each Exposure Domain should be presented with all sample locations that are being used to calculate the EPC. It should also indicate points that will be excavated to bring the EPC down to meet the applicable Type 4 RRS.

*Response: A figure showing the samples per domain is provided in attached **Figure 1**. The sample points in each domain are also listed in the attached Tables.*

Comment 2) Groundwater Sampling

a) Although the 9th VRP Semi-Annual Status Update indicates that ground water samples were collected according to the operating procedures recommended by the USEPA Region 4 Science and Ecosystem Support Division, SESCPROC-301-R4 (April 26, 2017), EPD's review found that in many cases groundwater samples were collected with final turbidity readings above 10 NTUs and without removing up to five well volumes. EPD recommends using the multiple purge volume method rather than the low flow/low volume method when turbidity of samples is an issue. Purging should continue until the turbidity is 10 NTUs or less or until at least 5 well volumes have been removed from the well before taking the sample, as outlined in SESDPROC-301-R4 referenced above.

Response: As noted in the 9th Semi-Annual Status Update, samples were collected from the eight (8) monitoring wells at the site using the "low-flow method". This approach was selected after consultation with EPD on the most appropriate sampling technique for this particular site. It is noted that wells MW-18, -19, and -20, had turbidities greater than 10 NTU. Wells MW-15, -17,- 21,- 22,- 23, as well as the resampling event at MW-20 had values less than 10 NTU. The turbidity was believed due primarily to the presence of iron bacteria in the shallow wells. EPD's comment is noted and future groundwater sampling events will involve purging at least five volumes of water from the wells.

b) Despite the turbidity issues mentioned in the comment above, EPD can concur with the results presented and can agree with most of the arguments presented in Section 3.4 of the 9th VRP Semi-Annual Status Update. EPD agrees that a leaching assessment is not appropriate due to the fact that ground water has not been impacted after more than 100 years since the operation began at the site. However, the argument that this site was not listed on the HSO for groundwater is incorrect. The original RQSM scoring for groundwater at this site was 14.45, which exceeds the threshold value of 10.0.

Response: It is noted that the site was previously listed for groundwater. Given the recent data and the historical nature of past potential releases, we understand that no further consideration will be given to groundwater impacts in future activities.

Comment 3) Other Comments

a) EPD's previous comment letter (June 21, 2017) requested a set of revised electronic copies of the large format maps so that soil data was legible. EPD previously commented on this issue in the VRP Application comments dated March 15, 2013. Please revise Figures 3.1-3.8 of the 2nd Semi-Annual Status update and Figure 2.1 of the 3rd Semi-Annual Status update and include them in the forthcoming CSR.

Response: Electronic copies of the referenced figures are included in the attached CD. A paper copy of each is also included with this submittal.

b) EPD is still awaiting results from additional delineation sampling to address Comment 3a in EPD's previous comment letter. Section 1.0 of the 9th Semi-Annual Status update indicates that you are planning to focus on those delineation efforts. Results from those samples and updated figures should also be included in the forthcoming CSR.

Response: At this time, we do not anticipate the need for additional sampling to accomplish the delineations to Type 1 or 2, or background concentrations, whichever will apply.

North Domain Soil Samples

ample Poi	Arsenic	Lead	Domain	S / SS
804/0-2	1.1	97	NORTH	S
901/0-1	5	440	NORTH	S
902/0-4	9.7	850	NORTH	S
903/0-1	9.4	1600	NORTH	S
904/0-1	5.6	720	NORTH	S
905/0-2	15	280	NORTH	S
922(0-1)	4.1	630	NORTH	S
923(0-1)	7.3	360	NORTH	S
1001/0-1	6.4	280	NORTH	S
1002/0-4	17	710	NORTH	S
1002/4-5		2.8	NORTH	SS
1003/0-5	12	1000	NORTH	S
1004/0-4	9.5	160	NORTH	S
1005/0-3	9.9	300	NORTH	S
1101/0-1	7.6	560	NORTH	S
1103/0-1		860	NORTH	S
1142(0-1)	15		NORTH	S
1201/0-1	8.4	310	NORTH	S
1301/0-2	13	360	NORTH	S
1334(0-1)	2.4		NORTH	S
1444(0-1)	3.4	24	NORTH	S
1501/0-1	4.2	26	NORTH	S

South Domain Soil Samples

ample Poir	Arsenic	D_Arsenic	Lead	Domain	S / SS
001/0-1			230	SOUTH	S
102/0-1			1000	SOUTH	S
201/0-1	13	1	1800	SOUTH	S
202/0-2	11	1	640	SOUTH	S
301/0-1	24	1	710	SOUTH	S
302/0-1	11	1	25	SOUTH	S
302/2-3	1.1	0	3.1	SOUTH	SS
303/0-1	14	1	1100	SOUTH	S
401/0-1	73	1	880	SOUTH	S
402/0-1	35	1	380	SOUTH	S
403/0-1	30	1	1300	SOUTH	S
419(0-1)	15	1	2500	SOUTH	S
501/0-1	56	1	1200	SOUTH	S
502/0-2	35	1	2000	SOUTH	S
502/2-3	15	1	2600	SOUTH	SS
503/0-1	11	1	700	SOUTH	S
524(0-1)			90	SOUTH	S
601/0-1	1	0	32	SOUTH	S
602/0-1	300	1	5100	SOUTH	S
603/0-1	10	1	44	SOUTH	S
604/0-2	17	1	1000	SOUTH	S
625(0-1)			680	SOUTH	S
701/0-1	130	1	600	SOUTH	S
702/0-1	34	1	27000	SOUTH	S
702/2-3	1.3	0	3.3	SOUTH	SS
703/0-1	13	1	510	SOUTH	S
704/0-2	13	1	1700	SOUTH	S
721(0-1)			1800	SOUTH	S
722(0-1)			940	SOUTH	S
801/0-1	11	1	1400	SOUTH	S
802/0-2	14	1	400	SOUTH	S
803/0-1	5.3	1	120	SOUTH	S

Points to be removed to meet Type 3-4 RRS

889 SUBSURFACE MEAN W/O 3 PTS.

East Domain Soil Samples

Sample Pc	Arsenic	Lead	Domain	S / SS
004(0-1)	32	160	EAST	S
005(0-1)	1.7		EAST	S
007(0-1)	10		EAST	S
101(0-1)	4.8		EAST	S
101/0-1		330	EAST	S
205(0-1)	3.4		EAST	S
205/0-1		140	EAST	S
209(0-1)	36	210	EAST	S
304/0-1	4.5	240	EAST	S
312(0-1)	15	130	EAST	S
405/0-1	1.6	150	EAST	S
505/0-1	19	1200	EAST	S
506/0-1	5.3	2900	EAST	S
522(0-1)	3.2	820	EAST	S
523(0-1)		520	EAST	S
525(0-1)		160	EAST	S
526(0-1)		350	EAST	S
527(0-1)		170	EAST	S
606/0-1	3.1	560	EAST	S
607/0-1		900	EAST	S
624(0-1)	1.3	46	EAST	S
719(0-1)	7.2	1000	EAST	S
806(0-1)	1.5		EAST	S
806/0-1		180	EAST	S
821/2-3		3.5	EAST	SS
822(0-1)	160	5400	EAST	S
823(0-1)	7.8		EAST	S
824(0-1)	5.9		EAST	S
1104/0-1	110	470	EAST	S
1104/1-2	2.4		EAST	S
1105/0-1	37		EAST	S
1202/0-1			EAST	S
1204/0-1			EAST	S
1302/0-1			EAST	S
1304/0-1			EAST	S

Points to be removed to meet Type 3-4 RRS

West Domain Soil Samples

ample Poir	Arsenic	D_Arsenic	Lead	Domain	S / SS
002(0-1.0)	18	1	140	WEST	S
003(0-2.0)	210	1	310	WEST	S
003 (2-3.0)	51	1	350	WEST	SS
006(0-1)	17	1		WEST	S
103/0-1	7.1	1		WEST	S
104/0-1				WEST	S
105(0-2.5)	27	1	340	WEST	S
106(0-2.0)	120	1	370	WEST	S
107(0-1)	15	1		WEST	S
203/0-2	380	1	300	WEST	S
204(0-1)				WEST	S
204/0-1	7.2	1		WEST	S
206(0-1.0)	20	1	280	WEST	S
207(0-1)				WEST	S
208(0-1)				WEST	S
210(0-1)				WEST	S
404/0-2	260	1	500	WEST	S
504/0-2	61	1	370	WEST	S
504/3-4	1	0	12	WEST	SS
605/0-2	79	1	590	WEST	S
705/0-3	60	1	270	WEST	S
805/0-3	74	1	470	WEST	S
906/0-2	37	1	310	WEST	S
921(0-3.5)	45	1	250	WEST	S
1006/0-2	17	1	190	WEST	S
1026(0-1.0	71	1	110	WEST	S
1102/0-2	4.1	1	61	WEST	S
1203/0-1	51	1	410	WEST	S
1303/0-1	24	1	250	WEST	S
1332(0-1)	160	1	210	WEST	S
1333(0-1)	56	1	3.7	WEST	S
1401/0-1	1.1	0	18	WEST	S
1402/0-1	23	1		WEST	S
1403/0-1	41	1	350	WEST	S
1502/0-1	10	1	44	WEST	S
1503/0-1	26	1	130	WEST	S
1516(0-1)	27	1	98	WEST	S
1601/0-1	2.4	1	140	WEST	S
1602/0-1	19	1	35	WEST	S
1603/0-1	10	1		WEST	S
1724(0-1)	1.1	0	26	WEST	S
1830(0.1)	6.1	1	230	WEST	S
1831(0-1)				WEST	S
2215(0-1)	8.9	1	290	WEST	S
2216(0-1)	2.2	1	90	WEST	S

Points to be removed to meet Type 3-4 RRS

South
UCL Statistics for Data Sets with Non-Detects

User Selected Options

Date/Time of Computation	ProUCL 5.18/30/2017 2:23:46 PM
From File	PAH + Metals Soil Data_b.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Arsenic all

General Statistics

Total Number of Observations	23	Number of Distinct Observations	16
		Number of Missing Observations	6
Number of Detects	22	Number of Non-Detects	1
Number of Distinct Detects	15	Number of Distinct Non-Detects	1
Minimum Detect	5.3	Minimum Non-Detect	1
Maximum Detect	300	Maximum Non-Detect	1
Variance Detects	4174	Percent Non-Detects	4.35%
Mean Detects	39.79	SD Detects	64.6
Median Detects	14.5	CV Detects	1.624
Skewness Detects	3.518	Kurtosis Detects	13.48
Mean of Logged Detects	3.099	SD of Logged Detects	0.952

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.508	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.911	Detected Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.348	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.184	Detected Data Not Normal at 5% Significance Level	

Detected Data Not Normal at 5% Significance Level

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

KM Mean	38.1	KM Standard Error of Mean	13.28
KM SD	62.24	95% KM (BCA) UCL	62.75
95% KM (t) UCL	60.91	95% KM (Percentile Bootstrap) UCL	62.36
95% KM (z) UCL	59.95	95% KM Bootstrap t UCL	109.6
90% KM Chebyshev UCL	77.95	95% KM Chebyshev UCL	96
97.5% KM Chebyshev UCL	121	99% KM Chebyshev UCL	170.3

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.95	Anderson-Darling GOF Test	
5% A-D Critical Value	0.771	Detected Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.241	Kolmogorov-Smirnov GOF	
5% K-S Critical Value	0.191	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)	0.989	k star (bias corrected MLE)	0.884
Theta hat (MLE)	40.23	Theta star (bias corrected MLE)	44.99
nu hat (MLE)	43.51	nu star (bias corrected)	38.91
Mean (detects)	39.79		

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	0.01	Mean	38.06
Maximum	300	Median	14
SD	63.66	CV	1.673
k hat (MLE)	0.692	k star (bias corrected MLE)	0.631
Theta hat (MLE)	55.01	Theta star (bias corrected MLE)	60.35
nu hat (MLE)	31.82	nu star (bias corrected)	29.01
Adjusted Level of Significance (β)	0.0389		
Approximate Chi Square Value (29.01, α)	17.71	Adjusted Chi Square Value (29.01, β)	17.07

Prepared by: L Ouy 8/18/17
Checked by: LMS 8/30/17

95% Gamma Approximate UCL (use when n>=50)	62.32	95% Gamma Adjusted UCL (use when n<50)	64.65

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	38.1	SD (KM)	62.24
Variance (KM)	3873	SE of Mean (KM)	13.28
k hat (KM)	0.375	k star (KM)	0.355
nu hat (KM)	17.24	nu star (KM)	16.32
theta hat (KM)	101.7	theta star (KM)	107.4
80% gamma percentile (KM)	60.47	90% gamma percentile (KM)	109.8
95% gamma percentile (KM)	164.9	99% gamma percentile (KM)	305.3

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (16.32, α)	8.191	Adjusted Chi Square Value (16.32, β)	7.775
95% Gamma Approximate KM-UCL (use when n>=50	75.93	95% Gamma Adjusted KM-UCL (use when n<50)	79.99

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.881	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.911	Detected Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.205	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.184	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	38.16	Mean in Log Scale	3.001
SD in Original Scale	63.6	SD in Log Scale	1.042
95% t UCL (assumes normality of ROS data)	60.93	95% Percentile Bootstrap UCL	62.73
95% BCA Bootstrap UCL	72.7	95% Bootstrap t UCL	105.1
95% H-UCL (Log ROS)	61.44		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	2.964	KM Geo Mean	19.38
KM SD (logged)	1.108	95% Critical H Value (KM-Log)	2.67
KM Standard Error of Mean (logged)	0.236	95% H-UCL (KM -Log)	67.26
KM SD (logged)	1.108	95% Critical H Value (KM-Log)	2.67
KM Standard Error of Mean (logged)	0.236		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	38.08	Mean in Log Scale	2.934
SD in Original Scale	63.65	SD in Log Scale	1.221
95% t UCL (Assumes normality)	60.87	95% H-Stat UCL	82.79

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

Nonparametric Distribution Free UCL Statistics
Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use
95% KM (Chebyshev) UCL **96**

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.

Lead **All Samples**

General Statistics

Total Number of Observations	29	Number of Distinct Observations	27
		Number of Missing Observations	0
Minimum	25	**Mean**	**1927**
Maximum	27000	Median	880
SD	4927	Std. Error of Mean	915
Coefficient of Variation	2.557	Skewness	5.045

Normal GOF Test

Shapiro Wilk Test Statistic	0.338	Shapiro Wilk GOF Test	

Prepared by: L Ouy 8/18/17
Checked by: LMS 8/30/17

5% Shapiro Wilk Critical Value	0.926	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.391	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.161	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			

Assuming Normal Distribution			
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	3483	95% Adjusted-CLT UCL (Chen-1995)	4348
		95% Modified-t UCL (Johnson-1978)	3626

Gamma GOF Test			
A-D Test Statistic	1.572	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.802	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.216	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.171	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			

Gamma Statistics			
k hat (MLE)	0.582	k star (bias corrected MLE)	0.545
Theta hat (MLE)	3313	Theta star (bias corrected MLE)	3539
nu hat (MLE)	33.74	nu star (bias corrected)	31.58
MLE Mean (bias corrected)	1927	MLE Sd (bias corrected)	2611
		Approximate Chi Square Value (0.05)	19.74
Adjusted Level of Significance	0.0407	Adjusted Chi Square Value	19.18

Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	3083	95% Adjusted Gamma UCL (use when n<50)	3173

Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.932	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.926	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.163	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.161	Data Not Lognormal at 5% Significance Level	
Data appear Approximate Lognormal at 5% Significance Level			

Lognormal Statistics			
Minimum of Logged Data	3.219	Mean of logged Data	6.497
Maximum of Logged Data	10.2	SD of logged Data	1.487

Assuming Lognormal Distribution			
95% H-UCL	4822	90% Chebyshev (MVUE) UCL	3794
95% Chebyshev (MVUE) UCL	4670	97.5% Chebyshev (MVUE) UCL	5886
99% Chebyshev (MVUE) UCL	8274		

Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			

Nonparametric Distribution Free UCLs			
95% CLT UCL	3432	95% Jackknife UCL	3483
95% Standard Bootstrap UCL	3385	95% Bootstrap-t UCL	10096
95% Hall's Bootstrap UCL	9864	95% Percentile Bootstrap UCL	3695
95% BCA Bootstrap UCL	4719		
90% Chebyshev(Mean, Sd) UCL	4672	95% Chebyshev(Mean, Sd) UCL	5915
97.5% Chebyshev(Mean, Sd) UCL	7641	99% Chebyshev(Mean, Sd) UCL	11031

Suggested UCL to Use	
95% H-UCL	4822

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.

ProUCL computes and outputs H-statistic based UCLs for historical reasons only.
H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.
It is therefore recommended to avoid the use of H-statistic based 95% UCLs.
Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.

Prepared by: L Ouy 8/18/17
Checked by: LMS 8/30/17

South Domain
UCL Statistics for Uncensored Full Data Sets

User Selected Options
Date/Time of Computation ProUCL 5.12/14/2019 2:10:56 PM
From File WorkSheet.xls
Full Precision OFF
Confidence Coefficient 95%
Number of Bootstrap Operations 2000

Lead w/o 702 (0-1), 602 (0-1), 701 (0-1)

General Statistics

Total Number of Observations	26	Number of Distinct Observations	24
		Number of Missing Observations	3
Minimum	25	Mean	**891.6**
Maximum	2500	Median	795
SD	675.9	Std. Error of Mean	132.5
Coefficient of Variation	0.758	Skewness	0.602

Normal GOF Test

Shapiro Wilk Test Statistic	0.944	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.92	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.106	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.17	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	1118	95% Adjusted-CLT UCL (Chen-1995)	1126
		95% Modified-t UCL (Johnson-1978)	1121

Gamma GOF Test

A-D Test Statistic	0.647	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.771	Detected data appear Gamma Distributed at 5% Significance Leve	
K-S Test Statistic	0.152	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.176	Detected data appear Gamma Distributed at 5% Significance Leve	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.11	k star (bias corrected MLE)	1.008
Theta hat (MLE)	802.9	Theta star (bias corrected MLE)	884.5
nu hat (MLE)	57.74	nu star (bias corrected)	52.42
MLE Mean (bias corrected)	891.6	MLE Sd (bias corrected)	888
		Approximate Chi Square Value (0.05)	36.79
Adjusted Level of Significance	0.0398	Adjusted Chi Square Value	35.92

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1270	95% Adjusted Gamma UCL (use when n<50)	1301

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.856	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.92	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.209	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.17	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.219	Mean of logged Data	6.279
Maximum of Logged Data	7.824	SD of logged Data	1.308

Assuming Lognormal Distribution

95% H-UCL	2699	90% Chebyshev (MVUE) UCL	2284
95% Chebyshev (MVUE) UCL	2782	97.5% Chebyshev (MVUE) UCL	3473
99% Chebyshev (MVUE) UCL	4829		

Nonparametric Distribution Free UCL Statistics
Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	1110	95% Jackknife UCL	1118
95% Standard Bootstrap UCL	1105	95% Bootstrap-t UCL	1139
95% Hall's Bootstrap UCL	1122	95% Percentile Bootstrap UCL	1115
95% BCA Bootstrap UCL	1126		
90% Chebyshev(Mean, Sd) UCL	1289	95% Chebyshev(Mean, Sd) UCL	1469
97.5% Chebyshev(Mean, Sd) UCL	1719	99% Chebyshev(Mean, Sd) UCL	2210

Suggested UCL to Use

95% Student's-t UCL	1118

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.

UCL Statistics for Data Sets with Non-Detects

User Selected Options

Date/Time of Computation	ProUCL 5.12/14/2019 2:09:59 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Arsenic w/o 702 (0-1), 602 (0-1), 701 (0-1)

General Statistics

Total Number of Observations	20	Number of Distinct Observations	13
		Number of Missing Observations	9
Number of Detects	19	Number of Non-Detects	1
Number of Distinct Detects	12	Number of Distinct Non-Detects	1
Minimum Detect	5.3	Minimum Non-Detect	1
Maximum Detect	73	Maximum Non-Detect	1
Variance Detects	306.3	Percent Non-Detects	5%
Mean Detects	21.65	SD Detects	17.5
Median Detects	14	CV Detects	0.808
Skewness Detects	1.938	Kurtosis Detects	3.529
Mean of Logged Detects	2.846	SD of Logged Detects	0.655

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.738	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.901	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.289	Lilliefors GOF Test
5% Lilliefors Critical Value	0.197	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

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

KM Mean	20.62	KM Standard Error of Mean	3.952
KM SD	17.2	95% KM (BCA) UCL	27.7
95% KM (t) UCL	27.45	95% KM (Percentile Bootstrap) UCL	27.87
95% KM (z) UCL	27.11	95% KM Bootstrap t UCL	32.63
90% KM Chebyshev UCL	32.47	95% KM Chebyshev UCL	37.84
97.5% KM Chebyshev UCL	45.29	99% KM Chebyshev UCL	59.93

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.221	Anderson-Darling GOF Test
5% A-D Critical Value	0.751	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.251	Kolmogorov-Smirnov GOF
5% K-S Critical Value	0.201	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)	2.342	k star (bias corrected MLE)	2.007
Theta hat (MLE)	9.245	Theta star (bias corrected MLE)	10.79
nu hat (MLE)	88.98	nu star (bias corrected)	76.26
Mean (detects)	21.65		

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	0.01	Mean	20.57
Maximum	73	Median	13.5
SD	17.71	CV	0.861
k hat (MLE)	1.045	k star (bias corrected MLE)	0.921
Theta hat (MLE)	19.69	Theta star (bias corrected MLE)	22.32
nu hat (MLE)	41.78	nu star (bias corrected)	36.85
Adjusted Level of Significance (β)	0.038		
Approximate Chi Square Value (36.85, α)	23.95	Adjusted Chi Square Value (36.85, β)	23.13
95% Gamma Approximate UCL (use when n>=50)	31.64	95% Gamma Adjusted UCL (use when n<50)	32.76

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	20.62	SD (KM)	17.2
Variance (KM)	295.9	SE of Mean (KM)	3.952
k hat (KM)	1.436	k star (KM)	1.254
nu hat (KM)	57.45	nu star (KM)	50.17
theta hat (KM)	14.35	theta star (KM)	16.44
80% gamma percentile (KM)	32.5	90% gamma percentile (KM)	44.89
95% gamma percentile (KM)	57.06	99% gamma percentile (KM)	84.89

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (50.17, α)	34.91	Adjusted Chi Square Value (50.17, β)	33.9
95% Gamma Approximate KM-UCL (use when n>=5(	29.63	95% Gamma Adjusted KM-UCL (use when n<50)	30.51

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.91	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.901	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.215	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.197	Detected Data Not Lognormal at 5% Significance Level	

Detected Data appear Approximate Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	20.74	Mean in Log Scale	2.768
SD in Original Scale	17.5	SD in Log Scale	0.728
95% t UCL (assumes normality of ROS data)	27.51	95% Percentile Bootstrap UCL	28
95% BCA Bootstrap UCL	30.05	95% Bootstrap t UCL	32.32
95% H-UCL (Log ROS)	30.32		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	2.704	KM Geo Mean	14.94
KM SD (logged)	0.878	95% Critical H Value (KM-Log)	2.462
KM Standard Error of Mean (logged)	0.202	95% H-UCL (KM -Log)	36.09
KM SD (logged)	0.878	95% Critical H Value (KM-Log)	2.462
KM Standard Error of Mean (logged)	0.202		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	20.59	Mean in Log Scale	2.669
SD in Original Scale	17.68	SD in Log Scale	1.017
95% t UCL (Assumes normality)	27.42	95% H-Stat UCL	44.97

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

Nonparametric Distribution Free UCL Statistics
Detected Data appear Approximate Lognormal Distributed at 5% Significance Level

Suggested UCL to Use

KM H-UCL	**36.09**

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.

EAST
UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.18/30/2017 1:47:23 PM
From File	PAH + Metals Soil Data.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Arsenic All

General Statistics

Total Number of Observations	22	Number of Distinct Observations	22
		Number of Missing Observations	8
Minimum	1.3	Mean	21.49
Maximum	160	Median	5.6
SD	39.15	Std. Error of Mean	8.346
Coefficient of Variation	1.822	Skewness	2.861

Normal GOF Test

Shapiro Wilk Test Statistic	0.552	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.911	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.303	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.184	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	35.85	95% Adjusted-CLT UCL (Chen-1995)	40.65
		95% Modified-t UCL (Johnson-1978)	36.7

Gamma GOF Test

A-D Test Statistic	1.412	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.795	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.224	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.195	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			

Gamma Statistics

k hat (MLE)	0.604	k star (bias corrected MLE)	0.552
Theta hat (MLE)	35.58	Theta star (bias corrected MLE)	38.93
nu hat (MLE)	26.57	nu star (bias corrected)	24.28
MLE Mean (bias corrected)	21.49	MLE Sd (bias corrected)	28.92
		Approximate Chi Square Value (0.05)	14.06
Adjusted Level of Significance	0.0386	Adjusted Chi Square Value	13.48

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	37.1	95% Adjusted Gamma UCL (use when n<50)	38.69

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.933	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.911	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.134	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.184	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			

Lognormal Statistics

Minimum of Logged Data	0.262	Mean of logged Data	2.045
Maximum of Logged Data	5.075	SD of logged Data	1.37

Assuming Lognormal Distribution

95% H-UCL	50.44	90% Chebyshev (MVUE) UCL	37.52

Prepared by: L Ouy 8/18/17
Checked by: LMS 8/30/17

95% Chebyshev (MVUE) UCL	46.2	97.5% Chebyshev (MVUE) UCL	58.25
99% Chebyshev (MVUE) UCL	81.93		

Nonparametric Distribution Free UCL Statistics
Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	35.21	95% Jackknife UCL	35.85
95% Standard Bootstrap UCL	34.83	95% Bootstrap-t UCL	67.58
95% Hall's Bootstrap UCL	96.99	95% Percentile Bootstrap UCL	36.93
95% BCA Bootstrap UCL	41.28		
90% Chebyshev(Mean, Sd) UCL	46.53	95% Chebyshev(Mean, Sd) UCL	57.87
97.5% Chebyshev(Mean, Sd) UCL	73.61	99% Chebyshev(Mean, Sd) UCL	104.5

Suggested UCL to Use
95% Chebyshev (Mean, Sd) UCL **57.87**

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.

Lead All

General Statistics

Total Number of Observations	21	Number of Distinct Observations	20
		Number of Missing Observations	7
Minimum	46	**Mean**	**763.6**
Maximum	5400	Median	330
SD	1236	Std. Error of Mean	269.7
Coefficient of Variation	1.619	Skewness	3.132

Normal GOF Test

Shapiro Wilk Test Statistic	0.558	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.908	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.281	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.188	Data Not Normal at 5% Significance Level	

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	1229	95% Adjusted-CLT UCL (Chen-1995)	1404
		95% Modified-t UCL (Johnson-1978)	1260

Gamma GOF Test

A-D Test Statistic	1.179	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.779	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.171	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.196	Detected data appear Gamma Distributed at 5% Significance Leve	

Detected data follow Appr. Gamma Distribution at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.828	k star (bias corrected MLE)	0.742
Theta hat (MLE)	921.8	Theta star (bias corrected MLE)	1029
nu hat (MLE)	34.79	nu star (bias corrected)	31.16
MLE Mean (bias corrected)	763.6	MLE Sd (bias corrected)	886.6
		Approximate Chi Square Value (0.05)	19.4
Adjusted Level of Significance	0.0383	Adjusted Chi Square Value	18.69

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	1226	95% Adjusted Gamma UCL (use when n<50)	1273

Lognormal GOF Test

Prepared by: L Ouy 8/18/17
Checked by: LMS 8/30/17

Shapiro Wilk Test Statistic	0.951	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.908	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.128	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.188	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			

Lognormal Statistics			
Minimum of Logged Data	3.829	Mean of logged Data	5.925
Maximum of Logged Data	8.594	SD of logged Data	1.136

Assuming Lognormal Distribution			
95% H-UCL	1437	90% Chebyshev (MVUE) UCL	1262
95% Chebyshev (MVUE) UCL	1525	97.5% Chebyshev (MVUE) UCL	1891
99% Chebyshev (MVUE) UCL	2608		

Nonparametric Distribution Free UCL Statistics
Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs			
95% CLT UCL	1207	95% Jackknife UCL	1229
95% Standard Bootstrap UCL	1187	95% Bootstrap-t UCL	2201
95% Hall's Bootstrap UCL	3190	95% Percentile Bootstrap UCL	1255
95% BCA Bootstrap UCL	1493		
90% Chebyshev(Mean, Sd) UCL	1573	95% Chebyshev(Mean, Sd) UCL	1939
97.5% Chebyshev(Mean, Sd) UCL	2448	99% Chebyshev(Mean, Sd) UCL	3447

Suggested UCL to Use	
95% Adjusted Gamma UCL	1273

When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

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.

Prepared by: L Ouy 8/18/17
Checked by: LMS 8/30/17

East Domain
UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.12/14/2019 2:27:56 PM
From File	WorkSheet_a.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Arsenic w/o 822 (0-1)

General Statistics

Total Number of Observations	21	Number of Distinct Observations	21
		Number of Missing Observations	9
Minimum	1.3	Mean	14.89
Maximum	110	Median	5.3
SD	24.58	Std. Error of Mean	5.364
Coefficient of Variation	1.651	Skewness	3.217

Normal GOF Test

Shapiro Wilk Test Statistic	0.568	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.908	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.293	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.188	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	24.14	95% Adjusted-CLT UCL (Chen-1995)	27.74
		95% Modified-t UCL (Johnson-1978)	24.77

Gamma GOF Test

A-D Test Statistic	1.079	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.783	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.207	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.197	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			

Gamma Statistics

k hat (MLE)	0.749	k star (bias corrected MLE)	0.674
Theta hat (MLE)	19.89	Theta star (bias corrected MLE)	22.11
nu hat (MLE)	31.45	nu star (bias corrected)	28.29
MLE Mean (bias corrected)	14.89	MLE Sd (bias corrected)	18.14
		Approximate Chi Square Value (0.05)	17.15
Adjusted Level of Significance	0.0383	Adjusted Chi Square Value	16.49

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	24.56	95% Adjusted Gamma UCL (use when n<50)	25.55

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.945	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.908	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.117	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.188	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			

Lognormal Statistics

Minimum of Logged Data	0.262	Mean of logged Data	1.901
Maximum of Logged Data	4.7	SD of logged Data	1.221

Assuming Lognormal Distribution

95% H-UCL	30.94	90% Chebyshev (MVUE) UCL	25.69

95% Chebyshev (MVUE) UCL	31.29	97.5% Chebyshev (MVUE) UCL	39.07
99% Chebyshev (MVUE) UCL	54.35		

Nonparametric Distribution Free UCL Statistics
Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	23.71	95% Jackknife UCL	24.14
95% Standard Bootstrap UCL	23.44	95% Bootstrap-t UCL	35.09
95% Hall's Bootstrap UCL	53.63	95% Percentile Bootstrap UCL	24.45
95% BCA Bootstrap UCL	28.82		
90% Chebyshev(Mean, Sd) UCL	30.98	95% Chebyshev(Mean, Sd) UCL	38.27
97.5% Chebyshev(Mean, Sd) UCL	48.39	99% Chebyshev(Mean, Sd) UCL	68.26

Suggested UCL to Use
95% Chebyshev (Mean, Sd) UCL **38.27**

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.

Lead **w/o 822 (0-1)**

General Statistics

Total Number of Observations	20	Number of Distinct Observations	19
		Number of Missing Observations	8
Minimum	46	**Mean**	**531.8**
Maximum	2900	Median	285
SD	648.4	Std. Error of Mean	145
Coefficient of Variation	1.219	Skewness	2.831

Normal GOF Test

Shapiro Wilk Test Statistic	0.662	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.905	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.233	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.192	Data Not Normal at 5% Significance Level	

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	782.5	95% Adjusted-CLT UCL (Chen-1995)	868.3
		95% Modified-t UCL (Johnson-1978)	797.8

Gamma GOF Test

A-D Test Statistic	0.722	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.764	Detected data appear Gamma Distributed at 5% Significance Leve	
K-S Test Statistic	0.168	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.199	Detected data appear Gamma Distributed at 5% Significance Leve	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.17	k star (bias corrected MLE)	1.028
Theta hat (MLE)	454.6	Theta star (bias corrected MLE)	517.5
nu hat (MLE)	46.79	nu star (bias corrected)	41.11
MLE Mean (bias corrected)	531.8	MLE Sd (bias corrected)	524.6
		Approximate Chi Square Value (0.05)	27.41
Adjusted Level of Significance	0.038	Adjusted Chi Square Value	26.53

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	797.5	95% Adjusted Gamma UCL (use when n<50)	824

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.964	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.905	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.129	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.192	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			

Lognormal Statistics			
Minimum of Logged Data	3.829	Mean of logged Data	5.791
Maximum of Logged Data	7.972	SD of logged Data	0.982

Assuming Lognormal Distribution			
95% H-UCL	955.2	90% Chebyshev (MVUE) UCL	890.3
95% Chebyshev (MVUE) UCL	1061	97.5% Chebyshev (MVUE) UCL	1298
99% Chebyshev (MVUE) UCL	1764		

Nonparametric Distribution Free UCL Statistics
Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs			
95% CLT UCL	770.3	95% Jackknife UCL	782.5
95% Standard Bootstrap UCL	769.8	95% Bootstrap-t UCL	1008
95% Hall's Bootstrap UCL	1736	95% Percentile Bootstrap UCL	774
95% BCA Bootstrap UCL	887.8		
90% Chebyshev(Mean, Sd) UCL	966.8	95% Chebyshev(Mean, Sd) UCL	1164
97.5% Chebyshev(Mean, Sd) UCL	1437	99% Chebyshev(Mean, Sd) UCL	1974

Suggested UCL to Use	
95% Adjusted Gamma UCL	824

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.

West
UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.18/30/2017 2:02:56 PM
From File	PAH + Metals Soil Data_a.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Arsenic **All**

General Statistics

Total Number of Observations	37	Number of Distinct Observations	33
		Number of Missing Observations	6
Number of Detects	35	Number of Non-Detects	2
Number of Distinct Detects	32	Number of Distinct Non-Detects	1
Minimum Detect	2.2	Minimum Non-Detect	1.1
Maximum Detect	380	Maximum Non-Detect	1.1
Variance Detects	6551	Percent Non-Detects	5.41%
Mean Detects	57.03	SD Detects	80.94
Median Detects	26	CV Detects	1.419
Skewness Detects	2.664	Kurtosis Detects	7.619
Mean of Logged Detects	3.312	SD of Logged Detects	1.254

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.653	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.934	Detected Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.252	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.148	Detected Data Not Normal at 5% Significance Level	
Detected Data Not Normal at 5% Significance Level			

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

KM Mean	54.01	KM Standard Error of Mean	13.11
KM SD	78.61	95% KM (BCA) UCL	77.62
95% KM (t) UCL	76.14	95% KM (Percentile Bootstrap) UCL	76.44
95% KM (z) UCL	75.57	95% KM Bootstrap t UCL	91.26
90% KM Chebyshev UCL	93.34	95% KM Chebyshev UCL	111.2
97.5% KM Chebyshev UCL	135.9	99% KM Chebyshev UCL	184.5

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.773	Anderson-Darling GOF Test	
5% A-D Critical Value	0.785	Detected data appear Gamma Distributed at 5% Significance Leve	
K-S Test Statistic	0.154	Kolmogorov-Smirnov GOF	
5% K-S Critical Value	0.154	Detected data appear Gamma Distributed at 5% Significance Leve	
Detected data appear Gamma Distributed at 5% Significance Level			

Gamma Statistics on Detected Data Only

k hat (MLE)	0.81	k star (bias corrected MLE)	0.76
Theta hat (MLE)	70.42	Theta star (bias corrected MLE)	75.09
nu hat (MLE)	56.69	nu star (bias corrected)	53.17
Mean (detects)	57.03		

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	0.01	Mean	53.95
Maximum	380	Median	24
SD	79.74	CV	1.478
k hat (MLE)	0.565	k star (bias corrected MLE)	0.537
Theta hat (MLE)	95.53	Theta star (bias corrected MLE)	100.5
nu hat (MLE)	41.79	nu star (bias corrected)	39.74
Adjusted Level of Significance (β)	0.0431		
Approximate Chi Square Value (39.74, α)	26.29	Adjusted Chi Square Value (39.74, β)	25.82
95% Gamma Approximate UCL (use when n>=50)	81.52	95% Gamma Adjusted UCL (use when n<50)	83.03

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	54.01	SD (KM)	78.61
Variance (KM)	6180	SE of Mean (KM)	13.11
k hat (KM)	0.472	k star (KM)	0.452
nu hat (KM)	34.92	nu star (KM)	33.43
theta hat (KM)	114.4	theta star (KM)	119.6
80% gamma percentile (KM)	88.17	90% gamma percentile (KM)	149.1
95% gamma percentile (KM)	215.1	99% gamma percentile (KM)	378.8

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (33.43, α)	21.21	Adjusted Chi Square Value (33.43, β)	20.78
95% Gamma Approximate KM-UCL (use when n>=50)	85.13	95% Gamma Adjusted KM-UCL (use when n<50)	86.86

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.984	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.934	Detected Data appear Lognormal at 5% Significance Level	

Prepared by: L Ouy 8/18/17
Checked by: LMS 8/30/17

Lilliefors Test Statistic	0.0765	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.148	Detected Data appear Lognormal at 5% Significance Level	
Detected Data appear Lognormal at 5% Significance Level			

Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	54.02	Mean in Log Scale	3.148
SD in Original Scale	79.69	SD in Log Scale	1.403
95% t UCL (assumes normality of ROS data)	76.14	95% Percentile Bootstrap UCL	75.9
95% BCA Bootstrap UCL	85.32	95% Bootstrap t UCL	90.27
95% H-UCL (Log ROS)	122.5		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution			
KM Mean (logged)	3.138	KM Geo Mean	23.06
KM SD (logged)	1.405	95% Critical H Value (KM-Log)	2.89
KM Standard Error of Mean (logged)	0.234	95% H-UCL (KM -Log)	121.7
KM SD (logged)	1.405	95% Critical H Value (KM-Log)	2.89
KM Standard Error of Mean (logged)	0.234		

DL/2 Statistics			
DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	53.98	Mean in Log Scale	3.101
SD in Original Scale	79.72	SD in Log Scale	1.512
95% t UCL (Assumes normality)	76.1	95% H-Stat UCL	149.8
DL/2 is not a recommended method, provided for comparisons and historical reasons			

Nonparametric Distribution Free UCL Statistics
Detected Data appear Gamma Distributed at 5% Significance Level

Suggested UCL to Use
Gamma Adjusted KM-UCL (use when k<=1 and 15 < n < 50 but k<=1) **86.86**

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.

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.18/30/2017 2:17:38 PM
From File	PAH + Metals Soil Data_a.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Lead **All**

General Statistics			
Total Number of Observations	31	Number of Distinct Observations	27
		Number of Missing Observations	12
Minimum	3.7	Mean	**231.8**
Maximum	590	Median	250
SD	153.1	Std. Error of Mean	27.49
Coefficient of Variation	0.66	Skewness	0.347

Normal GOF Test			
Shapiro Wilk Test Statistic	0.961	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.929	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.113	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.156	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			

Assuming Normal Distribution			
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	278.5	95% Adjusted-CLT UCL (Chen-1995)	278.8
		95% Modified-t UCL (Johnson-1978)	278.7

Gamma GOF Test			
A-D Test Statistic	0.783	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.765	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.161	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.161	Detected data appear Gamma Distributed at 5% Significance Leve	
Detected data follow Appr. Gamma Distribution at 5% Significance Level			

Gamma Statistics			
k hat (MLE)	1.442	k star (bias corrected MLE)	1.324
Theta hat (MLE)	160.8	Theta star (bias corrected MLE)	175.1
nu hat (MLE)	89.37	nu star (bias corrected)	82.06
MLE Mean (bias corrected)	231.8	MLE Sd (bias corrected)	201.5
		Approximate Chi Square Value (0.05)	62.18
Adjusted Level of Significance	0.0413	Adjusted Chi Square Value	61.22

Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	305.9	95% Adjusted Gamma UCL (use when n<50)	310.7

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Checked by: LMS 8/30/17

Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.849	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.929	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.181	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.156	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	1.308	Mean of logged Data	5.061
Maximum of Logged Data	6.38	SD of logged Data	1.132
Assuming Lognormal Distribution			
95% H-UCL	510.2	90% Chebyshev (MVUE) UCL	498.7
95% Chebyshev (MVUE) UCL	593.3	97.5% Chebyshev (MVUE) UCL	724.7
99% Chebyshev (MVUE) UCL	982.8		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	277	95% Jackknife UCL	278.5
95% Standard Bootstrap UCL	274.7	95% Bootstrap-t UCL	280.1
95% Hall's Bootstrap UCL	281.5	95% Percentile Bootstrap UCL	279.1
95% BCA Bootstrap UCL	275.4		
90% Chebyshev(Mean, Sd) UCL	314.3	95% Chebyshev(Mean, Sd) UCL	351.6
97.5% Chebyshev(Mean, Sd) UCL	403.5	99% Chebyshev(Mean, Sd) UCL	505.3
Suggested UCL to Use			
95% Student's-t UCL	278.5		

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.

Prepared by: L Ouy 8/18/17
Checked by: LMS 8/30/17

West Domain
UCL Statistics for Data Sets with Non-Detects

User Selected Options

Date/Time of Computation	ProUCL 5.12/14/2019 2:37:28 PM
From File	WorkSheet_b.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Arsenic w/o 203 (0-2), 404 (0-2), 003 (0-2), 1332 (0-1)

General Statistics

Total Number of Observations	33	Number of Distinct Observations	29
		Number of Missing Observations	10
Number of Detects	31	Number of Non-Detects	2
Number of Distinct Detects	28	Number of Distinct Non-Detects	1
Minimum Detect	2.2	Minimum Non-Detect	1.1
Maximum Detect	120	Maximum Non-Detect	1.1
Variance Detects	783.4	Percent Non-Detects	6.06%
Mean Detects	31.81	SD Detects	27.99
Median Detects	23	CV Detects	0.88
Skewness Detects	1.343	Kurtosis Detects	1.793
Mean of Logged Detects	3.032	SD of Logged Detects	1.029

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.866	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.929	Detected Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.213	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.156	Detected Data Not Normal at 5% Significance Level	

Detected Data Not Normal at 5% Significance Level

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

KM Mean	29.95	KM Standard Error of Mean	4.897
KM SD	27.67	95% KM (BCA) UCL	37.82
95% KM (t) UCL	38.24	95% KM (Percentile Bootstrap) UCL	37.58
95% KM (z) UCL	38	95% KM Bootstrap t UCL	40.07
90% KM Chebyshev UCL	44.64	95% KM Chebyshev UCL	51.29
97.5% KM Chebyshev UCL	60.53	99% KM Chebyshev UCL	78.67

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.222	Anderson-Darling GOF Test	
5% A-D Critical Value	0.768	Detected data appear Gamma Distributed at 5% Significance Leve	
K-S Test Statistic	0.0993	Kolmogorov-Smirnov GOF	
5% K-S Critical Value	0.161	Detected data appear Gamma Distributed at 5% Significance Leve	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.311	k star (bias corrected MLE)	1.206
Theta hat (MLE)	24.26	Theta star (bias corrected MLE)	26.38
nu hat (MLE)	81.28	nu star (bias corrected)	74.75
Mean (detects)	31.81		

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	0.01	Mean	29.88
Maximum	120	Median	20
SD	28.17	CV	0.943
k hat (MLE)	0.726	k star (bias corrected MLE)	0.68
Theta hat (MLE)	41.14	Theta star (bias corrected MLE)	43.91
nu hat (MLE)	47.93	nu star (bias corrected)	44.91
Adjusted Level of Significance (β)	0.0419		
Approximate Chi Square Value (44.91, α)	30.53	Adjusted Chi Square Value (44.91, β)	29.92
95% Gamma Approximate UCL (use when n>=50)	43.94	95% Gamma Adjusted UCL (use when n<50)	44.84

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	29.95	SD (KM)	27.67
Variance (KM)	765.9	SE of Mean (KM)	4.897
k hat (KM)	1.171	k star (KM)	1.085
nu hat (KM)	77.27	nu star (KM)	71.58
theta hat (KM)	25.58	theta star (KM)	27.61
80% gamma percentile (KM)	47.86	90% gamma percentile (KM)	67.58
95% gamma percentile (KM)	87.18	99% gamma percentile (KM)	132.4

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (71.58, α)	53.1	Adjusted Chi Square Value (71.58, β)	52.28
95% Gamma Approximate KM-UCL (use when n>=50)	40.37	95% Gamma Adjusted KM-UCL (use when n<50)	41

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.963	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.929	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.101	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.156	Detected Data appear Lognormal at 5% Significance Level	

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	29.99	Mean in Log Scale	2.885
SD in Original Scale	28.06	SD in Log Scale	1.159
95% t UCL (assumes normality of ROS data)	38.26	95% Percentile Bootstrap UCL	38.01
95% BCA Bootstrap UCL	38.57	95% Bootstrap t UCL	40.26
95% H-UCL (Log ROS)	60.11		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	2.854	KM Geo Mean	17.36
KM SD (logged)	1.206	95% Critical H Value (KM-Log)	2.699
KM Standard Error of Mean (logged)	0.213	95% H-UCL (KM -Log)	63.85
KM SD (logged)	1.206	95% Critical H Value (KM-Log)	2.699
KM Standard Error of Mean (logged)	0.213		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	29.91	Mean in Log Scale	2.812
SD in Original Scale	28.14	SD in Log Scale	1.329
95% t UCL (Assumes normality)	38.21	95% H-Stat UCL	78.96

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

Nonparametric Distribution Free UCL Statistics

Detected Data appear Gamma Distributed at 5% Significance Level

Suggested UCL to Use

95% KM Adjusted Gamma UCL	**41**	95% GROS Adjusted Gamma UCL	44.84

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options

Date/Time of Computation	ProUCL 5.12/14/2019 2:43:50 PM
From File	WorkSheet_b.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Lead w/o 203 (0-2), 404 (0-2), 003 (0-2), 1332 (0-1)

General Statistics

Total Number of Observations	27	Number of Distinct Observations	24
		Number of Missing Observations	16
Minimum	3.7	**Mean**	**217.2**
Maximum	590	Median	230

SD	153.7	Std. Error of Mean	29.57
Coefficient of Variation	0.707	Skewness	0.478

Normal GOF Test

Shapiro Wilk Test Statistic	0.952	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.923	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.137	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.167	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	267.7	95% Adjusted-CLT UCL (Chen-1995)	268.8
		95% Modified-t UCL (Johnson-1978)	268.1

Gamma GOF Test

A-D Test Statistic	0.561	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.767	Detected data appear Gamma Distributed at 5% Significance Leve	
K-S Test Statistic	0.158	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.172	Detected data appear Gamma Distributed at 5% Significance Leve	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.325	k star (bias corrected MLE)	1.202
Theta hat (MLE)	164	Theta star (bias corrected MLE)	180.7
nu hat (MLE)	71.53	nu star (bias corrected)	64.92
MLE Mean (bias corrected)	217.2	MLE Sd (bias corrected)	198.1
		Approximate Chi Square Value (0.05)	47.38
Adjusted Level of Significance	0.0401	Adjusted Chi Square Value	46.42

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	297.7	95% Adjusted Gamma UCL (use when n<50)	303.8

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.87	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.923	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.177	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.167	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.308	Mean of logged Data	4.958
Maximum of Logged Data	6.38	SD of logged Data	1.175

Assuming Lognormal Distribution

95% H-UCL	535.4	90% Chebyshev (MVUE) UCL	490.5
95% Chebyshev (MVUE) UCL	589.3	97.5% Chebyshev (MVUE) UCL	726.4
99% Chebyshev (MVUE) UCL	995.7		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	265.9	95% Jackknife UCL	267.7
95% Standard Bootstrap UCL	263.5	95% Bootstrap-t UCL	273.5
95% Hall's Bootstrap UCL	272.8	95% Percentile Bootstrap UCL	267.3
95% BCA Bootstrap UCL	268.7		
90% Chebyshev(Mean, Sd) UCL	306	95% Chebyshev(Mean, Sd) UCL	346.2
97.5% Chebyshev(Mean, Sd) UCL	401.9	99% Chebyshev(Mean, Sd) UCL	511.5

Suggested UCL to Use

95% Student's-t UCL	267.7

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.

MAGNETIC

ENTLEMAN STREET

ST. JAMES A.M.E. CHURCH

DOW ELECTRONICS, INC.

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MAYOR & ALDERMEN CITY OF SAVANNAH

SHIPWATCH PARTNERS

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SAVANNAH & CHA

MATCH LINE SEE BELOW FOR CONTINUATION

HUBERT MIDDLE SCHOOL

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

STEVENS OIL/SCRAP SITE

MATCH LINE

TION FOR
THAM COUNTY

LIBERTY STREET

LEGEND

- Property Line
- RRS
- Background
- 30A — Sample Point
- 100/0-1 — Depth of Sample / Concentration in mg/Kg

GRAPHIC SCALE IN FEET

60 0 60 120 180 240

CSX TRANSPORTATION

HC HOLLEY CONSULTANTS

REVISIONS & DATE

FIGURE 2.1
SOIL SAMPLE LOCATIONS
CSXT DEPRIEST SIGNAL SHOP
SAVANNAH, GA

DESIGNED BY	CHECKED BY	SCALE	DATE
–	REH	INDICATED	AUG 2005

LIBERTY STREET
EAST BROAD STREET
WHEATON STREET
SITE
GWINNETT STREET
WATERS AVE.

VICINITY MAP
N.T.S.

MAGNETIC

ENTLEMAN STREET

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DOW ELECTRONICS, INC.

THE MASONIC BLDG. ASSOC.

MAYOR & ALDERMEN CITY OF SAVANNAH

SHIPWATCH PARTNERS

MATHILDA PARK

BG

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BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

EAST BROAD STREET ELEMENTARY SCHOOL

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

HUBERT MIDDLE SCHOOL

STEVENS OIL/SCRAP SITE

MATCH LINE SEE BELOW FOR CONTINUATION

MATCH LINE

LIBERTY STREET

LEGEND

- Property Line
- RRS
- Background
- 30A — Sample Point
- 100/0-1 — Depth of Sample
- Concentration in mg/Kg

BG (0-2) = <2.1 mg/Kg

BG (>2) = 3.2 mg/Kg

RRS (0-2) = 121 mg/Kg

RRS (>2) = 121 mg/Kg

GRAPHIC SCALE IN FEET

60 0 60 120 180 240

VICINITY MAP
N.T.S.

LIBERTY STREET · EAST BROAD STREET · WHEATON STREET · GWINNETT STREET · WATERS AVE. · SITE

CSX TRANSPORTATION

HOLLEY CONSULTANTS

REVISIONS & DATE

FIGURE 3.1
ANTIMONY SOIL DELINEATION
CSXT DEPRIEST SIGNAL SHOP
SAVANNAH, GA

DESIGNED BY	CHECKED BY	SCALE	DATE
–	REH	INDICATED	FEB 2014

MAGNETIC

ST. JAMES A.M.E. CHURCH

DOW ELECTRONICS, INC.

THE MASONIC BLDG. ASSOC.

MAYOR & ALDERMEN CITY OF SAVANNAH

SHIPWATCH PARTNERS

MATHILDA PARK

SHIPWATCH PARTNERS

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

EAST BROAD STREET ELEMENTARY SCHOOL

ENTLEMAN STREET 24' R/W

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

HUBERT MIDDLE SCHOOL

STEVENS OIL/SCRAP SITE

MATCH LINE SEE BELOW FOR CONTINUATION

MATCH LINE

LIBERTY STREET

LEGEND

- Property Line
- RRS
- Background
- 30A — Sample Point
- 100/0-1 — Depth of Sample
- Concentration in mg/Kg

BG (0-2) = 12 mg/Kg

BG (>2) = 44 mg/Kg

RRS (0-2) = 109 mg/Kg

RRS (>2) = 3,972 mg/Kg

GRAPHIC SCALE IN FEET

60 0 60 120 180 240

VICINITY MAP
N.T.S.

LIBERTY STREET, WHEATON STREET, EAST BROAD STREET, SITE, GWINNETT STREET, WATERS AVE.

CSX TRANSPORTATION

HOLLEY CONSULTANTS

REVISIONS & DATE
1. REVISE RRS AND DELINEATION 03/05/08

FIGURE 3.2
ARSENIC SOIL DELINEATION
CSXT DEPRIEST SIGNAL SHOP
SAVANNAH, GA

DESIGNED BY	CHECKED BY	SCALE	DATE
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ENTLEMAN STREET

ST. JAMES A.M.E. CHURCH

DOW ELECTRONICS, INC.

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MAYOR & ALDERMEN CITY OF SAVANNAH

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MATHILDA PARK

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BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

EAST BROAD STREET ELEMENTARY SCHOOL

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

HUBERT MIDDLE SCHOOL

STEVENS OIL/SCRAP SITE

MATCH LINE SEE BELOW FOR CONTINUATION

LEGEND

- Property Line
- RRS
- Background
- 30A — Sample Point
- 100/0-1 — Depth of Sample / Concentration in mg/Kg

BG (0-2) = 110 mg/Kg

BG (>2) = 30 mg/Kg

RRS (0-2) = 1,000 mg/Kg

RRS (>2) = 1,000 mg/Kg

MATCH LINE

LIBERTY STREET

BUILDING

ASPHALT PAVEMENT

CHAIN LINK FENCE

VICINITY MAP
N.T.S.

LIBERTY STREET

EAST BROAD STREET

WHEATON STREET

GWINNETT STREET

WATERS AVE.

SITE

GRAPHIC SCALE IN FEET

60 0 60 120 180 240

CSX TRANSPORTATION

HOLLEY CONSULTANTS

REVISIONS & DATE

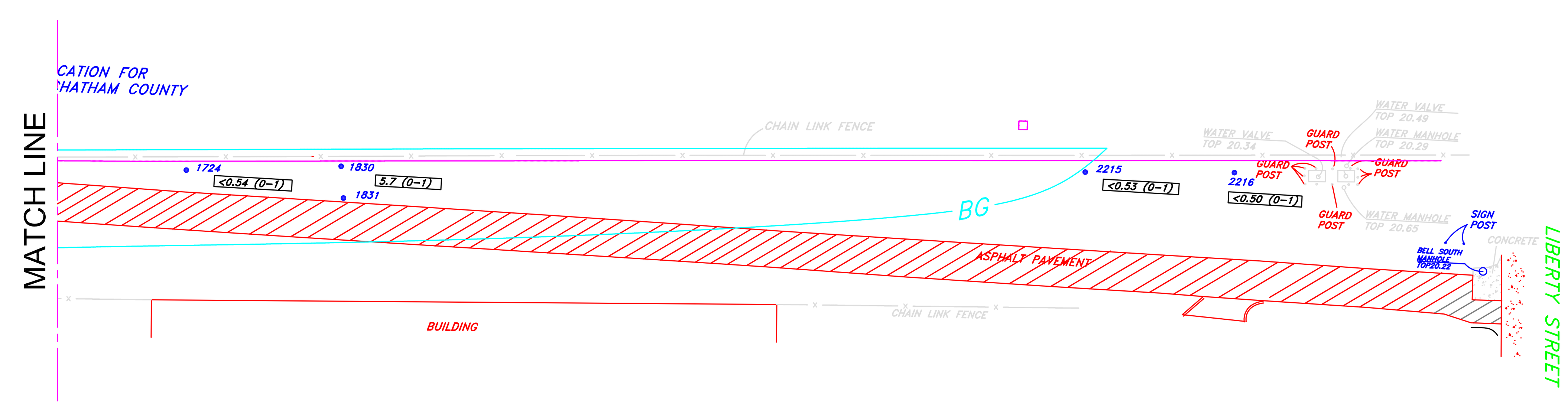
FIGURE 3.3

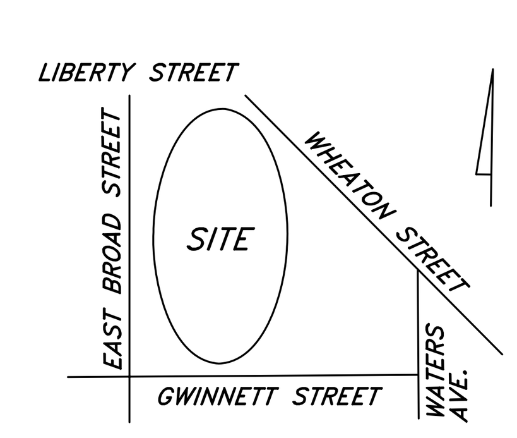
BARIUM SOIL DELINEATION

CSXT DEPRIEST SIGNAL SHOP

SAVANNAH, GA

DESIGNED BY	CHECKED BY	SCALE	DATE
–	REH	INDICATED	FEB 2014





VICINITY MAP
N.T.S.

LEGEND

- Property Line
- RRS
- Background
- Sample Point (30A)
- Depth of Sample (100/0-1)
- Concentration in mg/Kg

BG (0-2) = 0.68 mg/Kg
BG (>2) = <0.65 mg/Kg
RRS (0-2) = 114 mg/Kg
RRS (>2) = 114 mg/Kg

CSX TRANSPORTATION

HOLLEY CONSULTANTS

REVISIONS & DATE	FIGURE 3.4 CADMIUM SOIL DELINEATION CSXT DEPRIEST SIGNAL SHOP SAVANNAH, GA			
	DESIGNED BY	CHECKED BY	SCALE	DATE
	–	REH	INDICATED	FEB 2014

MAGNETIC

ENTLEMAN STREET
24' R/W

ST. JAMES A.M.E. CHURCH

THE MASONIC BLDG. ASSOC.

DOW ELECTRONICS, INC.

MAYOR & ALDERMEN CITY OF SAVANNAH

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BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

EAST BROAD STREET ELEMENTARY SCHOOL

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

HUBERT MIDDLE SCHOOL

STEVENS OIL/SCRAP SITE

MATCH LINE SEE BELOW FOR CONTINUATION

MATCH LINE

LIBERTY STREET

LEGEND

- Property Line
- RRS
- Background
- 30A — Sample Point
- 100/0-1 — Depth of Sample
- Concentration in mg/Kg

BG (0-2) = 11 mg/Kg
BG (>2) = 19 mg/Kg
RRS (0-2) = 322 mg/Kg
RRS (>2) = 38,665 mg/Kg

GRAPHIC SCALE IN FEET
60 0 60 120 180 240

VICINITY MAP
N.T.S.

LIBERTY STREET
EAST BROAD STREET
SITE
WHEATON STREET
GWINNETT STREET
WATERS AVE.

CSX TRANSPORTATION

HOLLEY CONSULTANTS

REVISIONS & DATE

FIGURE 3.5
CHROMIUM SOIL DELINEATION
CSXT DEPRIEST SIGNAL SHOP
SAVANNAH, GA

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–	REH	INDICATED	FEB 2014

MAGNETIC

ENTLEMAN STREET
24' R/W

ST. JAMES A.M.E. CHURCH

DOW ELECTRONICS, INC.

THE MASONIC BLDG. ASSOC.

MAYOR & ALDERMEN CITY OF SAVANNAH

SHIPWATCH PARTNERS

MATHILDA PARK

SHIPWATCH PARTNERS

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

EAST BROAD STREET ELEMENTARY SCHOOL

BOARD OF EDUCATION SAVANNAH & CHATHA

MATCH LINE SEE BELOW FOR CONTINUATION

RRS

BG

CHAIN LINK FENCE

GRAVEL ROAD

RAILROAD TRACK

PAVEMENT

ASPHALT PAVING

CONCRETE

METAL BUILDING

BLOCK BUILDING

LOADING DOCK

RAMP

MONITORING WELL 17 TOP CASING 19.54

MONITORING WELL 18 TOP17.65 TOP PVC 17.53

MONITORING WELL 19 TOP17.66 TOP PVC 17.34

MONITORING WELL 12 TOP15.74 TOP CASING 15.55

BENCHMARK RE-SPIKE W/ 5/P ELEV. 17.76 NGL (NGVD 1929)

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

NOTE: AREA LIMITED BY PREVIOUS REMEDIATION

HUBERT MIDDLE SCHOOL

STEVENS OIL/SCRAP SITE

MATCH LINE

LIBERTY STREET

BUILDING

ASPHALT PAVEMENT

LEGEND

- Property Line
- RRS
- Background
- 30A — Sample Point
- 100/0-1 — Depth of Sample
- Concentration in mg/Kg

BG (0-2) = 402 mg/Kg
BG (>2) = 290 mg/Kg
RRS (0-2) = 1,180 mg/Kg
RRS (>2) = 4,942 mg/Kg

GRAPHIC SCALE IN FEET
60 0 60 120 180 240

LIBERTY STREET
EAST BROAD STREET
WHEATON STREET
GWINNETT STREET
WATERS AVE.
SITE

VICINITY MAP
N.T.S.

CSX TRANSPORTATION

HOLLEY CONSULTANTS

REVISIONS & DATE

FIGURE 3.6
LEAD SOIL DELINEATION
CSXT DEPRIEST SIGNAL SHOP
SAVANNAH, GA

DESIGNED BY	CHECKED BY	SCALE	DATE
–	REH	INDICATED	FEB 2014

MAGNETIC

ENTLEMAN STREET

ST. JAMES A.M.E. CHURCH

DOW ELECTRONICS, INC.

THE MASONIC BLDG. ASSOC.

MAYOR & ALDERMEN CITY OF SAVANNAH

SHIPWATCH PARTNERS

MATHILDA PARK

SHIPWATCH PARTNERS

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

EAST BROAD STREET ELEMENTARY SCHOOL

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

HUBERT MIDDLE SCHOOL

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

STEVENS OIL/SCRAP SITE

MATCH LINE SEE BELOW FOR CONTINUATION

LEGEND

- Property Line
- RRS
- Background
- 30A — Sample Point
- 100/0-1 — Depth of Sample / Concentration in mg/Kg

BG (0-2) = <1.2 mg/Kg

BG (>2) = <1.1 mg/Kg

RRS (0-2) = 240 mg/Kg

RRS (>2) = 240 mg/Kg

MATCH LINE

BUILDING

CHAIN LINK FENCE

ASPHALT PAVEMENT

LIBERTY STREET

GRAPHIC SCALE IN FEET

60 0 60 120 180 240

VICINITY MAP
N.T.S.

LIBERTY STREET

EAST BROAD STREET

WHEATON STREET

GWINNETT STREET

WATERS AVE.

SITE

CSX TRANSPORTATION

HOLLEY CONSULTANTS

REVISIONS & DATE

FIGURE 3.7
SILVER SOIL DELINEATION
CSXT DEPRIEST SIGNAL SHOP
SAVANNAH, GA

DESIGNED BY	CHECKED BY	SCALE	DATE
–	REH	INDICATED	FEB 2014

MAGNETIC

ENTLEMAN STREET

ST. JAMES A.M.E. CHURCH

DOW ELECTRONICS, INC.

THE MASONIC BLDG. ASSOC.

MAYOR & ALDERMEN CITY OF SAVANNAH

SHIPWATCH PARTNERS

MATHILDA PARK

SHIPWATCH PARTNERS

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

EAST BROAD STREET ELEMENTARY SCHOOL

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

MATCH LINE SEE BELOW FOR CONTINUATION

BOARD OF EDUCATION FOR SAVANNAH & CHATHAM COUNTY

HUBERT MIDDLE SCHOOL

STEVENS OIL/SCRAP SITE

LEGEND

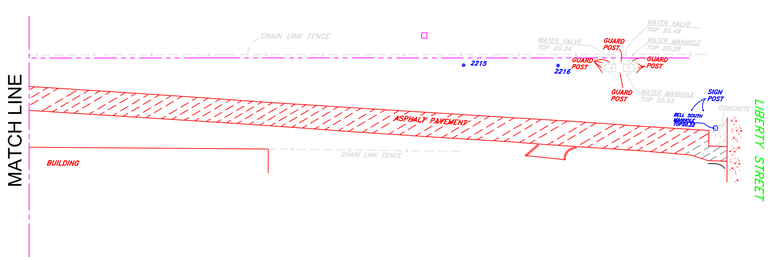
- Property Line
- RRS
- Background
- 30A — Sample Point
- 100/0-1 — Depth of Sample
- Concentration in mg/Kg

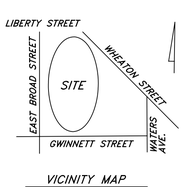
BG (0-2) = Detection Limits

BG (>2) = Detection Limits

RRS for BAP (0-2) = 22,000 Ug/Kg

RRS for BAP (>2) = 1,004,000 Ug/Kg





VICINITY MAP
N.T.S.

GRAPHIC SCALE IN FEET
60 0 60 120 180 240

CSX TRANSPORTATION

HOLLEY CONSULTANTS

REVISIONS & DATE

FIGURE 3.8
SVOC SOIL DELINEATION
CSXT DEPRIEST SIGNAL SHOP
SAVANNAH, GA

DESIGNED BY	CHECKED BY	SCALE	DATE
–	REH	INDICATED	AUG 2005