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ENVIRONMENTAL MANAGEMENT

BECHTEL JACOBS COMPANY LLC
ACCELERATED CLEANUP CONTRACT
WITH THE UNITED STATES
U.S. DEPARTMENT OF ENERGY

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BJC/OR-3174

Environmental Management Waste Management Facility Waste Lot Profile For K-770 Scrap Yard Soils and Miscellaneous Debris East Tennessee Technology Park Oak Ridge, Tennessee

EMWMF Waste Lot 4.12

This document is approved for public release per review by:

[signature] 4/16/09

BJC ETTP Classification & Information Office

Date

BECHTEL JACOBS
Bechtel Jacobs Company LLC

Interoffice Memorandum

To: G. J. Hampshire
Waste Management Project; 241-1312

From: J. M. Davenport
ETTP D&D/RA Project

Date: April 30, 2009

File: ETDD-09-014

Subject: DE-AC05-98OR22700: Environmental Management Waste Management Facility Waste Lot Profile for K-770 Scrap Yard Soils and Miscellaneous Debris, East Tennessee Technology Park, Oak Ridge, Tennessee EMWMF Waste Lot 4.12 (BJC/OR-3174)

The purpose of this memorandum is to transmit one copy of the subject Environmental Management Waste Management Facility (EMWMF) profile to the EMWMF Waste Acceptance Criteria Attainment Board for approval.

The ETTP D&D/RA Project looks forward to approval of this profile. Please call if you have any questions.

JMD:sp

Enclosure: EMWMF Waste Lot 4.12 Profile

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BJC/OR-3174

Environmental Management Waste Management Facility Waste Lot Profile for K-770 Scrap Yard Soils and Miscellaneous Debris East Tennessee Technology Park Oak Ridge, Tennessee

EMWMF Waste Lot 4.12

Date Issued—April 2009

Prepared for the
U.S. Department of Energy
Office of Environmental Management

BECHTEL JACOBS COMPANY LLC
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APPROVALS

ENVIRONMENTAL MANAGEMENT
WASTE MANAGEMENT FACILITY
WASTE LOT PROFILE FOR
K-770 SCRAP YARD SOILS AND MISCELLANEOUS DEBRIS
EAST TENNESSEE TECHNOLOGY PARK
OAK RIDGE, TENNESSEE
EMWMF WASTE LOT 4.12

BJC/OR-3174

April 2009

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USQD Review Determination: ☐ USQD ☒ UCD ☐ CAT X ☐ N/A USQD/UCD/CAT X No: UCD-YT-EMWMF-0170

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CONTENTS

TABLES

ACRONYMS

ACM	asbestos-containing material
ASA	Auditable Safety Analysis
BJC	Bechtel Jacobs Company LLC
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
CROET	Community Reuse Organization of East Tennessee
D&D	Decontamination and Demolition
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EMWMF	Environmental Management Waste Management Facility
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
LCP	Limited Characterization Plan
LLW	low-level waste
PCB	polychlorinated biphenyl
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act of 1976
SOF	sum of fractions
SRC	site-related contaminant
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TDEC	Tennessee Department of Environment and Conservation
TRU	transuranic
TSCA	Toxic Substances Control Act of 1976
TVA	Tennessee Valley Authority
UCL_{95}	95% upper confidence limit on the mean
VWSF	volume-weighted sum of fractions
WAC	waste acceptance criteria
WACFACS	Waste Acceptance Criteria Forecasting Analysis Capability System
WHP	Waste Handling Plan

1. INTRODUCTION

Waste Lot 4.12 consists of approximately 17,500 yd^3 of low-level, radioactively contaminated soil, concrete, and incidental metal and debris generated from remedial actions at the K-770 Scrap Metal Yard and Contaminated Debris Site (the K-770 Scrap Yard) at the East Tennessee Technology Park (ETTP). The excavated soil will be transported by dump truck to the Environmental Management Waste Management Facility (EMWMF). This profile provides project-specific information to demonstrate compliance with *Attainment Plan for Risk/Toxicity-based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2001).

The K-770 Scrap Yard is an approximately 36-acre storage area located southwest of the main portion of ETTP, outside the security perimeter fence in the Powerhouse Area adjacent to the Clinch River. The K-770 area was used to store radioactively contaminated or suspected contaminated materials during and previous to the K-25 Site cascade upgrading program. The waste storage facility began operation in the 1960s and is estimated to at one time contain in excess of 40,000 tons of low-level, radioactively contaminated scrap metal. Scrap metal was taken to the site when it was found to contain alpha or beta/gamma activity on the surface or if the scrap metal originated from a process building.

The segregated metal debris was removed from the site as part of the K-770 Scrap Removal Action (RA) Project that was completed in fiscal year (FY) 2007 by Bechtel Jacobs Company LLC (BJC). An area of approximately 10 acres is located in EUs 29 and 31 where the scrap was originally located in the 100-year floodplain. In the process of moving the materials around and establishing segregated waste piles above the 100-year floodplain, the footprint of the site was expanded by 10-15 acres in EUs 30 and 32. The area in EUs 29 and 31 that was cleared of metallic debris in the floodplain was sown with grass. The areas in EUs 30 and 32 have some scattered vegetation but are generally open and accessible.

With limited exception, all materials contained in the scrap yard have been removed and disposed at the EMWMF. Soils that underlay the original waste storage area in EUs 29 and 31 as well as soils that underlay the scrap piles in EUs 30 and 32 show substantially elevated radioactivity. In addition to soils present at the site, remaining portions of foundations/floor slabs for Bldgs. K-725, K-726, and K-736 as well as the unnamed pad at the northeast corner of the site constructed to support the sort and segregation operations at the K-770 Scrap Removal Project in 2006 and several other small, unnamed concrete pads are included in this waste lot. While many of these foundations/floor slabs will be removed because they are contaminated, some of the smaller unamed concrete pads will be removed in order to access contaminated soils that are around and under the pads and regrade the site. Appendix E contains a map showing the areas of soil and concrete pads that are expected to be excavated. Soils in the areas indicated on this map will be removed to approximately one foot below the surface. (This corresponds to the soil interval sampled and analyzed to characterize this waste lot.) Contaminants present in the soils are directly derived from metallic debris and rubbish handled by the waste storage operations, are concentrated in the top few inches, and include the predominant constituents of concern associated with the metallic waste already disposed at EMWMF. Additionally, some residual metallic debris remains embedded in the shallow soils that underlay the former debris piles. This residual metallic debris is eligible for disposal in the EMWMF WAC criteria as defined in *Waste Profile for: Disposal of the Scrap Removal Project Waste Lot 65.1 East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2004a). This waste, however, has been included in Waste Lot 4.12 to conform to the more rigorous profiling requirements currently contained in *Waste Acceptance Criteria Attainment Team Project Execution Plan Environmental Management Waste Management Facility, Oak Ridge Reservation, Tennessee* (BJC 2008a). It comprises approximately 5% of the total mass of material that will be generated under this RA. Incidental amounts of wood and other debris items and secondary waste generated during the RA are also included in this waste lot.

Supporting documentation for this waste lot profile is included in the following appendices:

Appendix A: Waste Anomaly Detection Plan and Checklist;

Appendix B: Detailed Process Knowledge Description,

Appendix C: Controlled Data Set,

Appendix D: Environmental Compliance Assessment,

Appendix E: Waste Handling Plan Crosswalk, Sampling Approach, Calculation/Measurement Methods,

Appendix F: Data Quality Objectives Checklist,

Appendix G: Data Quality Assessment,

Appendix H: Waste Acceptance Criteria Forecasting Analysis Capability System (WACFACS) Attachment 3 and VWSF Transmittal Letter,

Appendix I: Approved Variance Requests,

Appendix J: CERCLA documentation, and

Appendix K: EMWMF Nuclear Criticality Compliance Documentation.

2. ADMINISTRATIVE WAC COMPLIANCE

2.1 CERCLA ACTION

This RA will be executed in accordance with *Record of Decision for Interim Remedial Actions for Selected Contaminated Areas Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2002). The soil and remaining portions of foundations/floor slabs (with the exception of the K-725 concrete slab) in this waste lot will be managed in accordance with *Waste Handling Plan, Part II for the K-770 Soils within Zone 1 East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2006), the remaining metal debris will be managed in accordance with *Waste Handling Plan, Part II for the East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2004), and the K-725 concrete foundation slab will be managed in accordance with *Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2005). Core Team approval documentation for the waste handling plans is provided in Appendix B and applicable CERCLA documentation is provided in Appendix J of this profile.

2.2 PROHIBITED WASTE TYPES

The characterization data and the results described in this waste profile demonstrate that Waste Lot 4.12 is not transuranic (TRU) waste. Through process knowledge, the waste is not high-level radioactive waste, spent nuclear fuel, or 11e(2) byproduct wastes and is LLW as defined in DOE Manual 435.1-1. Soil/concrete samples were not collected for Am-241, Pu-238, or Pu-239/240 analysis as part of Waste Lot 4.12 because these TRU isotopes were eliminated as SRCs based on process knowledge and historical analytical data provided in the Waste Lot 65.1 profile (2004a). Soil/concrete samples collected for Waste Lot 4.12 characterization were analyzed for Np-237, which was eliminated as a SRC due to "less than 20% J-flag detection rate for all detected results." However, in order to demonstrate compliance with EMWMF Administrative Waste Acceptance Criteria (WAC), Table 1 conservatively incorporates the maximum concentrations from the Waste Lot 65.1 profile for the TRU isotopes that were eliminated as SRCs in this waste lot and assumes the maximum detection limit (DL) or estimated J-flagged result bounds the TRU isotope's activity/mass concentration in this waste lot. The sum of the TRU isotopes maximum DL or estimated J-flagged concentration of the waste is approximately 3.54E-04 nCi/g, which is approximately 6 orders of magnitude below the TRU waste criterion of 100 nCi/g. This waste lot will be managed and disposed as LLW.

Table 1. Total transuranics in Waste Lot 4.12

Isotope	Maximum concentration (pCi/g)	TRU isotopes (nCi/g)
Americium-241[1]	2.13E-02	2.13E-05
Neptunium-237[2]	3.20E-01	3.20E-4
Plutonium-238[1]	1.70E-03	1.73E-06
Plutonium-239/240[1]	1.11E-02	1.11E-05
Sum of TRU isotopes	**3.54E-01**	**3.54E-04**

[1] Data taken from Waste Lot 65.1 profile
[2] Data taken from Waste Lot 4.12 Controlled Data Set

2.3 PROHIBITION OF FREE LIQUIDS

Waste Lot 4.12 contains radioactively contaminated soil, concrete, and incidental miscellaneous debris (vegetation, wood, scrap metal). Free liquids are not acceptable within individual waste packages or conveyances (dump trucks) offered for disposal at EMMWF. As a control measure, the Waste Packaging Specialist will perform a visual inspection for all waste containers/conveyances prior to shipment to ensure all waste meets the description provided in the approved waste profile and the waste and container meet applicable WAC and DOT requirements. Notwithstanding, prior to shipment, containers will be visually inspected to confirm the absence of free liquids.

2.4 RESOURCE CONSERVATION AND RECOVERY ACT

Based on analytical data and process knowledge, the waste for disposal at EMWMF does not contain listed wastes, nor was it mixed with or derived from a listed hazardous waste (see Appendix D). In addition, based on analytical data, waste included in Waste Lot 4.12 will not exhibit any Resource Conservation and Recovery Act characteristics as defined under 40 *Code of Federal Regulations (CFR)* 261.10–261.33. The cumulative evaluation of sampling and analysis data, prior knowledge of sources of the waste, and current sorting and segregation administrative controls in place have been thoroughly documented in this profile package. Since the waste lot has been determined to be RCRA non-hazardous low level waste (i.e., does not exhibit a RCRA-characteristic and is not RCRA-listed), the restrictions for disposing of waste containing concentrations of contaminants (i.e., Underlying Hazardous Constituents) listed in 40 CFR 268.48 do not apply.

2.4.1 Characteristics of Ignitability

The waste lot does not exhibit the characteristic of ignitability as defined by 40 CFR 261.21. The waste will not be a liquid or compressed gas and will not be capable, under standard temperature and pressure, of causing fire through friction, adsorption of moisture, or spontaneous combustion.

2.4.2 Characteristics of Corrosivity

The waste lot does not exhibit the characteristic of corrosivity as defined by 40 *CFR* 261.22. The waste will not be aqueous, nor will it be a liquid that corrodes steel at a rate greater that 6.35 mm/year.

2.4.3 Characteristics of Reactivity

The waste lot does not exhibit the characteristic of reactivity as defined by 40 *CFR* 261.23.

2.4.4 Characteristics of Toxicity

The waste lot does not exhibit the characteristic of toxicity as defined by 40 *CFR* 261.24. Table 2 summarizes the toxicity characteristic waste determination. Table 2 provides the maximum concentration for each RCRA constituent and compares it to the constituent's regulatory limit. Maximum concentration values are presented even if the constituent was not detected. (If the constituent was not detected, then the maximum detection limit was used for the comparision.) In cases where chemicals were analyzed for Total concentration rather than TCLP, the comparision was performed using the "20 times rule." Table 2 does not contain the results of concrete sampling. Fourteen Total Metal samples were collected from the concrete foundations/floor slabs. None of the metal concentrations in concrete exceeded 20 times the TCLP limit. Therefore, collection of TCLP Metal samples from concrete was not warranted.

Based on review of process knowledge information, the Waste Lot 4.12 Controlled Data Set, and Total/TCLP Metal/VOA/SVOA statistical summaries, ETTP D&D/RA Project Environmental Compliance has determined that this waste lot is not RCRA listed- or characteristic hazardous waste as attested by signature on the Waste Lot 4.12 profile approval page and information provided in Appendix D.

Table 2. RCRA Toxicity Characterization for Waste Lot 4.12

Contaminant	Units	Samples	Detects	Maximum Conc.[1]	Converted Maximum Result[2]	Regulatory Limit (mg/L)	Exceeds TCLP Limit
Arsenic	mg/L	43	0	0.0317	N/A	5.0	N
Barium	mg/L	43	43	1.77	N/A	100.0	N
Benzene	mg/kg	42	4	0.006	0.0003	0.5	N
Cadmium	mg/L	43	25	0.096	N/A	1.0	N
Carbon tetrachloride	mg/kg	42	0	0.006	0.0003	0.5	N
Chlorobenzene	mg/kg	42	0	0.006	0.0003	100.0	N
Chloroform	mg/kg	42	6	0.003	0.00015	6.0	N
Chromium	mg/L	43	7	0.03	N/A	5.0	N
Cresol[3]	mg/kg	43	4	0.58	0.029	200.0	N
1,4-Dichlorobenzene	mg/L	43	0	0.05	N/A	7.5	N
1,2-Dichloroethane	mg/kg	42	0	0.006	0.0003	0.5	N
1,1-Dichloroethylene	mg/kg	42	0	0.006	0.0003	0.7	N
2,4-Dinitrotoluene	mg/L	43	0	0.05	N/A	0.13	N
Hexachlorobenzene	mg/L	43	0	0.05	N/A	0.13	N
Hexachlorobutadiene	mg/L	43	0	0.05	N/A	0.5	N
Hexachloroethane	mg/L	43	0	0.05	N/A	3.0	N
Lead	mg/L	43	11	0.599	N/A	5.0	N
Mercury	mg/L	43	6	0.00015	N/A	0.2	N
Methyl ethyl ketone	mg/kg	42	14	0.045	0.00225	200.0	N
Nitrobenzene	mg/L	43	0	0.05	N/A	2.0	N
Pentachlorophenol	mg/L	43	0	0.12	N/A	100.0	N
Pyridine	mg/L	43	0	0.05	N/A	5.0	N
Selenium	mg/L	43	0	0.0413	N/A	1.0	N
Silver	mg/L	43	1	0.0074	N/A	5.0	N
Tetrachloroethylene	mg/kg	42	1	0.006	0.0003	0.7	N

Contaminant	Units	Samples	Detects	Maximum Conc.[1]	Converted Maximum Result[2]	Regulatory Limit (mg/L)	Exceeds TCLP Limit
Trichloroethene	mg/kg	42	0	0.006	0.0003	0.5	N
2,4,5-Trichlorophenol	mg/L	43	0	0.12	N/A	400.0	N
2,4,6-Trichlorophenol	mg/L	43	0	0.05	N/A	2.0	N
Vinyl chloride	mg/kg	42	0	0.01	0.0005	0.2	N

[1] *Maximum concentration reported regardless of detect or non-detect.*

[2] *Maximum Totals (mg/kg) result divided by 20 to produce RCRA TCLP comparison.*

[3] *Represents collective assessment of 2-Methylphenol and 3-& 4-MethylphenolTCLP data.*

2.5 TOXIC SUBSTANCES CONTROL ACT LAND DISPOSAL REQUIREMENTS

This waste lot does not include TSCA-regulated polychlorinated biphenyl (PCB) waste. Analytical data from both soil and concrete samples provided in Appendices C and G of this profile confirm the presence of PCBs, specifically Aroclor-1248, Aroclor-1254, and Aroclor-1260, with Total PCB concentrations of < 23 parts per million (ppm). All other aroclors were non-detects (i.e., U-flagged) or were screened out as a site related contaminant (SRC) per Appendix C of DOE 2001b.

2.6 INFECTIOUS WASTE PROHIBITIONS

As determined through process knowledge there is no evidence that infectious wastes is associated with Waste Lot Profile 4.12, nor will infectious waste be generated during the execution of this removal action.

2.7 PYROPHORIC MATERIALS PROHIBITION

As determined through process knowledge and historical data, there is no evidence that pyrophoric materials are present in Waste Lot Profile 4.12, nor will pyrophoric materials be generated during the execution of this removal action.

2.8 EXCLUSION OF WASTES CAPABLE OF DETONATION OR EXPLOSIVE DECOMPOSITION

As determined through process knowledge and historical data, there is no evidence that wastes capable of detonation or explosive decomposition are present in Waste Lot Profile 4.12 nor will wastes capable of detonation or explosion be generated during the execution of this removal action.

2.9 TOXIC GASES, VAPORS, OR FUMES PROHIBITION

There is no historical knowledge or sampling data evidence that wastes containing or capable of producing toxic gases, vapors, or fumes are included in this waste lot.

2.10 STRUCTURAL STABILITY DETERMINATION

Waste consisting of soil, concrete, miscellaneous debris, wood, miscellaneous metal, etc. will be packaged in lined dump trucks, for bulk disposal at EMWMF. Packaging and transportation of these items will not introduce additional external or internal void space. This material can be processed at EMWMF with heavy equipment (i.e., a D7 bulldozer) to achieve stability requirements listed in Table A.3 of the EMWMF administrative WAC (DOE 2001).

2.11 VOID SPACE REQUIREMENTS

Waste consisting of soil, concrete, miscellaneous debris, wood, miscellaneous metal, etc. will be packaged in lined dump trucks, for direct disposal at EMWMF. Packaging and transportation of these items will not introduce additional external or internal void space. This waste will not contain significant void space when disposed at EMWMF and will meet the void space requirements listed in Table A.3 of the EMWMF administrative WAC (DOE 2001).

2.12 CONTAINER VOID SPACE REQUIREMENTS

This waste lot consists of non-containerized waste transported to EMWMF dump trucks. This waste does not include containerized waste. Therefore, this requirement is not applicable.

2.13 AVERAGE TOTAL URANIUM LIMITS

The average total uranium activity concentrations present in the waste lot, as indicated by statistical analysis of radiological analytical data in Table 6 and Appendix F of this document, are summarized in Table 3. Average Total Uranium pCi/g concentrations do not exceed the respective limits defined in Table A.3 of the EMWMF administrative WAC (DOE 2001). Equations used to derive average ug/g or ppm from average pCi/g values are provided in Appendix E of this document.

Table 3. Total uranium concentration in Waste Lot 4.12

Isotope	Average concentration (pCi/g)	Concentration (ppm)
Uranium-233/234	39.45	6.4E-03
Uranium-235	5.07	2.30
Uranium-238	33.45	98.38
Total	77.97	100.69
WAC limits	7.14E+02	1.03E+03

2.14 CRITICALITY SAFETY EVALUATION

Criticality safety is not a concern for bulk shipments (i.e., dump trucks) based on the results of the Nuclear Criticality Safety EMWMF Material Screening Form shown in Appendix K. The requirements identified in Table A.3 of the EMWMF administrative WAC (DOE 2001) to maintain the containerized and bulk shipped waste in a subcritical condition during all phases of cell operation will be met. A formal NCSD is not required as indicated on the EMWMF Material Screen form.

2.15 TDEC WASTE CLASS

This waste offered for disposal at the EMWMF is classified as TDEC Class A waste based on Tennessee LLW regulations in TN1200-2-11-.17(6). The sampling data results (maximum concentration) were compared with the regulatory limits in the above regulations for both long-lived and short-lived radionuclides. The SOF is shown in Table 4 and Table 5. Given that the SOF for long-lived and short-lived radionuclides is less than 0.1 and 1.0, respectively, the appropriate waste classification is Class A.

Table 4. Tennessee LLW classification of long-lived radionuclides for Waste Lot 4.12

Radionuclide	Class A limit (pCi/g)	Maximum concentration (pCi/g)	Fraction
Carbon-14	4.70E+06	Not present	N/A
Carbon-14 in activated metal	4.70E+07	Not present	N/A
Nickel-59 in activated metal	1.38E+08	Not present	N/A
Niobium-94 in activated metal	1.20E+05	Not present	N/A
Technetium-99	1.80E+06	6.29E+02	3.49E-04
Iodine-129	4.70E+04	Not present	N/A
Alpha emitting transuranics[1]	1.00E+05	3.54E-01	3.54E-06
Plutonium-241	3.50E+06	Not present	N/A
Curium-242	2.00E+07	Not present	N/A
		Sum of fractions	**3.53E-04**

[1] Alpha emitting transuranics is summation of Am-241, Np-237, Pu-238, and Pu-239/240 maximum DL concentrations; LLW = low-level waste; N/A = not applicable

Table 5. Tennessee LLW classification of short-lived radionuclides for Waste Lot 4.12

Radionuclide	Class A Limit (pCi/g)	Maximum concentration (pCi/g)	Fraction
Total all nuclides $T_{1/2}$ <5 years	4.50E+08	N/A	N/A
Hydrogen-3	2.60E+07	Not present	N/A
Cobalt-60	4.50E+08	1.87E+00.	4.16E-09
Nickel-63	2.20E+06	Not present	N/A
Nickel-63 in activated metal	4.10E+09	Not present	N/A
Strontium-90	4.10E+09	Not present	NA
Cesium-137	2.70E+09	2.86E+01	1.06E-08
		Sum of fractions	**1.58E-08**

LLW = low-level waste
N/A = Not applicable
UCL = upper confidence limit on the mean

3. ANALYTIC WAC COMPLIANCE

This waste lot was characterized in accordance with *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2008b), provided in Appendix E of this profile. Appendix E also contains a map showing the locations of the samples used to characterize this waste lot. This sample and analysis plan (SAP) was developed to provide data of known quality for use in determining the final disposal path for the waste in this waste lot using the historical data and process knowledge summarized in Appendix B and was approved by the Remedial Action Core Team (see Appendix B). A comprehensive set of analyses was performed on the samples collected from the waste in this waste lot. Project personnel performed a cross-check of sampling and analysis prescribed in the SAP with the analytical results peformed upon receipt of the analyses from the laboratories.

All samples prescribed in the SAP were collected and analyzed, with the exception of one (1) random composite soil sample that was to be collected for Total VOA analysis. The ETTP D&D/RA Project Core Team was notified of this deviation and the results of the Data Quality Assessment (DQA) performed on data used to characterize this waste lot. Core Team meeting minutes documenting this discussion are included in Appendix B of this profile. The evaluation of Data Quality Objectives (DQOs) in Appendix F and the DQA in Appendix G considered this deviation. It was concluded that the DQOs were met and this deviation had no impact on the ability to characterize this waste lot for EMWMF disposal. Also, since the decision to include the residual metallic debris in this waste lot was made after the characterization sampling was completed, it has been determined that the characterization sampling can serve as an upper-bound proxy for this small percentage of the waste lot (estimated at 5%). See Appendix B for the justification for this determination.

Additionally, soil samples collected to characterize this waste lot were not analyzed for the metals strontium and tin. Historical data indicate that these metals may be present in the waste lot soils at very low concentrations. However, for the reasons cited in Appendix B, historical data are not considered reliable and were not used to quantitatively characterize this waste lot. To characterize these two metals in the soils in this waste lot, the EMWMF Waste Lot 65.1 profile (BJC 2004) was reviewed (see Appendix B). Samples of metallic debris in the scrap yard were analyzed for strontium and tin in the EMWMF Waste Lot 65.1 profile. Strontium was not detected. Based on these results, the Project concluded that strontium was not present in the waste lot soils. Tin was detected in the EMWMF Waste Lot 65.1 profile. Based on these results, the Project concluded that tin was present in the waste lot soils. Tin was quantitatively characterized for this waste lot by incorporating the input values for tin in the Waste Lot 65.1 Waste Acceptance Criteria Forecasting Analysis Capability Systems (WACFACS) in the WACFACS input for this waste lot.

In general, 32 systematic random composite samples, 13 biased composite samples, and 4 field replicate composite samples were collected from the K-770 soils for individual/Total PCB analysis, Total/TCLP Semi-Volatile Organic Analysis (SVOA), Total/TCLP Metals analysis, and Radiological Parameters analysis. 31 of the 32 systematic random composite soil samples, 13 of the 13 biased composite soil samples, and 3 field replicate soil samples were collected for Total Volatile Organic Analysis (VOA). In addition, 14 systematic random samples and 1 field replicate sample were collected from K-770 Scrap Yard concrete pads for Total Metals analysis, individual/Total PCB analysis, and Radiological Parameters analysis. Total Pesticide/Herbicide samples were not collected based on process knowledge. Justification for sampling and analytical approaches is provided in SAP Sections 3.0 and 4.0, respectively.

Samples collected in accordance with the approved SAP were submitted to Sample Management Office-approved laboratories for analysis in accordance with the analytical methods presented in the SAP.

Results for solid matrices were required on a dry-weight basis. All data (i.e., 100%) were reviewed for quality assurance and quality control, and all data results used in this profile were validated. For the purposes of waste lot characterization and development of this waste lot profile, SAP chemical/radiological sample data were used to identify and delineate the extent of chemical and radiological contamination in the waste lot. Sample results for two biased composite soil samples (Z1-EU33BW-442 and Z1-EU33BW-445) were not included in the Controlled Dataset for this waste lot due to elevated Tc-99 pCi/g concentrations, and the soils associated with these sample locations have been identified as anomalous waste in Appendix A. Np-237 results for biased composite soil sample EU32BW-433 and its replicate sample were rejected due to the replicate sample Relative Percent Difference being out of range, possibly due to uranium interference. Review and analysis of Total VOA data identified 2-Butanone (MEK), and Acetone as SRCs with maximum and UCL95 concentrations below 0.5 mg/kg; therefore, the omission of 1 additional Total VOA result for the sample not collected does not have any impact on EMWMF Analytical WAC Sum of Fractions (SOF). All remaining sample data were complete, useable, and sufficient to adequately assess EMWMF Analytical WAC compliance (see Appendix G).

Analytical data and process knowledge are presented in the Controlled Data Set, Appendix G (Data Quality Assessment) and Appendix B (Process Knowledge) of this profile. The controlled data set has been provided to the EMWMF Waste Acceptance Criteria Attainment Team. The data were used to identify SRCs and incorporate the reported values into the Waste Acceptance Criteria Forecasting Analysis Capability System (WACFACS). Guidance prescribed in Appendix B of the EMWMF WAC Attainment Plan (DOE 2001) was used exclusively to demonstrate analytical WAC compliance. The output of WACFACS provides evidence that this waste is within acceptable limits, as discussed below. The Shapiro-Wilk (S-W) Test, as described in Appendix C of the EMWMF WAC Attainment plan, was used for evaluating all analytes containing under 50 data points to demonstrate analytic WAC compliance. For all PERT beta-distributed data sets "Upper 95th Confidence Interval Calculations for a PERT Beta PDF", Redus & Associates, was used to determine UCL_{95} values. The test results, sample calculations, and raw data spreadsheets, created from the analytical data sets, have been included in Appendix G for reference.

Table 6 provides the specific number of samples and detects for SRCs related to this waste lot. Appendix E has the complete data set used to develop Table 6.

Table 6. Waste Lot 4.12 K-770 Scrap Yard Soils EMWMF SRC Summary Statistics

SRC	Units	N	Detects	Minimum	Median	Maximum	Arithmetic Mean	PDF	LN Mean	Standard Deviation	E(X)	UCL95
Tc-99	pCi/g	57	37	1.290	4.310	629.000	20.26	B			107.92	287.20
U-233/234	pCi/g	57	56	0.110	10.200	1360.000	39.45	LN	2.061	1.626	29.50	54.43
U-235	pCi/g	57	44	0.050	1.080	185.000	5.07	LN	-0.120	1.647	3.44	6.45
U-238	pCi/g	57	57	0.430	7.650	1150.000	33.45	LN	1.841	1.659	25.00	47.09
Antimony	mg/kg	57	35	0.115	0.500	65.100	2.01	B			11.20	29.79
Barium	mg/kg	57	57	31.300	71.500	395.000	80.37	B			118.72	231.67
Boron	mg/kg	57	57	1.900	5.900	39.100	7.43	LN	1.798	0.625	7.34	8.64
Chromium	mg/kg	57	57	9.700	26.000	2880.000	102.74	B			498.95	1319.51
Lead	mg/kg	57	57	2.900	36.600	733.000	60.60	LN	3.380	1.279	66.50	97.11
Manganese	mg/kg	57	57	59.200	496.000	2210.000	618.75	LN	6.192	0.734	640.00	781.20
Molybdenum	mg/kg	57	57	0.690	2.700	69.200	5.56	B			13.45	33.51
Selenium	mg/kg	57	12	0.230	0.275	25.700	0.82	B			4.51	11.75
Tin	mg/kg	42	14	15.500	23.200	232.000	37.400	B			56.700	120.000
Vanadium	mg/kg	57	57	8.000	21.800	52.900	22.29	N		9.428	22.29	24.38
2-Methylnaphthalene	mg/kg	43	30	0.020	0.071	0.300	0.10	B			0.10	0.19
3 & 4 Methylphenol	mg/kg	43	4	0.019	0.190	0.580	0.19	B			0.23	0.41
Acenaphthene	mg/kg	43	14	0.019	0.185	1.200	0.17	B			0.33	0.70
Acenaphthylene	mg/kg	43	5	0.019	0.190	0.205	0.17	B			0.16	0.20
Acetone	mg/kg	42	31	0.004	0.026	0.260	0.06	B			0.06	0.14
Benzoic Acid	mg/kg	43	17	0.022	0.185	0.290	0.15	B			0.18	0.25
Carbazole	mg/kg	43	16	0.021	0.190	1.100	0.16	B			0.31	0.66
Naphthalene	mg/kg	43	21	0.019	0.180	0.205	0.12	B			0.16	0.20
Phenol	mg/kg	43	7	0.023	0.190	1.100	0.19	B			0.31	0.66

EMWMF = Environmental Management Waste Management Facility; E(X) = expected concentration in waste lot; N = number of samples; LN = lognormal, N = normal, B = PERT beta; PDF = probability density function; SOF = sum of fractions SRC = site-related contaminant; UCL_{95} = 95% upper confidence limit on the mean; MOC = Material of Construction; NA = Not Applicable; Standard Deviation = standard deviation of data for normal distribution and standard deviation of log transform for lognormal distribution

Appendix G (Data Quality Assessment) of this profile provides the basis for elimination of all EMWMF analytic WAC SRCs in accordance with the WAC Attainment Plan (DOE 2001). Numerous chemicals and radiological isotopes were eliminated either: 1) there were no detects (i.e., all U-flag data), 2) J-flags only were present in less than 20% of the "detected" samples, and 3) detected chemical and/or isotopes (non U- or J-flagged laboratory qualifier codes or data validation codes) were present in less than 5% of the sample data and the reported results were less than 2 times the detection limit (2 x DL). Chemicals and/or isotopes eliminated based on process knowledge were: 1) either not identified in the SAP as potential contaminants of concern for disposition under this EMWMF waste lot or are not expected to be present in the debris waste, 2) based on process knowledge of past operations, or 3) certain SRCs were analyzed in other ETTP facilities and not detected thus there is logic that they would also not be present in this waste lot.

Data for the SRCs that were not eliminated based on analytical results were then evaluated statistically to determine concentrations (i.e., minimum, arithmetic mean, median, and maximum), probability distribution functions (i.e., normal, log-normal, or PERT beta), and the UCL95 concentration. U.S. Environmental Protection Agency (EPA) software (ProUCL v4.00.02) and Redus & Associates QND software were used to analyze data. Statistical summaries and detail are provided in Appendix G. These data were used in WACFACS to determine the SOFs for the waste lot.

3.1 CARCINOGENIC WAC SRCs

The WACFACS data input sheet is included in Appendix G. The carcinogenic SOF is 0.67 and the UCL_{95} SOF is 1.71. Tc-99, U-233/234, and U-238 contributes > 1% of its respective CA WAC limit. Refer to Appendix H for the WACFACS VWSF Transmittal letter.

3.2 HAZARD INDEX WAC

The WACFACS data input sheet is included in Appendix G. The Hazard Index SOF is 0.17 and the UCL_{95} SOF is 0.37. U-238, antimony, lead, and tin each contribute 1% or greater of its respective HI WAC limit. Refer to Appendix H for the WACFACS VWSF Transmittal letter.

3.3 CARCINOGENIC WAC 3-YEAR VWSF COMPLIANCE

The expected carcinogenic volume-weighted SOF (VWSF) for this waste lot is 7.20E-03 Refer to Appendix H for the WACFACS VWSF Transmittal letter.

3.4 HAZARD INDEX WAC 3-YEAR VWSF COMPLIANCE

The expected Hazard Index VWSF for this waste lot is 1.84E-03. Refer to Appendix H for the WACFACS VWSF Transmittal letter.

4. ASA-DERIVED WAC COMPLIANCE

The Auditable Safety Analysis (ASA) Radiological SOF for this waste lot was calculated using the UCL_{95} of each SRC (unless otherwise noted) in the waste and was divided by the ASA limits listed in Table A.2 of the EMWMF WAC (DOE 2001). Table 7 summarizes the SOFs of radionuclide SRC UCL_{95} to the EMWMF ASA-derived WAC. The calculated ASA total SOF is 1.60E-03. Since the ASA total SOF is <0.05, no further consideration is needed.

Table 7. Radiological ASA sum of fractions for Waste Lot Profile 4.12

Isotope	UCL_{95} concentration (pCi/g)	ASA WAC concentration (pCi/g)	ASA SOF (UCL_{95}/WAC)
Cs-137	1.31E+01	1.50E+06	8.71E-06
Co-60	1.40E-01	6.90E+06	2.03E-08
K-40	1.44E+01	4.20E+06	3.44E-06
Tc-99	2.87E+02	4.20E+07	6.84E-06
Th-228	1.24E+00	2.5E+04	4.96E-05
Th-232	1.13E+00	2.5E+03	4.52E-04
U-233/234	5.44E+01	1.00E+05	5.44E-04
U-235	6.45E+00	1.00E+05	6.45E-05
U-238	4.71E+01	1.00E+05	4.71E-04
Total ASA Sum of UCL_{95} Fractions			**1.60E-03**

ASA = Auditable Safety Analysis
SOF = sum of fractions
UCL_{95} = 95% upper confidence limit on the mean
WAC = waste acceptance criteria

Chemical SRCs are shown in Table 8 below. This table presents the waste lot ASA chemicals of concern with Reportable Quantities and their respective UCL-95 mg/kg value.

Table 8. Chemical SRC concentrations for Waste Lot Profile 4.12

Chemical	UCL_{95} value (mg/kg)
Antimony	29.79
Arsenic	8.10
Barium	231.67
Beryllium	1.12
Cadmium	3.56
Chromium	1,319.51
Copper	592.50
Lead	97.11
Mercury	7.80
Nickel	220.10

Table 8. Chemical SRC concentrations for Waste Lot Profile 4.12

Chemical	UCL_{95} value (mg/kg)
Selenium	11.75
Silver	0.66
Tin	120.7
Vanadium	24.38
Zinc	571.60
PCB-1248	5.96
PCB-1254	3.66
PCB-1260	1.45
Total PCBs	10.90
2-Butanone (MEK)	0.02
2-Methylnaphthalene	0.19
3&4 Methylphenol	0.41
Acenaphthene	0.70
Acenaphthalene	0.20
Acetone	0.14
Anthracene	1.54
Benz(a)anthracene	4.65
Benzo(a)pyrene	3.83
Benzo(b)fluorathene	3.46
Benzo(ghi)perylene	2.60
Benzo(k)fluoranthene	3.74
Benzoic Acid	0.25
Bis-(2-ethylhexyl)phthalate	63.20
Butyl benzyl phthalate	6.49
Carbazole	0.66
Chrysene	4.52
Dibenz(ah)anthracene	1.06
Dibenzofuran	0.38
Di-n-octylphthalate	0.41
Fluoranthene	11.9
Fluorene	0.70
Indeno(123cd)pyrene	2.36
Naphthalene	0.20
Phenanthrene	5.11
Phenol	0.66
Pyrene	7.39

SRC = site related contaminant

5. PHYSICAL WAC COMPLIANCE

To ensure compliance with the following physical WAC requirements and to ensure all waste meets the description provided in this waste lot profile, the ETTP D&D/RA Project will generate and manage waste in accordance with BJC project-specific and company-level plans and procedures, as follows:

- *Waste Management Plan for the ETTP Closure and ETTP D&D Projects at the East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2004b),
- Oak Ridge Reservation Waste Certification Program Plan (BJC 2001),
- Generator Requirements for Transferring Waste (BJC-WM-2001), and
- *Technical Information for Delivery of Waste to the Environmental Management Waste Management Facility* (BJC 2007).

5.1 CONTAINER REQUIREMENTS

This waste lot will be transported to EMWMF primarily by use of bulk packages/conveyances (i.e., dump trucks, flat bed trucks, super sacks, and intermodal containers) for direct disposal at EMWMF. EMWMF WAC container requirements will be met.

5.2 SIZE REQUIREMENTS

This waste lot will meet the physical size requirements listed in the EMWMF WAC (BJC 2007). All materials shall fit within roll-offs, dump truck, intermodal, or supersack container. All single debris items shall have dimensions less than 4' x 4' x 6'.

5.3 WEIGHT REQUIREMENTS

This waste lot will meet the weight requirements listed in the EMWMF Physical WAC (BJC 2007). All single debris items will weigh less than 24,000 pounds

5.4 CONCRETE DEBRIS REQUIREMENTS

All concrete debris included in this waste lot will be transported by dump truck, intermodal container, or super sacks, and will be capable of direct placement in the cell. Concrete items will be reduced to a maximum dimension of 1 foot or be shipped as large blocks with the rebar cut flush with the concrete block surface to the maximum extent practical. Therefore, EMWMF WAC concrete debris requirements will be met.

5.5 STEEL PLATE REQUIREMENTS

This waste lot will contain steel plates. The maximum dimension of the steel plate will be less than the minimum inside dimensions of the haulage container. Further, the steel plates will not be bent or forced into a container and shall not extend above the top of the container. Therefore, EMWMF WAC steel plate requirements will be met.

5.6 PIPE REQUIREMENTS

All small diameter pipe (less than or equal to 6 inches diameter) generated under this waste lot will meet the EMWMF physical WAC (less than 8 feet in length, segregated, and transported in dump trucks or intermodal containers as unique shipments; or less than 15 feet length, segregated, bundled, secured to pallets, and transported by flat bed truck as unique shipment). Any pipe greater than 6 inches in diameter and any pipe greater than 12 inches in diameter will be managed in accordance with the EMWMF WAC. See Appendix I for the blanket variance EMWMF-BV-07-01 that will be invoked for Waste Lot 4.12.

5.7 ASBESTOS- AND BERYLLIUM DUST-CONTAINING WASTE REQUIREMENTS

Process knowledge indicates that this waste lot could include items containing friable and non-friable asbestos materials. Any asbestos-containing materials identified will be sent for disposal in accordance with the PWAC or an approved variance request. The project intends to invoke blanket variances EMWMF-BV-08-01 and EMWMF-BV-08-02, as applicable, for the packaging, transport, and disposal of items containing asbestos. These variances are included in Appendix I. Decisions regarding the generation and packaging of ACM will be made under the direction of a certified industrial hygienist/AHERA inspector.

No beryllium containing waste is present in this waste lot and the beryllium dust containing waste requirement is not applicable. [Some of the waste may contain very low concentrations of beryllium (<2 ppm). These concentrations are well below the level required to define this waste as "beryllium waste material" (>1000 ppm) under the appropriate BJC procedure.] Additional supporting information is provided in Appendix B.

5.8 MISCELLANEOUS DEBRIS REQUIREMENTS

Miscellaneous debris will be size-reduced to meet EMWMF physical WAC and strategically loaded for direct disposal (burial) at the EMWMF. The EMWMF miscellaneous debris requirement will be met.

5.9 CONTAINERIZED COMPACTABLE WASTE

Compactable debris waste generated as part of this waste lot is expected to be disposed of in bulk via dump truck or intermodal container or super sacks. Any empty containers will be crushed and/or size-reduced by the generator prior to delivery to EMWMF. Therefore, EMWMF WAC containerized compactable waste requirements will be met

5.10 REBAR REQUIREMENTS

It is possible that rebar will be encountered during the demolition of the concrete slab foundations of the buildings. If rebar is encountered, it will be handled in accordance with approved variance EMWMF-VR-144 (included in Appendix I). This includes removing as much concrete as practicable from the rebar, cutting rebar to lengths less than 4-feet long, and shipping this waste with debris generated during this time.

5.11 NONCRUSHABLE CONTAINER REQUIREMENTS

Waste generated as part of this waste lot is expected to be disposed of in bulk via dump truck or intermodal container or super sacks. Any empty containers will be crushed and/or size-reduced by the generator prior to disposal. Non-crushable container will not be used, therefore this requirements is not applicable.

5.12 CONTAINER LINER REQUIREMENTS

Containers used to transport this waste lot will be lined in accordance with the requirements of the EMWMF physical WAC (BJC 2007).

5.13 DOSE RATE REQUIREMENTS

All unshielded contact dose rates for Waste Lot 4.12 containers will be below the EMWMF WAC limiting dose rate of 200 mrem/h on contact. The final DOT survey will document that no container exceeded 10 mrem/h at 2 meters from any surface of the container. Final dose rate measurements prior to shipment will be conducted to ensure compliance with DOT requirements and the EMWMF WAC.

6. CERCLA DOCUMENTATION

Applicable sections of *Record of Decision for Interim Remedial Actions for Selected Contaminated Areas Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2002), *Waste Handling Plan, Part II for the K-770 Soils within Zone 1 East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2006), *Waste Handling Plan, Part II for the East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2004), and *Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2005) are provided in Appendix J.

7. REFERENCES

BJC (Bechtel Jacobs Company LLC) 2001. *Oak Ridge Reservation Waste Certification Program Plan*, BJC/OR-57, Bechtel Jacobs Company LLC, Oak Ridge, TN.

BJC 2004a. *Waste Profile for Disposal of the Scrap Metal Project Waste Lot 65.1 East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1857, Rev. 1, Bechtel Jacobs Company LLC, Oak Ridge, TN.

BJC 2004b. *Waste Management Plan for the ETTP Closure and ETTP D&D Projects at the East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1678, Bechtel Jacobs Company LLC, Oak Ridge, TN.

BJC 2007. *Technical Information for Delivery of Waste to the Environmental Management Waste Management Facility*, 23900-SC-BC008U-A001, Rev. 7, Bechtel Jacobs Company LLC, Oak Ridge, TN.

BJC 2008a. *Waste Acceptance Criteria Attainment Team Project Execution Plan Environmental Management Waste Management Facility, Oak Ridge Reservation, Tennessee,* BJC/OR-1091, Rev. 4, Bechtel Jacobs Company LLC, Oak Ridge, TN.

BJC 2008b. *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment East Tennessee Technology Park, Oak Ridge, Tennessee,* BJC/OR-3088, Bechtel Jacobs Company LLC, Oak Ridge, TN.

DOE (US Department of Energy) 2001. *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-1909&D3, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2002. *Record of Decision for Interim Remedial Actions for Selected Contaminated Areas Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee,* DOE/OR/01-1997&D2, Office of Environmental Management, Oak Ridge, TN.

DOE 2004. *Waste Handling Plan, Part II for the ETTP Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee,* DOE/OR/01-2162&D2, Office of Environmental Management, Oak Ridge, TN.

DOE 2005. *Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee,* DOE/OR/01-2263&D2, Office of Environmental Management, Oak Ridge, TN.

DOE 2006. *Waste Handling Plan, Part II for the K-770 Soils within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee,* DOE/OR/01-2148&D2, Office of Environmental Management, Oak Ridge, TN.

APPENDIX A
WASTE ANOMALY DETECTION PLAN AND CHECKLIST

ANOMALY DETECTION PLAN FOR WASTE LOT 4.12

Introduction

This plan describes project personnel responsibilities and training requirements and identifies actions that the ETTP D&D/RA Project will conduct in order to ensure that no anomalous waste from the K-770 Scrap Yard is sent to the EMWMF. Any suspect, or identified, anomalous waste will be segregated and managed separately after review by trained project personnel with consultation from the EMWMF WAC Attainment Team as needed.

The wastes included in this waste lot are collectively referred to as the "K-770 Scrap Yard Soils" and consist of waste items as shown in the expected waste types in the Anomaly Detection Checklist. The anomaly detection process for this waste lot will rely principally on visual inspections, and sorting/ segregation of the wastes prior to shipment. Additionally, an understanding of the remediation logic is important from an anomaly detection perspective because the approach that will be implemented minimizes the likelihood that EMWMF anomalous waste will be included in this waste. Most EMWMF anomalous waste is be expected to be debris items. Debris items unearthed during soil excavation will be segregated and staged. Debris items will be sent for disposal upon conclusion of soil shipments. This allows for additional scrutiny of debris items for potentially-anomalous conditions, if necessary.

One example of an anomalous debris item is a Cs-137 cask. Three casks were discovered at random locations in the K-770 Scrap Yard area during the Scrap Remediation Project. These casks were cylindrical, nominally 20 in. in diameter, and 26-28 in. long. The casks were constructed of ½ in. to ¾ in. steel or poured concrete and were estimated to weigh 3,300-3,400 lbs. Photos of the steel cask and the suspected concrete cask are included in this ADP for reference. If a suspected cask is observed, work activities in the immediate area are to cease and workers removed. Project Waste Management will then be contacted.

Based on analytical data collected in accordance with BJC/OR-3088, *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee*, two distinct soil areas have been identified as anomalous waste due to elevated Tc-99 pCi/g concentrations. These soils areas are associated with Sample Locations Z1-EU33BW-442 (2,710 pCi/g Tc-99) and Z1-EU33BW-445 (40,600 pCi/g Tc-99). These locations are indicated on the site map included in this ADP. Soils within these areas will be excavated, packaged (in ST-90 containers), and controlled per BJC-WM-2001 before the generation of waste in this profile commences. Soil sampling will be performed to confirm that remaining soil is with the limits of this profile. This confirmation will be a comparison of Tc-99 levels in the soil with the UCL_{95} values in the profile. The anomalous waste is expected to be included in off-site DOE or commercial site waste profiles for disposal.

An Anomalies Risk Scoring Checklist has been completed for this waste lot (see below). The risk score has concurrence from ETTP D&D/RA Project Quality Assurance and the Waste Packaging Specialist for this waste lot. This waste lot has been determined to have a high risk of anomalies. This high risk score is primarily due to the potential hazards and the potential impacts at the EMWMF of an undetected Cs-137 cask. Because of the size and weight of a cask, it is unlikely that it would be undetected during a shallow soil excavation project. This has been considered in the graded approach to the rigor and Quality Assurance implementation required by this plan. The anomalous waste detection process employed by the ETTP D&D/RA Project is depicted in Fig. A.1

ETTP D&D/RA Project
EMWMF Anomalous Waste Detection Process

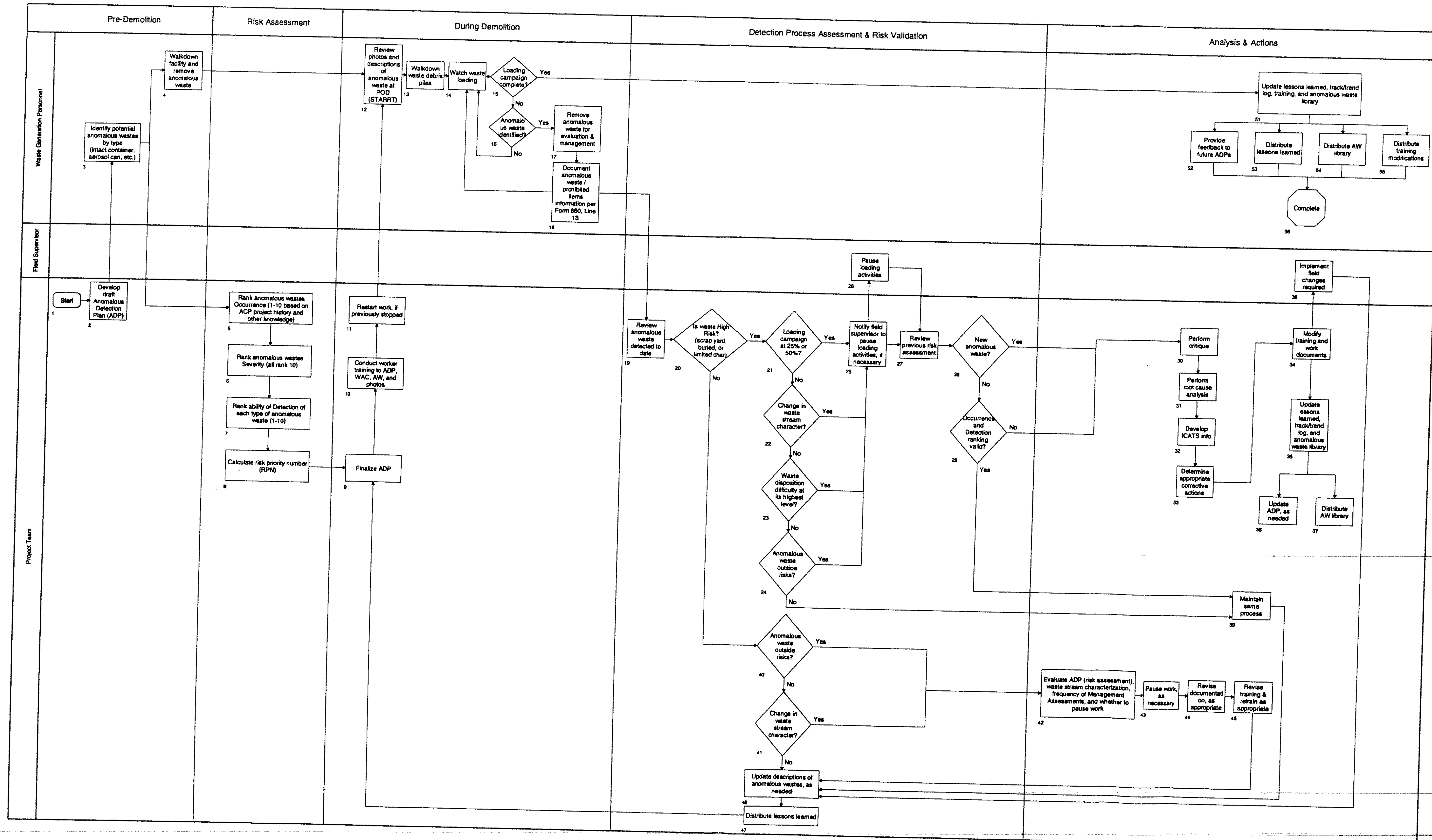


Fig. A.1. EMWMF anomalous waste detection process

Responsibilities

Personnel roles and responsibilities associated with execution of this plan are listed below. All personnel shall report non-conformances.

Waste Coordinator (WC)

Identify via profile description and other available information waste items authorized for disposal under this profile;

Ensure that the Waste Packaging Specialist is aware of the waste items that are authorized under this waste lot and any associated secondary waste;

Ensure that waste items offered for disposal under the Waste Lot 4.12 profile have been subjected to 100% visual inspection, sorting, and segregation prior to packaging and shipment of the wastes; and

Ensure that non-conformance actions are implemented.

Waste Packaging Specialist (WPS)

Conduct 100% visual inspection of individual waste items prior to and during sorting/segregation/packaging activities;

Ensure waste is placed in proper packages;

Apply a tamper indication device (TID) to package after filling if being staged prior to shipment;

Complete and sign the waste certification statements.

Field Personnel

At the direct instruction and oversight from the WPS, place waste items into an approved package

Transportation Specialist (TS)

Prepare shipping papers based on information received from WC and WPS and coordinate shipment to the EMWMF.

Training

Prior to commencement of the waste packaging activities, all field personnel will be briefed on the Waste Profile Anomaly Detection Plan, Waste Lot Anomaly Detection Checklist, list of items authorized for disposal, and Work Package or other requirements document(s) used to execute fieldwork associated with waste disposal under this profile. This training will include:

- Potential anomalies for this waste lot (using pictures and/or physical examples),
- How to identify anomalous waste, and

- How to respond to anomalous waste (e.g., segregate anomalous waste from remaining items or suspend work until the potential anomaly can be addressed by qualified Waste Management project personnel).

Workers performing the waste packaging activities, and generating this waste lot, will be periodically trained to recognize anomalous waste. This training may be conducted in the "plan-of-the-day meetings or tailgate briefings. In addition to the above training, workers will be directed to review:

Lessons Learned

- posted materials in break rooms and other traffic areas to maximize recognition and awareness of anomalous waste issues and response actions, and

- review of photographs and other visual aids associated with non-conforming waste items found or potentially present.

- Workers will be prompted at these meetings to inform managers of the number and types of anomalies that required removal prior to packaging the waste for transport the previous day.

Additionally, the WC and each WPS will be required to read the EMWMF Waste Lot 4.12 profile and the WAC Attainment Plan (DOE/OR/01-1909&D3) prior to certifying the waste in this waste lot for disposal.

Anomalies Risk Scoring Checklist for EMWMF Waste Lot 4.12	Date 4/1/09
Risk Criteria	Score (1 to 9)
Likelihood of waste lot to have anomalies. 9 – Extremely likely -0.95 probability of anomalies in the waste lot 7 – Very likely – 0.75 probability 5 – Likely – 0.5 probability (50 – 50 chance) 3 – Unlikely – 0.25 probability 1 – Very unlikely – 0.05 probability (almost no probability of anomalous waste)	9– Walk-downs, review of process knowledge (including previously approved/drafted waste profiles) confirm that anomalous waste items are in this waste lot.
Difficulty in detecting anomalies in the waste lot. The likelihood of a failure to detect an anomaly. Examples of factors that affect this are presence of soils or other conditions that minimize visual differences and the amount of different types of materials combined together. 9 – Extremely likely -0.95 probability of an anomaly could be undetected 7 – Very likely – 0.75 probability 5 – Likely – 0.5 probability (50 – 50 chance) 3 – Unlikely – 0.25 probability 1 – Very unlikely – 0.05 probability (almost no probability of detection failure)	3– Anomalous waste items are easily detected (especially Cs-137 casks), based on visual inspections (size and weight of anticipated anomalous waste items, no evidence of intentional burial at the site, etc.), radiological surveys,excavations will be shallow, and, sorting/segregation of residual metallic debris items.
Potential hazards associated with likely anomalies. The likelihood of the potential hazards, if brought in contact with workers could cause significant harm to those workers. 9 – Extremely likely -0.95 probability to cause extreme worker harm 7 – Very likely – 0.75 probability 5 – Likely – 0.5 probability (50 – 50 chance) 3 – Unlikely – 0.25 probability 1 – Very unlikely – 0.05 probability (almost no probability of any harm to workers)	9– An undetected Cs-137 cask could result in a significant potential hazard. However, the other K-770 Scrap Yard Soils materials contain only minor amounts or residual surface contamination. Safety documentation and Radiological Work Permits (RWPs) will define PPE requirements and administrative/ engineering controls to ensure protection of workers involved in waste packaging, transportation, and disposal activities.
Potential impact of likely anomalies on cell performance and the environment. The likelihood that undetected anomalies, if found in EMWMF would require EMWMF shutdown for removal to minimize environmental insult and/or noncompliance with regulations. 9 – Extremely likely -0.95 probability 7 – Very likely – 0.75 probability 5 – Likely – 0.5 probability (50 – 50 chance) 3 – Unlikely – 0.25 probability 1 – Very unlikely – 0.05 probability	9 – An undetected Cs-137 cask would likely result in a noncompliance with regulations governing the EMWMF. However,other anomalies would have minimal impact on cell performance or environment expected from undetected anomalous waste items being received at the EMWMF.
Total	30

Prepared by	Marshall Davenport [signature]	Date	4/1/09
Quality Engineer Review	Jim Moore [signature]	Date	4/2/09
Waste Packaging Specialist Review	[signature]	Date	4-2-9

Waste Packaging, Inspection, And Certification

All waste items will be subjected to a process consisting of 100% visual inspection by the WPS to identify anomalous wastes. Anomalous waste items will be sorted and segregated from acceptable waste items. Waste inspection, screening, packaging, and certification activities will be implemented using a graded approach based on risk to workers, the environment, and the public. All waste generation activities and loading of each container/shipment will be conducted under the supervision of a qualified WPS. The WPS will ensure that packaging requirements (e.g., minimization of void space, weight limits, conveyances are lined, as required, etc.) are met and that no anomalous waste is present in each shipment. If necessary, an absorbent material will be added to waste items and/or bulk shipment loads to prevent the buildup of free liquids during subsequent staging and/or transport to EMWMF.

Specific debris waste items in Waste Lot 4.12 will be identified and segregated. Visual inspection will be used to confirm the absence of free liquids or other prohibited items. Field verification screening methods that will be used to detect anomalies will primarily involve: visual inspection of the waste items to confirm that free liquids have not been introduced and to confirm EMWMF physical WAC compliance.

All anomalous waste items will be segregated from this waste lot, evaluated, and disposed accordingly. In the event that an anomalous item is identified after packaging and during loading of a conveyance to EMWMF, waste packaging operations will be suspended and the anomalous item will be removed and set aside for further evaluation by the project Waste Coordinator. An Anomaly Detection Checklist will be completed for each shipment of Waste Lot 4.12 wastes, certifying that all waste is in compliance with this profile. The WPS will sign the checklist prior to the waste leaving the site.

Process Validation Assessments

Process validation assessments will consist of two activities: examination of leading indicators and waste generation assessments. Leading indicators will be compiled when anomalous waste is detected and removed from packages or identified at the EMWMF. Documentation of items removed will be compiled into an ETTP D&D/RA Project "anomalous waste list." As the anomalous waste list is updated, the Project Waste Coordinator (or designee) will examine the types and number of anomalous waste items removed, and the time intervals between items requiring removal. This examination should also include information relayed through informal communications from those individuals involved in waste segregation/loading activities. An example of this type of information could concern significant or numerous potentially anomalous waste items requiring segregation for additional evaluation. The results of these examinations determine if this ADP needs to be revised, if the waste lot requires additional characterization, and/or more frequent waste generation assessments need to be conducted. The results of these examinations will also be provided to the Waste Packaging Specialists and other field personnel via updated training and/or plan of the day meetings.

An initial waste generation assessment/walk-down will be conducted by the ETTP D&D/RA Project Waste Coordinator, or designee, prior to the initial shipments of the waste to the EMWMF. A representative from ETTP D&D/RA Project Quality Assurance and Environmental Compliance will be invited to participate in these assessments/walk-downs, but because this is considered a high-risk waste lot only because of the impacts of an undetected Cs-137 cask, this participation is not required. This assessment/walk-down is expected to consist of an inspection of the preparation of the first two bulk containers for receipt of waste and inspection/observation of the waste to be loaded into the bulk containers. Prior to the initial bulk container leaving the site, the Waste Coordinator (or designee) will hold informal discussions with the Waste Packaging Specialist and the Transportation Specialist to ensure they are confident that: the waste conforms to the EMWMF WAC and the Waste Lot 4.12 profile requirements; shipping paperwork is in order; and any concerns have been satisfactorily addressed. In addition to the assessment/walk-down stated above, the project expects to conduct additional assessments/walk-downs:

- Quarterly,
- Upon restart of waste loading activities that were terminated for a significant period of time (over one month);
- If it is determined, based on worker input (or other leading indicators), that the character of the waste lot has changed; or
- If activities required by a corrective action plan, written in response to significant or repeated undetected anomalies are discovered at the EMWMF.

These additional assessments are expected to be similar in scope to the initial assessments described in this plan with one additional evaluation. Waste Packaging Specialists will be interviewed regarding the types and numbers of anomalous items identified and removed during the packaging of waste. At this time, documentation of anomalous waste (using the completion of the BJCF-860 documentation of items removed) will also be reviewed. The results of this assessment will be evaluated to determine if this ADP needs to be revised, if the waste lot itself needs additional characterization, and/or more frequent assessments (focusing on anomalous waste) need to be conducted.

Waste Lot Anomaly Detection Checklist:

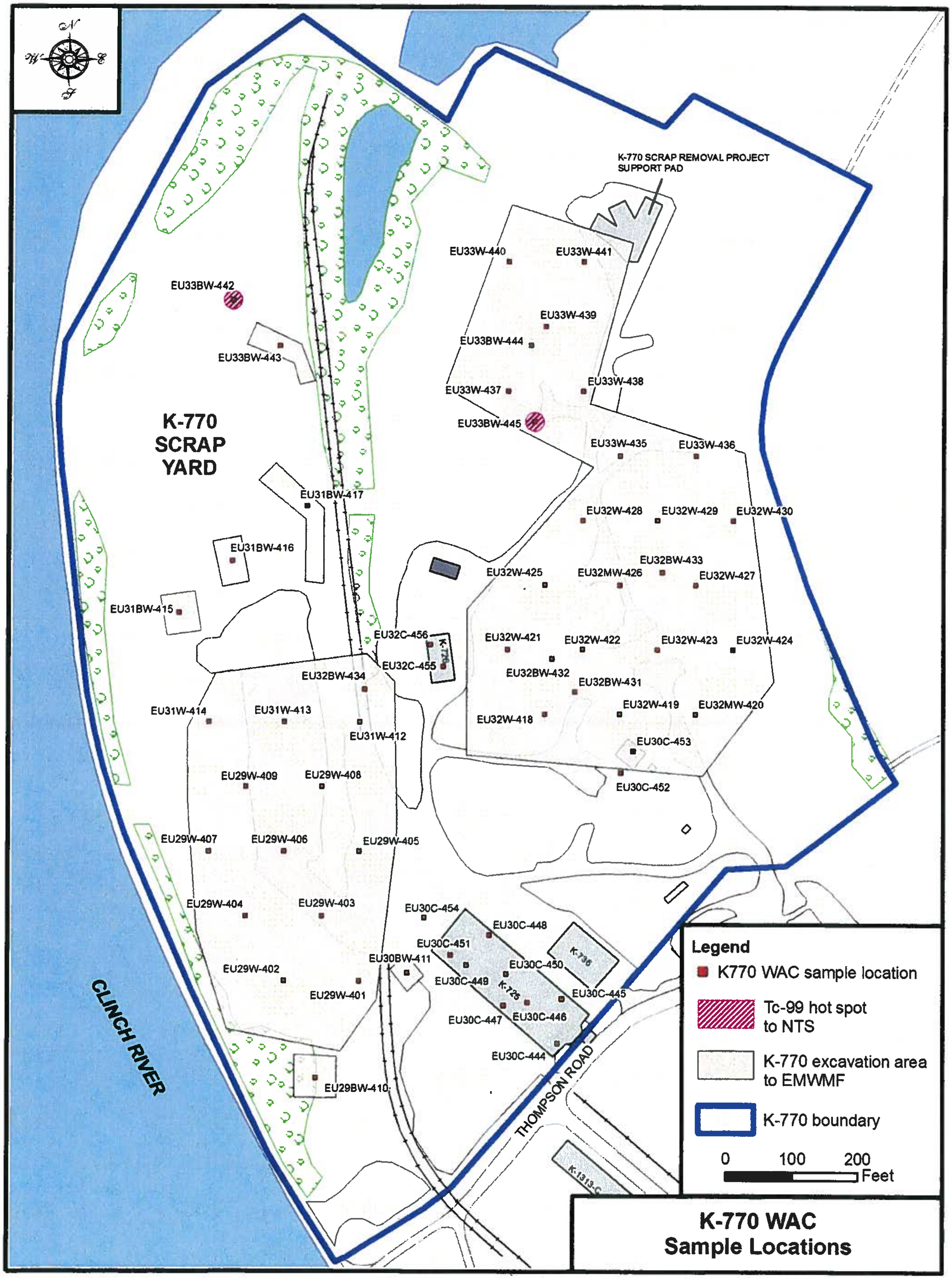
Waste Lot 4.12: K-770 Scrap Yard Soils
Expected Waste Types: This waste lot includes soils, residual metallic and other debris, and secondary wastes (tyvek, gloves, used personnal protection equipment, wipes, used radiological signage, etc.). Expected waste items may include: soil, metallic debris items, concrete, rebar, asbestos-containing material (e.g. exterior transite panels, pipe insulation), small diameter pipe (with and without insulation), structural and miscellaneous wood (railroad ties, lumber), conduit and/or wire, incidental plastic, paper, glass, and vegetation.
Physical Indicators of Potential Anomalies: • Waste material not generated during the K-770 Scrap Yard Soils remedial action • Soils associated with elevated Tc-99 concentrations surrounding sample locations Z1-EU33BW-442 and Z1-EU33BW-445 (see map in this ADP) • Containerized waste (the Tc-99 contaminated soils are expected to be containerized) • Universal Waste (mercury containing equipment [thermostats and switches], batteries, lamps [fluorescent bulbs], equipment known or suspected of containing freon, and pesticides) • RCRA waste (lead shapes, metal turnings, large concentrated quantities of small metallic debris, circuit boards, computer monitors/components, etc.) • Free liquids (water, oil, etc.) or equipment known or suspected of containing liquids/fluids • Used or unused chemicals (petroleum products, lube oils, dielectric fluids) • Process Equipment (valves, piping, from process gas operations) • Sealed sources (including those within manufactured products) • PCB transformers • Any suspect or confirmed high-activity materials • Cs-137 casks (see description and photographs in this ADP) • Yellow cake or other evidence of uranium product material (green- or yellow-colored residue) • Any unusual odors, such as solvent or acrid • Un-bagged PPE • Concrete blocks greater than 1-foot X 1-foot X 1-foot • Rebar that has not been sized and packaged in accordance with variance in profile (sheared from concrete, less than 4-feet in length, commingled with soil in dump trucks) • ACM waste that has not been packaged in accordance with PWAC or variances in profile • Any area identified as RCRA Hazardous or Universal Waste by Waste Management (spray paint, flagging, etc.) • Un-opened containers and aerosol cans, intact tanks or cylinders (sampling cylinders) • Any item that has not been subjected to visual inspection
Field Instrument Indicators of Potential Anomalies: Industrial Hygiene –Process knowledge eliminates the need for VOA/SVOA screens or continuous air monitoring Radiological Controls – Process Knowledge eliminates the need for radiological airborne continuous monitoring. Health Physics Survey Results that indicate unusual readings that would trigger ES&H and transportation concerns will be brought to the attention of the Waste Coordinator for evaluation.

Certification Statement (to be completed and sent with each waste shipment):

I certify that the wastes in this shipment conform to the descriptions found in the waste profile for Waste Lot ______________. For question regarding the contents of this shipment, call ______________________________.		
Printed name	Signature	Date
(Note: the phone number and printed name for this form may be electronically inserted. However, the waste lot number, signature, and date shall be handwritten in ink.		

PHOTOGRAPHS OF CESIUM-137 CASKS (W. L. 4.12 ANOMALOUS WASTE)

Approximate dimensions: 20" in diameter, 26-28" in length. Approximate wieght: 3,300-3,400 lbs. Photopraphs below are of a steel cask and a suspected concrete cask from the K-770 Scrap Removal Project.


K-770 SCRAP REMOVAL PROJECT SUPPORT PAD
K-770 SCRAP YARD
CLINCH RIVER
THOMPSON ROAD
EU33W-440
EU33W-441
EU33BW-442
EU33W-439
EU33BW-444
EU33BW-443
EU33W-437
EU33W-438
EU33BW-445
EU33W-435
EU33W-436
EU31BW-417
EU32W-428
EU32W-429
EU32W-430
EU31BW-416
EU32BW-433
EU32W-425
EU32MW-426
EU32W-427
EU31BW-415
EU32C-456
EU32W-421
EU32W-422
EU32W-423
EU32W-424
EU32C-455
EU32BW-432
EU32BW-434
EU32BW-431
EU31W-414
EU31W-413
EU32W-419
EU32MW-420
EU32W-418
EU31W-412
EU30C-453
EU29W-409
EU29W-408
EU30C-452
EU29W-407
EU29W-406
EU29W-405
EU29W-404
EU29W-403
EU30C-454
EU30C-448
EU30C-451
EU30BW-411
EU30C-450
EU29W-402
EU30C-449
EU30C-445
EU29W-401
EU30C-447
EU30C-446
EU30C-444
EU29BW-410
K-726
K-725
K-736
K-1313-C
Legend
K770 WAC sample location
Tc-99 hot spot to NTS
K-770 excavation area to EMWMF
K-770 boundary
0 100 200 Feet
K-770 WAC Sample Locations

APPENDIX B
WASTE LOT 4.12 PROCESS KNOWLEDGE

Appendix B: Waste Information, Facilities History, and Profile Documentation (Process Knowledge)

This appendix contains the process knowledge that supports the characterization of the waste in Waste Lot 4.12. It also contains documentation for statements and determinations in the profile. This appendix is sub-divided into sections that group similar sets of information. The following describes the organization of sections in this appendix and the information contained in each.

Section B.1, Waste Information for EMWMF Waste Lot 4.12 describes the K-770 Scrap Yard area and history. It also details the waste in the waste lot and previous characterization efforts in the K-770 Scrap Yard.

Section B.2 contains the Core Team approval documentation for the three waste handling plans that cover the waste in this waste lot (*Waste Handling Plan, Part II for the K-770 Soils within Zone 1 East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2006), *Waste Handling Plan, Part II for the East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2004), and *Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2005). This section also contains documentation of notification of the ETTP D&D/RA Core Team of deviations from the approved sample and analysis plan.

Section B.3 contains comments and responses from the EMWMF WAT review the profile received during its development.

B. 1. WASTE INFORMATION FOR EMWMF WASTE LOT 4.12

This section of Appendix B contains the description of the waste in this waste lot, the historical information, and process knowledge used in preparing this Environmental Management Waste Management Facility (EMWMF) profile. Most of the following information is from *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2008a), provided in Appendix E of this profile. The detailed process knowledge on the K-725 Building is from *K-770 Scrap Metal Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003a).

SITE DESCRIPTION

The K-770 Scrap Metal Yard and Contaminated Debris Site (the K-770 Scrap Yard) is a storage area located southwest of the main portion of East Tennessee Technology Park, outside the security perimeter fence in the Powerhouse Area adjacent to the Clinch River. The site is located upstream from the confluence of the Clinch River with Poplar Creek. The scrap yard is surrounded by a locked fence and scrap metal is stored on the ground in piles and as loose objects in the area. The K-770 Scrap Yard occupies an approximately 21-acre tract of land. Remaining portions of foundations/floor slabs for Bldgs. K-725, K-725-B, K-726, and K-736, as well as several other small concrete pads, are also located within this area.

The K-770 area was used to store radioactively contaminated or suspected contaminated materials during and previous to the cascade upgrading program. Other known or suspected contaminants include PCBs, mercury, and asbestos incidental to scrap metal operations that were stored at the site prior to initiation of a waste management tracking program in 1977. The waste storage facility began operation in the 1960s and is estimated to at one time contain in excess of 40,000 tons of low-level, radioactively contaminated scrap metal. Also, the scrap metal piles contained approximately 20,000 ft^2 of asbestos-containing material, which consisted primarily of metal pipe. Scrap metal was taken to the site when it was found to contain alpha or beta/gamma activity on the surface or if the scrap metal originated from a process building.

Prior to 1984, there was no segregation of the low-level, radioactively contaminated scrap metal brought to the K-770 Scrap Yard. Cleanup of the scrap yard was initiated when Martin Marietta Energy Systems, Inc. contracted Quadrex Corporation (Quadrex) to relocate the material out of the 100-year floodplain, reduce the size of the material in an on-site processing unit, and segregate the material into piles separated by metal type. Quadrex performed the Health Physics activities of the contract and subcontracted the task of material handling to Southern Alloy. All material Quadrex was permitted to handle was removed from the floodplain and segregated into piles. The segregated metal debris was removed from the site as part of the K-770 Scrap Removal RA Project that was completed in fiscal year (FY) 2007 by Bechtel Jacobs Company LLC (BJC). An area of approximately 10 acres is located in EUs 29 and 31 where the scrap was originally located in the 100-year floodplain. In the process of moving the materials around and establishing segregated waste piles above the 100-year floodplain, the footprint of the site was expanded by 10-15 acres in EUs 30 and 32. The area in EUs 29 and 31 that was cleared of metallic debris in the floodplain was sown with grass. The areas in EUs 30 and 32 have some scattered vegetation but are generally open and accessible. A concrete pad was constructed in the northeast portion of the site in 2006 to support waste sort and segregation activities associated with this RA (see site map in Appendix E).

Several material categories established for waste at the K-770 Site during the segregation phase include the following [more detailed information on these categories is in *K-770 Scrap Metal Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003a)]:

- Asbestos-containing material
- Rubbish
- Items with hot spots above acceptable limits
- Segregated metal
- Class 004
- Cooling tower wood

With limited exception, all materials contained in these segregated piles have been removed and disposed of at EMWMF during the Scrap Removal Project. Soils that underlay the original waste storage area in EUs 29 and 31 as well as soils that underlay the scrap piles in EUs 30 and 32 show substantially elevated radioactivity. In addition to soils present at the site, the remaining portions of foundations/floor slabs for Bldgs. K-725, K-726, and K-736, as well as the unnamed pad at the northeast corner of the site constructed to support the sort and segregation operations at the K-770 Scrap Removal Project and the several small, unnamed concrete pads are included in this waste lot. Contaminants present in these soils are directly derived from metallic debris and rubbish handled by the waste storage operations and include the predominant constituents of concern associated with the metallic waste already disposed of at EMWMF. Residual metallic debris embedded in the soils that underlay the debris piles comprise approximately 5% of the total mass of material that will be generated under this remedial action (RA).

Three Cs-137 casks were discovered at random locations in the K-770 Scrap Yard area during the Scrap Remediation Project. These casks were cylindrical, nominally 20 in. in diameter, and 26-28 in. long. The casks were constructed of ½ in. to ¾ in. steel or poured concrete and were estimated to weigh 3,300-3,400 lbs. For this reason Cs-137 casks are addressed in Appendix A of this profile (the ADP). Photos of the steel cask and the suspected concrete cask are also included in the ADP for reference while the waste in this waste lot is being generated.

SITE HISTORY

Beginning in 1944-45, this area was the site of a tank farm designated F-22 and used for storing Bunker C oil (No. 3 grade fuel oil). This oil was stored in 13 tanks, each with a 470,000-gal capacity adjacent to the Clinch River. Each tank was individually isolated by an earthen dike and a secondary dike around each group of three tanks. Fuel oil usage at the Powerhouse extended from 1944 through the end of 1953 and the tanks remained in place until 1954.

Scrap metal storage in this area began in the 1960s and waste management tracking operations began in 1977. From 1984 to 1986, the metals were segregated under a contract to Quadrex. The waste materials were separated by metal type and reduced in volume by shearing. Categories of metals were ACM, rubbish, items with radiological hot spots, and Class 004 (too large to shear). A Resource Conservation and Recovery Act of 1976 (RCRA) assessment was performed on this site in FY 1994 and all readily identified and accessible RCRA-regulated materials were removed.

The majority of metal at the K-770 Scrap Yard was generated during the Cascade Improvement Program/Cascade Upgrade Program. Most of the scrap metal passed through the K-1420 decontamination facility, where it was vacuumed and washed using water with dilute nitric acid or an alkaline detergent. This decontamination process removed transferable uranium prior to outside storage. In the 1980s, much of the scrap metal was segregated and size reduced. The metal was segregated into groupings of ferrous metals, non-ferrous metals, and other metals with potential recycle value. In addition to material from the ETTP Site (formerly known as the K-25 Site), materials from the Y-12 Site, Savannah River Site, and Oak Ridge National Laboratory (ORNL) were received at this scrap yard. Material from the Y-12 and

K-25 Sites was contaminated with uranium, the SRS material contained scrap metal released as part of a recycling program, and the ORNL waste included four heat exchangers. The total non-uranium based waste (i.e., non-K-25 Site or Y-12 Site waste) was < 0.5% of the total waste. The scrap yard material consisted of five primary waste piles of scrap metal that comprised approximately 40% of the waste by weight and were disposed of at EMWMF. All building structures within the area of the site have been demolished to the building slabs, which remain in place. All scrap metal that was not embedded in the surface soils has been removed and disposed of at EMWMF. All physical samples collected by the Zone 1 Dynamic Verification Sampling (DVS) Soils Characterization Program were analyzed for the presence of PCBs and metals. Results of these analyses indicated the metal concentrations in some samples could exceed the land disposal regulations. No volatile organic compounds (VOCs) were reported in any DVS samples above the industrial use preliminary remediation goals (PRGs), and only two DVS samples reported semivolatile organic compounds (SVOCs) present above the industrial use PRGs. Two samples were reported with PCBs above the Zone 1 average remediation levels (RLs).

K-725 Building

The K-725 Beryllium Building (now demolished, but with a remaining concrete pad) is located within Zone 1 and the Powerhouse Peninsula, in exposure unit (EU) 30. The remaining concrete pad is located adjacent to the K-770 Scrap Metal Yard and within the K-770 Scrap Metal Yard perimeter fence. For purposes of this process knowledge statement, the K-725 site is defined as the area that is bounded on the northwest by double parallel railroad tracks, on the southwest by the single railroad track spur, on the south and southeast by Thompson Road, and extends on the northeast and north approximately 50 feet beyond the perimeter of the concrete slab that remains after building demolition. The site includes an additional small area extending from the southeast corner of the building slab north of Thompson Road in order to include sample locations that were sampled subsequent to the sitewide remedial investigation.

K-725 Site History

The K-725 Beryllium Building was a concrete slab on grade with concrete walls and covered an area of 21,614 ft^2. The K-725 Building was originally a machine shop as part of the S-50 Thermal Diffusion Plant and for beryllium machining and experimentation (original building area 160 ft x 84 ft = 13,440 ft^2). The K-725 Building is sometimes referred to as Building F-10. From 1946 to 1951 the K-725 Building was used by the Fairchild Engines and Aircraft Corporation for the Nuclear Energy Propulsion for Aircraft project. The K-725 Building was also used for support activities for the Oak Ridge Gaseous Diffusion Plant, ORNL, and Hanford reactors. In April 1951, General Electric took over operations at the K-725 site and continued the NEPFA project and various other projects until September 1952. The K-725 site was found heavily contaminated with radionuclides in 1953. A concrete "skin coat" was placed over the original floor because of high alpha counts from depleted uranium handled in the building. Union Carbide took over operations after General Electric, and in the early 1970s they attempted to decontaminate the K-725 Building. This cleaning effort did not achieve acceptable levels. The building was then defined as a contamination area and was not made available for further use. The building was demolished in 1998. The concrete slab remains.

Hazardous materials used at the K-725 Beryllium Building included beryllium, beryllium oxides, beryllium carbides, depleted uranium, and mercury. Interviews revealed that traps containing mercury occasionally released mercury, which was swept down the floor drains in the cleanup.

According to historical reports, the ground between the K-725 Beryllium Building and the railroad tracks was "highly contaminated with beryllium powders, chips, oxides, carbides, etc." There was considerable steam cleaning of beryllium and radioactively contaminated equipment in front of the building where the railroad tracks cross the road. The area was suspected of contamination at "fairly high levels."

K-726 Building

The K-726 building was originally built as a boiler house to burn bunker C oil to support the Fercleve Thermal Diffusion experiments. The single-story, concrete/cinder block structure with a steel truss-supported metal corrugated roof is believed to have been constructed in 1944. It measured approximately 75 ft by 35 ft and had a concrete floor. Operations at this building were discontinued in 1945. Beginning in 1978, the building was used to store PCB-containing liquids and solids. The facility was diked with a sealed concrete floor and inspected weekly. The PCB materials were removed in 1994 and the building cleaned according to PCB regulations. It stood vacant from 1994 to 2006 (BJC 2000). The structure (including the concrete slab floor) was demolished in 2006 and only the subsurface portions of the foundation remain (see the attached K-726 Fact Sheet). This was visually confirmed by Project Waste Management and Environmental Compliance and Protection on January 8, 2009. [One could incorrectly conclude from the SAP (BJC 2008a) that the concrete floor of this facility is included in this waste lot.] Based on visual inspections following demolition, there is no evidence of PCB contamination on the remaining portions of the K-726 foundation (see the attached fact sheet).

K-736 Scrap Storage

K-736 was a steel-frame building with a corrugated metal shell on an asphalt pad. The building was built in 1986 to support metal recycling and decontamination activities at the K-770 Scrap Metal Storage Yard. These activities included a Tc-99 decontamination demonstration project, a negative-pressure decontamination demonstration, and surface decontamination by electrolytic separation. From the mid-1990s until it was demolished, it was used to store contaminated equipment from ETTP (BJC 2000). The asphalt pad remains at the K-770 Scrap Yard site.

PREVIOUS CHARACTERIZATION ACTIVITIES

K-770 Site Summary Document

The purpose of this report [*K-770 Scrap Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003a)] was to present a succinct summary of all available data for the K-770 Scrap Metal Yard and contaminated debris. The K-770 area was located in Exposure Units 29, 31, 32, 33, and part of 30. The report noted that the boundaries of the K-770 Scrap Yard had been expanded to include adjacent areas that may have been impacted by site operations. The data and information in this report was intended to support the remedial action decision-making process. The report included an analysis of aerial photographs and a summary of data for various media. The data for the K-770 soils are summarized in the following paragraphs. The data summary focused on the contaminants of concern (COCs) identified in the the Record of Decision (ROD) for selected contaminated areas in Zone 1 (DOE 2002).

In 1990, a sampling and radiological survey was performed to determine the presence, nature, and extent of contamination within the fenced boundaries of the K-770 Scrap Yard. A total of 99 soil samples were collected from 39 boring locations during the two rounds of sampling activities. Samples were collected from 0 to 2 ft below ground surface and analyzed for inorganic elements, gross alpha, beta, and gamma radioactivity; radionuclides, PCBs, and semi-volatile organic compounds. An additional sample was analyzed for VOCs. The reults indicated that radionuclides were widely dispersed across the site. In particular, the results for uranium and thorium, as well as metals and PCBs, revealed scattered contamination.

Sixty-five surface soil samples were collected in the area of the scapyard as part of the 1994 radiological survey conducted by Martin Marrietta Energy Systems. In this survey, a systematic walkover and RADMULE surveys were conducted over 11 grids covering approximately 23 acres of the scrap yard. Thirty-four of the soils samples were collected at locations that were biased by the results of the walkover and RADMULE surveys (samples were collected at locations having high radiation counts). The systematic walkover survey data file contained 20,391 data points and an additional 6,437 data points in the southeast corner of the site. The RADMULE collected 72,318 data points from the sodium iodide detectors. As in the previous investigation, the contamination appeared to be widely dispersed and scattered.

Soil samples were collected from five borings excavated for the sitewide RI. The borings were excavated to the water table at surface "hot spots" identified during the 1994 radiological walkover survey. Samples were collected from three depth intervals and analyzed for radionuclides and inorganic elements. Three depth intervals were sampled from each boring between the surface and 10-ft depth. A total of nine surface samples were also collected.

The COC data for samples taken within the site boundaries from all of these studies are combined into Tables 1 and 2 and Figures 2 through 4 of *K-770 Scrap Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003a). No PCBs were detected in the soil. Arsenic was detected in 24 samples with a maximum concentration of 33.3 mg/kg, beryllium was detected in all 35 samples with a maximum concentration of 0.87 mg/kg, and mercury was detected in 34 out of 35 samples analyzed for metals. The maximum mercury concentration detected was 4.1 mg/kg (estimated value). None of the metals exceeded it respective RL calculated in the ROD.

Radionuclides were detected at concentrations exceeding background criteria only in surface soil samples at the K-770 Scrap Yard. Cesium-137 was detected in 55 of the 86 samples analyzed. Cesium-137 exceeded its average RL (the average concentration to which EU must be remediated) of 2 pCi/g in 8 of the 55 detections. The maximum RL was exceeded in only 3 of the 55 detections. Neptunium-237 was detected in all of the 55 samples analyzed. Radium-226 was detected in all of the 55 samples analyzed, and no sample exceeded average RL of 5 pCi/g. Thorium-232 was detected in 83 out of 86 samples. Its average RL of 5 pCi/g was exceeded in seven samples, but no sample exceeded the maximum RL. Uranium-234 was detected in 85 out of the 86 samples. Its average RL of 700 pCi/g was exceeded in 9 samples, and the maximum allowable concentration was exceeded in 5 of the 85 detections. The average U-234 concentration was 1030 pCi/g. Uranium-235 was detected in 65 out of 86 samples. It was detected above its average RL (8 pCi/g) in 27 samples. Ten samples contained concentrations greater than the maximum RL. Uranium-238 was detected in 85 out of 86 samples. It was detected above its average RL in 31 samples and above the maximum RL in 9 samples. The average concentration was 840 pCi/g. Four samples contained uranuim in excess of 10,000 pCi/g and three were located near each other in the central portion of the site. These four samples were determined to have skewed the average for uranium concentration high due to their very high levels of activity.

The information and data in this summary report were used to confirm the process knowledge contained in the sample and analysis report and the waste handling plans. However, the data were not used in the characterization of the waste in this waste lot because of its age, and it was not collected to support waste disposal decisions.

K-725 Beryllium Building Site Summary Document

The purpose of this report [*K-725 Beryllium Building Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003b)] was to present a succinct summary of all available data for the K-725 Beryllium Building Site. For purposes of this document, the K-725 site is defined as the area that is bounded on the northwest by double parallel railroad tracks, on the southwest by the single railroad track spur, on the south and southeast by Thompson Road, and extends on the northeast and north approximately 50 feet beyond the perimeter of the concrete slab that remains after building demolition. The site includes an additional small area extending from the southeast corner of the building slab north of Thompson Road in order to include sample locations that were sampled subsequent to the sitewide remedial investigation.This data summary report was intended to provide all pertinent data and information for this site to support remedial action decision-making process.

Forty-four surface soil samples (0 to 0.5 ft) were collected from 40 locations in 1990 as part of the RCRA Facility Investigation. These soils were composited and analyzed for raiologicals and beryllium. Subsequently, surface soil sampling for radionuclides was included in a site-wide radiological walkover of Zone 1 in 1994 and 1995. Since the RI was drafted, the Reindustrialization Program at ETTP has taken numerous surface and subsurface soil samples in Zone 1. During 1998 and 2000, soils were sampled for metals, PCBs, radionuclides, volatile organic compounds and semi-volatile organic compounds. A total of 55 locations at the K-725 site have surface soil data (0 to 2 feet bgs), and 59 locations have subsurface soil data (0 to 10 feet bgs, which also includes all surface soil data locations). No surface water, sediment, or groundwater samples have been taken at the K-725.

COCs for the K-725 Beryllium Building included beryllium, PCBs, benzo(a)pyrene, dibenz(a,h)anthracene, cesium-137, thorium-232, uranium-235, and uranium-238. Analytical results for the K-725 Beryllium Building indicate that the contaminants are scattered around the building in an irregular pattern, and there appears to be no discernible distribution pattern except that the contaminants are found primarily in surface soil. There are a few hot spots around the building that may be related to past process activities or located near vents and drains that may have been points of releases from the building during accidental spills. Although both surface and subsurface soil samples were collected (see Table 1 of BJC 2003b), the only COCs of note at the K-725 site were in samples from the 0 – 0.5 ft sample depth.

Summaries of the analytical results and corresponding sampling locations and sample identifiers are presented in Table 1 of BJC 2003b. Sampling locations at the K-725 Beryllium Building site are shown in Figure 2 (BJC 2003b). Figure 3 (BJC 2003b) shows the relative uranium activity at the K-725 site, and Figure 4 (BJC 2003b) shows other radionuclide relative activity. Figure 5 (BJC 2003b) indicates the relative chemical concentrations at the K-725 site, and sample locations identified for remediation at the K-725 site are shown in Figure 6 (BJC 2003b).

The highest beryllium concentration of 442 mg/kg was located on the southwestern side of the building slab. Samples from adjacent sampling locations along the southwestern side of the building slab, also had elevated beryllium concentrations ranging from 6.2 mg/kg to 100 mg/kg. Two sampling locations the same area, also had slightly elevated concentrations (2.47 and 4.24 mg/kg, respectively). However, sampling locations on either side of these had low concentrations (0.9 mg/kg) as did all other sampling locations at the K-725 site (all other beryllium sample concentrations were <1.8 mg/kg).

Unlike beryllium, which was localized in one area along the southwestern side of the building slab, high radionuclide activity levels were distributed irregularly around the building slab. The highest cesium-137 level was 181 pCi/g near the southeastern corner of the building slab. The highest level of thorium-232 was 528 pCi/g on the opposite (southwestern) side of the building slab from the high cesium sample. No other thorium-232 activity level was higher than 19 pCi/g. The highest uranium-235 concentration was 11.84 pCi/g at the same location as the highest uranium-238 concentration (129.5 pCi/g). That location was in the northwest corner of the K-725 site, between the northwest corner of the building slab and the double railroad tracks. Sample locations in that vicinity had elevated, though not the highest, cesium-137 concentrations (50.8 pCi/g and 24.6 pCi/g, respectively). Uranium activity levels for adjacent samples were much lower.

The highest total PCB concentration (14.26 mg/kg) was found in surface soil at the same sampling location with the highest cesium-137 activity as well as slightly elevated thorium-232 (3.6 pCi/g) and uranium-238 (64.5 pCi/g) activities. The other location with notable uranium-238 activity (56.2 pCi/g) was on the northeastern side of the building slab. One sampling location, on the northeast side of the building slab, had elevated concentrations of cesium-137 (2.61 pCi/g) and thorium-232 (19.1pCi/g).

Three subsurface samples required drilling through the demolished K-725 Building's concrete slab to obtain samples at 3 to 10 ft bgs. Additional subsurface samples were collected at another location. Although COCs were detected in these subsurface samples, chemical concentrations and radionuclide activities were generally low.

In addition to the inorganics (arsenic, beryllium, and mercury) and radionuclides (Cs-137, Np-237, Ra-226, Tc-99, Th-232, U-234, U-235, U-238) that were analyzed and detected, several organics (1,1,1-TCA, 1,1,2-TCA, 1,1-DCE, carbon tectrachloride, and TCE were analyzed for but were not detected.

Semi-volatile organic compounds were also sampled. The highest level of dibenz(a,h)anthracene was 51 mg/kg collected in surface soil (0 to 0.5 ft) in October 2000. The next highest level was 7.33 mg/kg. All other dibenz(a,h)anthracene concentrations were less than 2 mg/kg. The highest level of benzo(a)pyrene was 169 mg/kg with the next highest level (20.8 mg/kg) also at K725-01. All other benzo(a)pyrene concentrations were less than 2 mg/kg.

The information and data in this summary report were used to confirm the process knowledge contained in the sample and analysis report and the waste handling plans. The beryllium results in this report as well as *K-770 Scrap Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2003a) were also used to support the conclusion in Section 5.7 of this profile that the waste in this waste lot is not a beryllium containing waste. However, the data were not used in the characterization of the waste in this waste lot because of its age, and it was not collected to support waste disposal decisions.

2008 Sampling and Analysis Plan for K-770 Soils

Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee (BJC 2008a) (see Appendix E of this profile) describes the following characterization activities.

Two investigative programs have been performed in EUs 29 and 31. An investigation conducted by CDM Federal Programs (CDM) under the Radiological Characterization of Inactive Waste Sites Program was performed in the mid-1990s, and Dynamic Verification Strategy (DVS) characterization of the area was performed in late 2004 and early 2005. Both programs used a combination of radiological walkover surveys and subsequent physical sampling to provide an assessment of this portion of the K-770 Waste Storage Site.

Radiation Walkover Surveys

A full-coverage survey of all open and accessible areas in EUs 29 and 31 and the southwestern portion of EU 33 were performed by CDM in the mid-1990s. This survey used a 2X2 NaI probe with geographic positioning equipment to obtain activity data coverage of the accessible areas. One large area of elevated activity and several smaller anomalies within the site were defined.

In 2004, BJC and Restoration Services Inc. conducted a walkover survey in EU 29 of the large area of elevated activity defined by the CDM survey. The more recent survey used a field instrument for detection of low-energy radiation (FIDLER) and was conducted to confirm the extent of elevated activity could be defined using a different field instrument. The FIDLER survey was successful in defining the same approximate boundary as defined by the CDM survey. The use of these survey instruments was to define areas of anomalous conditions and not to estimate quantitative radioisotopic concentrations.

Soil Sampling

Thirty-four surface soil samples were collected under the 1994 CDM assessment program. These were all biased samples selected to provide laboratory analyses in areas of significantly elevated radioactivity. Also, all of these samples were analyzed by gamma spectroscopy [U.S. Environmental Protection Agency (EPA) Method 901.1]. Concentrations of many of the primary Zone 1 radioisotopic contaminants of concern (COCs) cannot be accurately determined by this method; therefore, the radioisotopic concentrations results are considered unreliable and are not used in the assessment of the proposed waste lot.

Under the DVS Soils Characterization Program, the entire areas of EUs 29 and 31 were classified as Class 1 soil units. Based on the historic radiation walkover survey and historic sampling, there was a high degree of confidence that soil contamination in portions of the EUs was above Zone 1 maximum RLs and an RA was required. The sampling plan, as defined in the K-770 DQO Summary Report, defined a base program of 40 sample locations placed on a systematic grid over the two EUs. In addition, 21 biased sampling locations were added to the base program sample set. These additional locations where selected within areas of elevated activity as defined by the radiation walkover surveys and, in some cases, in proximity to the historic sample locations to determine the concentration of radioactive contaminants present and compare to the reported historic sample results.

As prescribed under the DVS characterization DQOs, the sampling methodology is biased to high radioactive contaminant areas and intervals. The sampling approach was designed to provide data to support an action/no-action determination as a program objective and produce a high biased data set. The analytical methods are designated in the Zone 1 Remedial Action Work Plan (DOE 2007) and are appropriate for all the respective radioisotopes. The data are 100% validated and are considered accurate to meet program DQO requirements.

The predominant radiological contaminants identified by the DVS data set include cesium-137 (maximum result = 27 pCi/g), technetium-99 (maximum result = 695 pCi/g), thorium-232 (maximum result = 60.7 pCi/g), uranium-234 (maximum result = 2090 pCi/g), uranium-235 (maximum result = 110 pCi/g), and uranium-238 (maximum result = 1660 pCi/g). With the exception of technicium-99, all of these isotopes are Zone 1 contaminants of concern. It is noted that neptunium was not detected in any DVS samples and radium-226 was detected at very low concentrations, with a maximum reported result of 3.1 pCi/g. These results are in contrast to very high reported concentrations in the historic data set analyzed by gamma spectroscopy. This substantial discrepancy supports the conclusion that the CDM data set is unreliable.

Other possible contaminants that may be present based on historic information include beryllium associated with the K-725 building slab, PCBs and wrapped pipe that contained asbestos. PCBs were stored in Bldg. K-726 prior to incineration.

A summary of sample results for U-238 from the DVS data set are presented in Table 1 of *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment, East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2008a). These data represent a high bias set and are not considered representative of average concentrations present in the waste in this waste lot. Therefore, the data are not considered appropriate for an EMWMF waste acceptance criteria (WAC) determination.

Concrete

No samples were collected from the concrete slabs/foundations during earlier investigations.

Residual Miscellaneous Metal

The residual metallic debris that remains embedded in the shallow soils that underlay the former debris piles was characterized for EMWMF disposal in the approved *Waste Profile for: Disposal of the Scrap Removal Project Waste Lot 65.1 East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2004a). However, this residual metallic debris has been included in this waste lot to meet the more rigorous profiling requirements currently contained in *Waste Acceptance Criteria Attainment Team Project Execution Plan Environmental Management Waste Management Facility, Oak Ridge Reservation, Tennessee* (BJC 2008a). This waste is expected to comprise approximately 5% of the total volume of waste in this waste lot. It has been characterized using the data collected for the soil and concrete in this profile as an upper-bound proxy.

To justify that the characterization data for the remainder of the waste in this waste lot can serve as an upper-bound proxy for the residual metallic debris, the characterization information in the Waste Lot 65.1 profile was compared to the characterization data in this waste lot. [EMWMF Waste Lot profiles 65.2 (BJC 2004b) and 65.3 (BJC 2005) characterized portions of the metallic debris in the K-770 Scrap Yard. However, because the scope of the characterization in these profiles was limited to small portions of the debris (aluminum and containerized waste), the Waste Lot 65.1 profile (BJC 2004a), which characterized most of the K-770 Scrap Yard debris was determined to be more representative of the metallic debris.] The initial comparison was of the carcinogenic (CA) and hazard index (HI) sums of fractions (SOFs) for the two waste lots. Waste Lot 4.12 had the higher sums-of fractions, with a CA SOF of 0.668 and an HI SOF of 0.147 (compared to a CA SOF of 0.120 and an HI SOF of 0.080 for Waste Lot 65.1). This indicates that, in general, the levels of contamination contributing to both SOFs are higher in Waste Lot 4.12.

A more detailed comparison of site related contaminants (SRCs) in the two waste lots was then performed. Waste Lot 65.1 identified five radiological SRCs (Tc-99, U-234, U-235, U-236, and U-238) with Tc-99 and U-238 as the only contributors to the CA SOF. Nine radiological SRCs were identified in Waste Lot 4.12. However, only four (Tc-99, U-234, U-235, and U-238) contributed to the CA SOF. Uranium-236 was eliminated as a potential SRC in Waste Lot 4.12 based on process knowledge. Uranium-236 was present at extremely low concentrations in Waste Lot 65.1 (a maximum value 0.0288 pCi/g) and did not contribute to the CA SOF in that profile. All four radionuclide SRCs that contributed to the CA SOF in Waste Lot 4.12 were present at significantly higher concentrations than the same four SRCs in Waste Lot 65.1. In fact, the expected value for each of these radionuclide SRCs in Waste Lot 4.12 exceeded their corresponding maximum value in Waste Lot 65.1. Waste Lot 65.1 identified five metal SRCs (barium, chromium, lead, tin, and vanadium) with chromium, lead, and tin, along with U-238, contributing to the HI SOF. Waste Lot 4.12 also identified barium, chromium, lead, tin and vanadium as SRCs (along with 21 additional metal SRCs). The primary contributors to the HI SOF in Waste Lot 4.12 were antimony (0.07), followed by lead (0.04), tin (0.03), and then U-238 (0.02). Lead was present at a maximum value ten times higher in Waste Lot 4.12 than in Waste Lot 65.1 (733 mg/kg versus 70.8 mg/kg). Barium was present at a maximum value of over two and a half times higher in Waste Lot 4.12 than in Waste Lot 65.1 (80.4 mg/kg versus 29 mg/kg). Chromium and vanadium were present at higher levels in Waste Lot 65.1 than Waste Lot 4.12. These are considered exceptions and do not affect the conclusion that Waste Lot 4.12 data can be used to represent the small amount of residual metallic debris in this waste lot.

A final comparison was performed on the levels of polychlorinated biphenyls (PCBs) in the two waste lots although neither profile identified PCBs as SRCs. Even though PCBs are present at low levels in both waste lots and neither waste lot is TSCA-regulated, levels of PCB contamination are greater in Waste Lot 4.12. Analyses for volatile and semi-volatile organics were not performed for Waste Lot 65.1 because the waste was scrap metal. Therefore, a comparison of specific organic compounds between the waste lots could not be performed. Waste Lot 4.12 did, however, identify nine organic compounds as SRCs (although none contributed to the HI SOF for the waste lot).

Characterization of Strontium and Tin in the Waste Lot

Soil samples collected to characterize this waste lot were not analyzed for the metals strontium and tin. Historical data indicate that these metals may be present in the waste lot soils at very low concentrations. However, for the reasons cited above, historical data are not considered reliable and were not used to quantitatively characterize this waste lot. Consistent with the radioactive contaminants in the soils, the metals in the soils were directly derived from the materials of construction in the metallic debris handled by the waste storage operations in the scrap yard. To characterize these two metals in the soils in this waste lot, the EMWMF Waste Lot 65.1 profile (BJC 2004a) was reviewed. [EMWMF Waste Lot profiles 65.2 (BJC 2004b) and 65.3 (BJC 2005) characterized portions of the metallic debris in the K-770 Scrap Yard. However, because the scope of the characterization in these profiles was limited to discrete portions of the debris (aluminum and containerized waste), the Waste Lot 65.1 profile (BJC 2004a), which characterized most of the K-770 Scrap Yard debris was determined to be more representative of the metallic debris.] Samples of metallic debris in the scrap yard were analyzed for strontium and tin in the EMWMF Waste Lot 65.1 profile. Strontium was not detected. [This is also supported with results from EMWMF Waste Lot profiles 65.2 (BJC 2004b) and 65.3 (BJC 2005).] Based on these results, the Project concluded that strontium was not present in the waste lot soils. Tin was detected in the EMWMF Waste Lot 65.1 profile. Based on these results, the Project concluded that tin was present in the waste lot soils.

Tin was quantitatively characterized for this waste lot by incorporating the input values for tin in the Waste Lot 65.1 Waste Acceptance Criteria Forecasting Analysis Capability Systems (WACFACS) in the WACFACS input for this waste lot. The WACFACS input for Waste Lot 65.1 are as follows:

Number of samples: 42

Number of detects: 14

Minimum detection value: 15.5 mg/kg

Median detection value: 23.2 mg/kg

Maximum detection value: 232 mg/kg

Arithmetic mean: 37.4 mg/kg

UCL_{95} value: 120.7 mg/kg

Data distribution: PERTBeta.

Accelerated Cleanup

Bechtel Jacobs Co. LLC

ETTP D&D Project

K-726 Fact Sheet

History and Background

K-726 is a former PCB storage facility (formerly K-1088) (Area 10). It is a one-story building (approximate dimensions 75 x 35 ft) that was constructed circa 1944 with concrete/cinder block interior and exterior walls (130 yd3), steel truss-supported corrugated metal sheet roof (est. 94 yd3), and concrete floor slab (est. 282 yd3). It has a concrete floor that was added post-construction to raise the building floor elevation above the 100-year flood plain. The raised concrete floor was reported to be 3-ft-thick concrete but other indications were that fill material was placed before pouring the raised concrete floor.

The building previously contained low-level uranium contaminated materials and, following the discovery of a leaking PCB container in 1992, underwent floor decontamination efforts to reduce the contamination levels. Following several decontamination attempts, the floor was still above 10-µg/100-cm2 clean up criteria. The EPA agreed in 1996 that the building could be closed with restrictions on utilization and that the facility be added to the list of Environmental Restoration units on the Federal Facility Agreement for future D&D.

Building Hazards/Contaminants

The primary contaminants of concern are residual PCB contamination, low-level radioactive contamination, and non-friable asbestos isolated parts of the roofing materials.

Waste Management

Waste characterization has been performed and documented as part of the DQO process. Based on this information, no further characterization is required for disposition of the K-726 building demolition debris. A total of 546 yd3 of demolition debris and concrete slab was disposed at EMWMF under Waste Lot 997.1. The forecasted demolition debris volume was 506 yd3. The non-friable asbestos roofing material, 30 yd3 of the total volume, was loaded into a double lined intermodal for disposal. The building demolition debris and the concrete slab, 516 yd3 of the total volume, was loaded into a double lined dump truck for disposal as PCB remediation waste.

Description of Demolition

Portions of the roofing material with the non-friable asbestos was sprayed with an encapsulant prior to demolition. The building debris and the concrete slab was demolished, size reduced and removed using an excavator with a shear attachment and an excavator with a bucket and thumb.

End State

The remaining subsurface concrete foundation and soils are left in an as-is condition and are scheduled for remediation under a separate contract. There is no presence of chemical contamination based on visual inspections, and therefore, no environmental monitoring is required. The radiological survey of the subsurface concrete foundation is above the release limits of the DOE Order 5400.5. Radiological controls boundary has been established around the perimeter to restrict access.

Deviations from the Action Memorandum

All ARARS were met, and there were no deviations from the Action Memorandum or the Waste Handling Plan.

Land Use Controls

None are required.

K-726 Building prior to Demolition

K-726 Building during Demolition

K-726 Building during Demolition

K-726 Building after Demolition

Bechtel Jacobs

REFERENCES

BJC (Bechtel Jacobs Company LLC) 2000. *Baseline Environmental Analysis Report for the K-725 Pad, K-1093, K-1545-A, and Adjacent Areas at the East Tennessee Technology Park, Oak Ridge, Tennessee,* BJC/OR-819, Bechtel Jacobs Company LLC, Oak Ridge, TN. Draft.

BJC 2003a. *K-770 Scrap Metal Yard Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee,* BJC/OR-1296, Bechtel Jacobs Company LLC, Oak Ridge, TN.

BJC 2003b. *K-725 Beryllium Building Site Summary Document, Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee,* BJC/OR-1298/D1, Bechtel Jacobs Company LLC, Oak Ridge, TN. Draft.

BJC 2004a. *Waste Profile for: Disposal of the Scrap Metal Project Waste Lot 65.1 East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1857, Rev. 1, Bechtel Jacobs Company LLC, Oak Ridge, TN. July.

BJC 2004b. *Waste Profile for: Disposal of the Scrap Metal Project Waste Lot 65.2 East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1859, Rev. 1, Bechtel Jacobs Company LLC, Oak Ridge, TN. August.

BJC 2005. *Waste Profile for: Disposal of the Scrap Metal Project Waste Lot 65.3 East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1857, Rev. 4, Bechtel Jacobs Company LLC, Oak Ridge, TN. May.

BJC 2008a. *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment East Tennessee Technology Park, Oak Ridge, Tennessee,* BJC/OR-3088, Bechtel Jacobs Company LLC, Oak Ridge, TN.

BJC 2008b. *Waste Acceptance Criteria Attainment Team Project Execution Plan Environmental Management Waste Management Facility, Oak Ridge Reservation, Tennessee,* BJC/OR-1091, Rev. 4, Bechtel Jacobs Company LLC, Oak Ridge, TN.

DOE 2002. *Record of Decision for Interim Remedial Actions for Selected Contaminated Areas Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-1997&D2, Office of Environmental Management, Oak Ridge, TN.

DOE 2004. *Waste Handling Plan, Part II for the ETTP Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee,* DOE/OR/01-2162&D2, Office of Environmental Management, Oak Ridge, TN.

DOE 2005. *Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee,* DOE/OR/01-2263&D2, Office of Environmental Management, Oak Ridge, TN.

DOE 2006. *Waste Handling Plan, Part II for the K-770 Soils within Zone1, East Tennessee Technology Park, Oak Ridge, Tennessee,* DOE/OR/01-2148&D2, Office of Environmental Management, Oak Ridge, TN.

INEL 1993. Memorandum AMU-101-93 from A.M. Umak dated July 20, 1993. Subject: "RCRA Scrap Metal." Westinghouse Idaho Nuclear Company, Inc. Idaho Falls, ID. (Referenced in WAT Comment Response Table.)

INEL
Idaho National Engineering Laboratory

fyi

#1

AMU-101-93

From : A. M. Umak
Phone : 6-9690/MS-5108
Date : July 20, 1993
Subject : RCRA Scrap Metal

To Distribution

All types of metal when discarded are considered to be RCRA solid waste. If the material is considered to be scrap metal as defined by RCRA and is recycled, then the scrap metal is exempt from regulation. If it is not recycled, then the metal must be characterized to determine if it is hazardous or non-hazardous as defined by RCRA.

Several types of metals (see Attachment 1) present at ICPP were analyzed. Based upon data available at this time, all the metals listed in Column A, Attachment 1, with all dimensions being greater than 1/4 inch, are considered to be non-hazardous and thus are exempt from regulations. Disposal of any metal with dimensions less than or equal to 1/4 inch, such as metal filings, shavings, turnings, grindings, etc., will have to be evaluated to determine if analysis is required before disposal. This will be necessary because evidence from characterization activities at ICPP and from information obtained by EPA suggest that the RCRA hazardous constituents may be more readily leached when metals are in these forms.

Data for metals listed in Column B, Attachment 1, are inconclusive at this time. Therefore, additional analyses will be required before disposal of these types of metal can occur. These metals should continue to be handled in accordance with WINCO procedure WN-3 "Handling Unknown Materials."

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To Jim Sorall	From Alan
Co.	Co.
Dept.	Phone #
Fax #	Fax #

All other types of metals regardless of size not listed in Attachment 1 must also be characterized prior to disposal. This would include such items as cadmium plated bolts.

If you have any questions please call Chris Kant at 526-3809.

A. M. Umek
Vice President and Manager
Westinghouse Idaho Nuclear Company

JCK:mf

Attachment

ATTACHMENT 1

NON-HAZARDOUS METALS (if greater than 1/4")	INCONCLUSIVE-FURTHER ANALYSIS REQUIRED
Column A	Column B
174 PH Stainless Steel	440 C Stainless Steel
304 Stainless Steel	Carpenter 20
304 L Stainless Steel	Nitronic 60
308 L Stainless Steel	
316 Stainless Steel	
347 Stainless Steel	
Carpenter 20-[illegible]3S	
Hastelloy C-4	
Hastelloy C-22	
Hastelloy C-276	
Hastelloy X	
Monel 400	
Nitronic 50	
Titanium	

B.2. SUPPORTING REGULATORY DOCUMENTATION

DOE-05-0974

I-10033-0183

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

November 7, 2005

Certified Mail
Return Receipt Requested

4WD-FFB

Mr. David G. Adler, Project Manager
Federal Facility Agreement
Oak Ridge Remediation Management Group
Department of Energy
P.O. Box 2001
Oak Ridge, TN 37831

SUBJ: EPA Review of the Waste Handling Plan, Part 2 for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE/OR/01-2263&D2)

Dear Mr. Adler:

The Environmental Protection Agency (EPA) has completed the review of the above referenced document. The review of this document did not generate any adverse comments. Therefore, EPA is approving the document as submitted.

If you have any questions regarding this matter, please feel free to contact me at (404) 562-8551.

Sincerely,

Constance Allison Jones

Constance Allison Jones, Senior RPM
KY/TN Federal Oversight Section
Federal Facilities Branch
Waste Management Division

cc: R. Doug McCoy, TDEC
Patricia Halsey, DOE
James Kopotic, DOE
Thomas Gebhart, TDEC
✓John Lea, Bechtel Jacobs
SSAB

RECEIVED NOV 14 2005

bcc: Lawrence Neville, OEA
Reading File
Site File

C.Jones/caj:4WD-FFB-404-562-8551/11-7-2005/C:\Old C Drive\Backup\Zone1\Approval of D2 WHP Part 2

Jones_________

DOE-05-1016

I-10033-0188

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DOE OVERSIGHT DIVISION
761 EMORY VALLEY ROAD
OAK RIDGE, TENNESSEE 37830-7072

November 21, 2005

David Adler
DOE FFA Project Manager
PO Box 2001
Oak Ridge, TN 37830

Dear Mr. Adler

TDEC Approval Letter
Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee
(DOE/OR/01-2263&D2)
August 2005

The Tennessee Department of Environment and Conservation, DOE Oversight Division has reviewed the above referenced document pursuant to the Federal Facility Agreement for the Oak Ridge Reservation. Because this document effectively addresses the concerns of the Core Team, the State approves the D2 version of this Waste Handling Plan as presented.

Questions or comments concerning the contents of this letter should be directed to Erin Dixon or Thomas Gebhart at the above address or by phone at (865) 481-0995.

Sincerely

Doug McCoy, FFA Manager
Environmental Restoration Program

cc Jeff Crane, EPA
Pat Halsey, DOE
Donna Perez, DOE

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DOE-04-0758 **I-10038-0063**

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

July 23, 2004

Certified Mail
Return Receipt Requested

4WD-FFB

Mr. David G. Adler
Federal Facility Agreement Manager
Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, TN 37831

SUBJ: Correction to Approval of the Waste Handling Plan, Part II, for the East Tennessee Technology Park Scrap Removal Project, East Tennessee Technology Park , Oak Ridge, Tennessee (DOE/OR/01-2162&D2)

Dear Mr. Adler:

This letter serves to correct the approval given to the Department of Energy on June 30, 2004. The Environmental Protection Agency (EPA) incorrectly identified the approval for the K-770 Scrap Metal Yard Waste Handling Plan, Part 2. The correct reference should have been given to the Waste Handling Plan, Part II, for the East Tennessee Technology Park Scrap Removal Project. As the scrap removal project also includes scrap metal located at the K-1064 Peninsula, this also approval applies to this activity.

If you have any questions, please feel free to contact me at (404) 562-8551 or electronically at jones.constance@epa.gov.

Sincerely,

Constance Allison Jones

Constance Allison Jones, Senior RPM
KY/TN Federal Oversight Section
Federal Facilities Branch

'04 JUL 29 PM2:33

cc: R. Doug McCoy, TDEC
Patricia Halsey, DOE
James Kopotic, DOE
SSAB
LOC

AUG 10 2004

DOE-04-0640

I-10033-0054

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

June 30, 2004

Certified Mail
Return Receipt Requested

4WD-FFB

Mr. David G. Adler
Federal Facility Agreement Manager
Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, TN 37831

SUBJ: EPA Approval of the K-770 Scrap MetalYard Waste Handling Plan Part 2, East Tennessee Technology Park, Oak Ridge, Tennessee

Dear Mr. Adler:

The U.S. Environmental Protection Agency (EPA) has completed its review of the above-referenced document. All of the changes requested by EPA have been incorporated. Therefore, EPA is approving the document as submitted.

If you have any questions regarading this matter, please feel free to contact me at (404) 562-8551or electronically at jones.constance@epa.gov.

Sincerely,

Constance Allison Jones, Senior RPM
KY/TN Federasl Oversight Section
Federal Facilities Branch

cc: R.Doug McCoy, TDEC
Patricia Halsey, DOE
SSAB
LOC

JUL 9 2004

DOE-04-0606

Janie

I-10033-0052

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DOE OVERSIGHT DIVISION
761 EMORY VALLEY ROAD
OAK RIDGE, TENNESSEE 37830-7072

June 17, 2004

David Adler
DOE FFA Project Manager
PO Box 2001
Oak Ridge, TN 37830

Dear Mr. Adler

TDEC Approval Letter
Waste Handling Plan, Part II ETTP Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee, (DOE/OR/01-2162&D1)
May 2004

The Tennessee Department of Environment and Conservation, DOE Oversight Division has reviewed the above referenced document pursuant to the Federal Facility Agreement for the Oak Ridge Reservation and approves the document as presented.

Questions or comments concerning the contents of this letter should be directed to Thomas Gebhart at the above address or by phone at (865) 481-0995.

Sincerely

Doug McCoy, FFA Manager
Environmental Restoration Program

cc Jeff Crane, EPA
Pat Halsey, DOE
Donna Perez, DOE

JUN 29 2004

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DOE-06-0755

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STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DOE OVERSIGHT DIVISION
761 EMORY VALLEY ROAD
OAK RIDGE, TENNESSEE 37830-7072

September 28, 2006

Mr. David Adler
DOE FFA Project Manager
PO Box 2001
Oak Ridge, TN 37830

Dear Mr. Adler

TDEC Approval Letter
Waste Handling Plan, Part II for the
K-770 Soils within Zone 1
East Tennessee Technology Park
Oak Ridge, Tennessee
DOE/OR/01-2148&D2
August, 2006

The Tennessee Department of Environment and Conservation, DOE Oversight Division has reviewed the above referenced document pursuant to the Federal Facility Agreement for the Oak Ridge Reservation and approves the document as presented.

Questions or comments concerning the contents of this letter should be directed to Erin Dixon or Thomas Gebhart at the above address or by phone at (865) 481-0995.

Sincerely

Doug McCoy

R. Doug McCoy
FFA Project Manager

cc: Jeff Crane – EPA
Pat Halsey – DOE
Donna Perez – DOE

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DOE-06-0744 **I-10038-0288**

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

September 18, 2006

Certified Mail
Return Receipt Requested

4WD-FFB

Mr. David G. Adler, Project Manager
Federal Facilities Agreement
Oak Ridge Remediation Group
Department of Energy
P.O. Box 2001
Oak Ridge, TN 37831

SUBJ: Waste Handling Plan, Part II for the K-770 Soils Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE/OR/01-2148&D1)

Dear Mr. Adler:

The Environmental Protection Agency has completed the review of the above-referenced document which was submitted on August 22, 2006. Based on this review, the document is approved as submitted.

If you have any questions, please feel free to contact me at (404) 562-8551 or electronically at: Jones.Constance@epa.gov.

Sincerely,

Constance Allison Jones

Constance Allison Jones, Senior RPM
KY/TN Federal Oversight Section
Federal Facilities Branch
Waste Management Division

cc: R. Doug McCoy, TDEC
Patricia Halsey, DOE
James Kopotic, DOE
SSAB
LOC

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bcc: Reading File
Site File

C.Jones/caj:4WD-FFB/404-562-8551/9-18-2006/My Documents\Backup\ORR\Zone 1\K-770 Scrap and Soils\EPA Approval of Part 2 K-770 WHP.doc

Jones caj 9/18/2006

REMEDIAL ACTION CORE TEAM
January 14, 2009 Meeting Minutes
2:00 p.m.

Attendees:

Lydia Birk (by phone)
Jeff Cange, BJC-OR
Sid Garland, BJC-OR
Thomas Gebhart, TDEC (by phone)
Douglas Hanahan, BJC-OR
Constance Jones, EPA
Richard Lee, RSI
Marie Meszaros, BJC-OR
Joy Sager, DOE-ORO
Ken Skinner, Matric
Lisa Shipe, BJC-OR
Mike Travaglini, DOE-ORO

Safety Topic—back safety.

Project Status

Zone 1

- Concurrence form FCN-ETTP-Zone 1-101 will be approved by EPA.
- K-770 WAC data have a single missing VOA analysis from that specific in the approved SAP. The missing sample result is only one out of 46 collected; none of the results show exceedances and the remaining data are statistically valid for WAC attainment. The EMWMF waste profile has been prepared and will be submitted to the EMWMF WAT for their review tomorrow. Since the deviation from the SAP does not affect a remediation decision, no approval is required by EPA and TDEC. However, there was no objection to the submittal of the profile with this deviation.
- Materials are being removed from K-1093 boxes to assess their disposition pathway.
- K-1093 SAP needs to refer to EUs. Jeff Cange will revise the document and resend as an MS Word file.
- K-1085 waste is still not removed but is being worked on.
- Contractor Spoils Area risk assessment is being prepared.

Zone 2

- K-1066 G yard SAP has been sent for comment.
- EU Z2-36 Technical Memorandum draft is complete.
- K-1070-B is behind schedule in shipping and actions are being taken to remedy the situation and increase the shipping rate.
- Additional sampling in EUs 11 and 18. Work packages are being prepared. A concurrence for the additional sampling in EU 18 is being prepared
- EU Z2-33 PCCR letter will be sent from TDEC today. BJC will revise and submit a D2 version. Need to add a date when K-1006 will be decontaminated and decommissioned.

Documentation

- Concurrence Forms
  - Powerhouse Duct Bank water sampling—FCN-ETTP-Zone 1-100 was approved by the Core Team.
  - EU Z2-11 additional sample location—FCN-ETP-Zone 2-102 was approved by the Core Team.
  - Adding Zone 1 debris to Scrap Yard WHP—has been submitted for comment.
- Document Status—No change.

Special Topic

- The SAP for WAC attainment for K-1035 pipes and pits was discussed. The following was agreed to:
  - Revise concurrence form Zone 2-097 to include the sub-slab sampling text and to say it will be performed in accordance with the Zone 2 RAWP.
  - Revise the SAP for WAC attainment to eliminate sub-slab sampling text and to say it will be performed in accordance with the Zone 2 RAWP
  - Revise the response to comments from EPA.

Discussions were held on the scope of RA activities where incorporated with D&D actions. This distinction is necessary to maintain the integrity of both programs when approved documents describe the implementation of RA activities and sampling tools required.

Next Meeting

Core Team: January 28, 2009

B.3. COMMENTS AND RESPONSES FROM EMWMF WAC ATTAINMENT TEAM REVIEW

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

DOCUMENT TITLE: Environmental management Waste Management Facility Waste Lot Profile for K-770 Scrap Yard Soils, East Tennessee Technology Park, EMWMF Waste Lot 4.12	Date Issued (on document): January 2008
DOCUMENT NUMBER: **BJC-ES-2710, Draft**	
NAME OF REVIEWER: WAC Attainment Team POC: John Hampshire, o57@bechteljacobs.org	DATE COMMENTS TRANSMITTED March 2009
ORGANIZATION: BJC/EMWMF WAC Attainment Team	

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
1	General	Are samples in the CDS that are outside of planned excavation area? Provide brief discussion in the introduction of what areas are included in the planned excavation including reference to an excavation map.	No samples in the CDS are outside of the planned excavation area. Text revised to clarify planned excavation and explain what is included in the waste lot. A reference to Appendix E map showing sample locations, concrete pad locations, and planned excavation areas has been added.	Accept
2	General	What is the process for controlling the excavations? How will additional soils be verified as complying with the profile? What screening level is associated with profile compliance?	Soil will be excavated from within the areas shown on the figure in Appendix E. No additional soils outside of these area are expected. However, it is possible that DVS results may indicate that additional soils outside of the areas may require excavation. If this happens, DVS results	Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			will be compared to the profile limits to determine if these soils comply with the profile. Additional waste volumes (up to the UCL_{95} volume in the profile) can be disposed in this manner.	
3	App B/D	Has EC explicitly agreed with the use of composite samples for RCRA characteristic determination given that historic samples indicated that some soils do not meet LDR? Pg 11 of SAP states, "Results of these analyses indicated that the metal concentrations in some samples could exceed the land disposal regulations."	Yes. The statement on Page 11 of the approved SAP refers to totals data (that is, the "20 times rule") not TCLP data.	Accept
4	App B/D	Appendix D states records of operations indicated RCRA Listed waste could have been spilled, managed, or dispositioned at the former S-50 site. Did any of the areas inside the planned areas of excavation support this operation? Please identify where the affected areas are located should the excavation expand to these areas. Does the comparison to organic data referenced in this appendix indicate that a no-longer contains determination was done? What supporting evidence was found during the review of the 1994 RCRA Assessment? What supporting evidence was found from the RCRA RFI conducted at K-725? How were hot spots around K-725 that may be related to past process activities or located near vents and drains that may	No, the S-50 site is not on the site map in Appendix E. It is to the south of the map towards K-722 and not included in this action. There is no indication that any of this waste was ever used, staged, or stored at the K-770 Scrap Yard site or that it was ever in contact with the materials (waste) in this waste lot. A no longer contains determination was not performed. It is not needed. This RFI has been reviewed and no additional supporting evidence was identified. This RFI only covered the K-770 Scrap Metal. The only RCRA constituent in this RFI is mercury. The waste in this profile was characterized in accordance with the Core Team-approved SAP. Historical	Accept Accept Accept Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		have been points of releases from the building during accidental spills been addressed (see Appendix B)?	sampling and process knowledge such as this were used during the development of the SAP. Soils adjacent to the K-725 foundation slab are not planned to require remediation.	
5	General	Were the K-726 concrete samples representative of both layers of concrete, especially the "high alpha" concrete?	Yes. The top layer of concrete is only a fraction of an inch thick (a "skin coat"). This was visually confirmed by Project Waste Management and EC&P on 3/25/2009. Concrete samples extended 3" into the slab. This was confirmed with the organization that performed the sampling (K. Skinner of RSI on 4/2/2009).	Accept
6	General	What is the basis for declaring 225 ft^2 of Tc-99 hot spots? Note that the excavation plan stated 500 ft^2, which itself would still have to be justified.	These references have been removed. The Tc-99 hot spots will have been removed and the surrounding soils, confirmed to meet the profile limits (expected to be a comparison of Tc-99 concentrations in the soil to the UCL_{95} concentrations in the profile) prior to the waste in this waste lot being generated. Text explaining this is in Appendix A. Appendix A also includes potential indicators of this waste being anomalous to this EMWMF waste lot such as it being placed in containers (expected to be ST-90s), marked, and controlled (per BJC-WM-2001).	Accept
7	General	If you want to use FIDLER to guide Tc-99 areas, you need formal correlation between U and Tc-99.	Tc-99 analysis on intrusive samples will be used for confirmation that the Tc-99 hot spots have been completely removed.	Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			See response to above comment.	
8	General	Why was there significant Cs-137 near the K-726 building?	There is no specific process knowledge to explain the presence of cesium in/near the former K-726 Building. Recent characterization does not confirm significant Cs-137 near K-726. *K-770 Scrap Metal Yard Site Summary Document (*BJC 2003a in profile) shows the highest Cs-137 concentrations in soil (18.9, 32.4, 53.3, and 193 pCi/g) about 200 feet southwest of the K-726 foundation. Samples collected 100 feet SW of K-726 show Cs-137 levels between 2 and 3 pCi/g. The 2004-2005 DVS site characterization effort included a broad suite of radionuclides and eliminated all fission products as COCs except Cs-137. Cs-137 results in the soil characterization data for this profile indicates Cs-137 is evenly distributed over the entire site at very low concentrations (<.75 pCi/g) with the exception of three samples (2.05, 3.48, and 28.6 pCi/g). None of these samples is within 150 feet of the K-726 pad and the two concrete samples of the remaining portions of the pad did not detect Cs-137. The soil location with the highest Cs-137 levels is very close to the location where one of the Cs-137 casks was located during the previous Scrap Removal Project. The sample location with the 3.48 pCi/g corresponds to the area showing the highest concentrations	Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			in BJC 2003a. A map showing waste lot characterization concentrations of Cs-137 in soil across the site is attached to this comment response table.	
9	General	Need to acknowledge that Cs-137 sources were found during scrap metal removal; do the areas of excavation in this waste lot include the soils associated with that portion of the site?	Text has been added to Appendices A and B. See responses to Comments 38, 41, and 42.	Accept
10	General	Does the BJC SOP still define beryllium waste as >1000 ppm?	Yes.	Accept
11	Title	Revise…Soils and <u>Miscellaneous Debris</u>"	Title revised.	Accept
12	Sec. 1	1st par. Add to contaminated soil, <u>concrete, and incidental metal and debris.</u>	Text added.	Accept
13	Sec. 1	3rd par. Address concrete pads in this paragraph and refer to a map that shows these pads within the area of excavation. Need to explain why these pads are included…because they are in the way?	Concrete pads are addressed in the 4th paragraph. Text has been revised to clarify which pads will be removed as a part of the removal action and clarify that some of the other pads will need to be removed to facilitate the action and regrading of the site. A reference to the map in Appendix E has also been added to Section 1.	Accept
14	Sec. 1	General – a brief paragraph describing the removal action would be beneficial with reference to B.3 for more details. For example, within the excavation bounds found in Map X, shallow soils will be removed to a depth of 1-foot…etc. Need to refer to map that shows limits of excavation. General – a table in this section that identifies the volume of soil, concrete, residual material, and wood/incidental waste is	A reference to the map has been added. Work description in Section B.3 has been removed. There is no requirement in the PEP for this table. The approximate volumes are	Accept Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		required.	contained in the text in this section and Section 3.	
		What is the technical basis for the 7,000 CY in this waste lot?	The volume has been revised based on excavating the areas shown on the map in Appendix E to an assumed depth of 1 foot (consistent with the soil sampling interval) and removing the K-725, K-726, K-770 Scrap Removal Support pad and the two small, unnamed concrete pads. Statement added to Section 1.The predicted waste volume is 17,500 yd^3 (including approximately 1,300 yd^3 of concrete).	Accept
		What verification data will be generated and how will verification data be used should additional material (both vertical and horizontal) be included in this waste lot?	Any verification will be performed in accordance with the regulator-approved RAWP for Zone 1 DVS (also see response to Comment 2).	Accept
15	Sec. 1	4th par. Paragraph needs to state that remaining metallic debris is included in this waste lot based on the review that the underlying soils data bounds the radiological and chemical characteristics found in scrap metal presented in WL 65.1. Provide a summary comparison of SRCs to demonstrate soils bound the debris.	The requested information concerning the metallic debris is included in Section 3 and the detailed comparison is in Appendix B. (This comparison is referenced in Section 3.)	Accept
16	Sec. 2	Break up paragraph to show what waste each WHPs is covering. Please provide evidence (e.g., excerpts from WHPs) that all pads are covered. Does any communication between the Core Team and the project exist about what waste is to be included under WL 4.12?	The paragraph clearly explains what part of the waste lot is included in each WHP. The intent of this section is to demonstrate that the waste lot will be generated by a CERCLA action. Language in the ROD indicates that all	Accept Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			wastes in the waste lot (including concrete pads) are part of the remediation. Applicable portions of the ROD have been added to Appendix J.	
17	Sec. 2.2	Are you trying to state that all TRU constituents were eliminated with PK, historical data, and non-detects for Np-237?	Yes. Data collected for W.L. 65.1 supplemented by Np-237 elimination due to < 20% j-flagged results was used as the basis for TRU isotope elimination.	Accept
18	Section 2.3	Remove "control measure" since WPS visual inspections are requirements per BJC-WM-2001. Delete last sentence that is redundant. Note: This discussion can be cleaned up to state Yes or No to the WAC requirement and why.	Annotated outline in PEP requires plans to confirm compliance with WAC be summarized.	Accept
19	Section 2.4	What is meant by adding "material size"? The RCRA assessment and removal activities that took place in 1994 should be added either here or in Appendix D.	Term removed. It is assumed that small pieces of metallic debris were included in the soil samples (and therefore characterized with the soil) The larger pieces of metallic debris would not be a hazardous concern based on the results of the INEL study that concluded that pieces of metal larger than 1/4" by 1/4" would not leach in amounts that would result in them being a hazardous waste. The INEL memorandum documenting the results of the study (INEL 1993) has been added to Appendix B. This 1994 RFI assessment covered only the scrap metal on this site. Also see response to Comment 4.	Accept Accept
20	Sec.	Provide brief discussion as to what waste matrices (soil, metal,	There were 42 Total VOAs samples	Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
	2.4.4	scrap, concrete) were sampled as required by SAP. It would be helpful to explain why there N=30 (VOC) and N=43 (metals & SVOCs). Is does not appear that concrete metal sample results were included in this summary or N=57. Explain why.	collected from soils, 43 Total SVOA/ TCLP SVOA samples collected from soils, and 43 Total Metal/TCLP Metal samples from soils. In addition, there were 14 Total Metal samples only collected from concrete. None of the metal concentrations in concrete exceeded 20 times the TCLP limit; therefore, collection of TCLP Metal samples from concrete is not warranted. Therefore, the maximum N = 43 for TCLP Metals and TCLP SVOAs. Tables in Appendix E show what medium was sampled.	
21	Sec. 2.5	PK suggests that PCBs from sources greater than 50 ppm were stored at the site including liquids staged for incineration. This section needs to discuss that the "as-found" concentration as characterized by the approved SAP is below 50 ppm; therefore, may be considered as non-regulated PCBs. Discuss that both soils and concrete were characterized for PCBs (N=57).	CERCLA ARARs do not require consideration of the source concentrations when making this determination. Both soils and concrete were characterized for PCBs.	Agree, which is why the clarification text was requested. The inclusion of these responses to comments in the profile is sufficient to accept this response.
22	Sec. 2.11	Revise "the waste will not contain significant void space when disposed at EMWMF."	Text revised.	Accept
23	Sec. 2.12	2nd sentence. Add "This waste lot does not include containerized waste; therefore, this requirement is not applicable.	Text revised.	Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
24	Sec. 2.13	Change Table 7 reference to Table 6? Table 6 – why do some SVOCs have only 42 samples?	Reference to Table 6 changed. Table corrected- all SVOCs have 43 samples.	Accept Accept
25	Sec. 3	2nd par. The Core Team Meeting Minutes in Appendix B were not found.	Minutes have been added.	Accept
26	Sec. 3	2nd par., last sentence. The decision to not characterize the residual metallic debris in this waste lot was included in the SAP (see Page 6), so why do you state this decision was made after characterization?	The decision to *include* the metal debris in this waste lot was made after characterization. Prior to that decision, the Project was planning to dispose of that waste under the approved scrap metal profile (Waste Lot 65.1). A justification for including the metal debris in this profile without characterizing it was then required. The Project justified the inclusion by comparing the profile limits for the scrap metal in the Waste Lot 65.1 with the limits for the soil in this profile to demonstrate that the metal was not as contaminated as the soil and therefore, the soil could act as an upper-bound proxy for the metal. This comparison is in Appendix B.	Accept
27	Sec. 3	The introductory material is confusing. If the intent is to discuss the relationship between historical data and current data, describe in a tabular format (1) when and where this historical data was collected relative to the current sampling location, (2) what the results of the historical data are (min, median, max, PDF, E(X), and UCL-95, and (3) why the data were or were not used as part of the DQA. If the intent is to summarize the sampling and the data collected, a table can summarize this	Historical data were only used in the development of the SAP and were not used for quantitative characterization of this waste lot. The characterization was performed in accordance with the Core Team-approved SAP. Revisions to this section were made to clarify	Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		information. Revise paragraph to explain the 32 random and 13 biased composite samples and refer to SAP with map. Also discuss why the total equals 59 samples when summed but 2 of them were removed due to hot spots therefore the total N=57.	Section 3 explains why the results for 42 VOA samples (31random samples plus 13 biased samples minus the 2 anomalousTc-99 samples equals 42), 43 SVOA (32 random plus 13 biased minus 2 Tc-99 equals 43), and 57 radiological and Total Metals (43 random plus biased samples plus 14 concrete samples equal 57) samples are presented in Table 6, and details the two sample locations removed due to elevated Tc-99 pCi/g results. This is also included in Appendix E and Appendix G. No additional delineation is required.	Accept
		Explain the 5-point composite scheme that was followed, including how VOCs were collected. Provide the reference in the SAP that defines the systematic random sample and how they were collected?	Section 4.8 of the SAP contains this information. The options for obtaining concrete samples are contained in Section 4.9 of the SAP.	Accept
		The SAP was not specific on the radioisotopes or chemicals that are considered as potential SRCs. Is this presented somewhere in the SAP or profile?	Section 4.7 of the SAP refers to the Zone 1 Quality Assurance Project Plan. That plan specifies the analytical information. The ETTP Site Zone 1 Lab SOW specifies the analytical methods to be performed and the analytes that will be included in the analyses. The lab work has been audited by EPA. The Lab SOW has been added to Appendix E.	Accept
28	Sec. 3	Page 13. It appears that PK does not preclude presence of fission products…is this sentence valid?	Sentence revised.	Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
29	Sec 3.1 and 3.2	The UCL-95 for each SOF incorrect. It is not the sum of the UCL-95 for each SRC as calculated in App G on page 2 of 2 of the spreadsheet "WL 4.12 K-770 Scrap Yard Soils EMWMF SRC Summary Statistics."	This section will be updated when results of WACFACS are received.	Accept
30	Sec. 4	Table 7– K-40 value should be 14.45 based on data set. Also, correct the statement in the last sentence of the 1st paragraph; it should be <0.05, not >0.5, to signal insignificant ASA SOFs.	Corrected in Table 7 as 1.44E+01. Corrected.	Accept Accept
31	Sec 5.2 and 5.3	Correct reference to be DOE 2001 instead of BJC 2007.	BJC 2007, *Technical Information for Delivery of Waste to the Environmental Management Waste Management Facility* is the correct reference for the citations in these sections.	Accept
32	Sec. 5.7	Is any ACM present of the surface currently? 2nd par. Revise…"No beryllium-dust containing waste is present. Based on sampling and analysis data in accordance with approved SAP, this waste lot contains a maximum Be concentration of < 2 ppm…"	None has been observed. Section 3 stated that sampling and analysis was in accordance with the SAP. The <2 ppm maximum value was confirmed to be correct.	Accept Accept
33	Sec. 5.9	Supersacks may be used for ACM in accordance with approved blanket variances.	This is true and that packaging option is available because the Project has included the appropriate blanket variance in Section 5.7	Accept
34	Sec. 5.10	Need to add PWAC variance that addresses rebar in final waste profile.	Variance added.	Accept
35	Sec. 5.11	Revise…"Noncrushable containers will not be used therefore	Text revised.	Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

OAK RIDGE PROGRAM DIVISION DOCUMENT REVIEW FORM

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		this requirement is not applicable.		
36	App A	How are high Tc-99 areas delineated in the field? Appendix B states that the high Tc-99 areas are 500 ft2...which is correct? Upon what is the size of these areas based?	See responses to Comments 6 and 7. See responses to Comments 6 and 7.	Accept
37	App A	Intro – states that anomalies are likely to be debris items. What screening basis will be used to identify anomalous debris? Suggest referring to the data comparison that indicated that the debris concentrations were less than the soils, and it is the soils that have the high Tc-99 results.	None, potentially anomalous debris items will be primarily identified visually. Although ADP states that instrument readings from RadCon could be used to identify potentially anomalous items. See responses to Comments 6 and 7.	Accept Accept
38	App A	The ADP needs to tackle head-on the problems encountered in the one area of the site that yielded the smoking pipes and the Cs-137 sources. Mark that area on the excavation maps, and explain that no excavation in this area is expected.	Cs-137 casks were not encountered in one specific area that is outside of the Scrap Yard. Therefore, these casks have been identified as potential anomalies that could be encountered during waste generation activities. These casks have been described (shape, approximate dimensions, approximate weight, etc.) and pictures have been included in this appendix.	Accept
39	App A	Responsibilities – Do WPS provide direction? Where does the AHERA inspector/CIH fit into R/R?	No, the WPSs do not provide direction. Text revised. The job description/work instructions specifies the roles and responsibilities of the AHERA inspector with regard to identifying ACM (before and during	Accept Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			demolition). It specifies when and where CIH requirements apply. It then specifies, during every phase of demolition, that inspections for anomalous waste will be conducted or waste will be observed for potentially anomalous waste.	
40	App A	Risk Scoring Checklist – what radiological screening will be conducted on debris items and soils? Also, since there is confirmation of anomalous items being present (the text of the likelihood checklist item), the score should be 9. On the other hand, the profile indicates that the other three items (difficulty and impacts) are not a problem at all, so perhaps these should be scored as "1"?	No radiological screening for anomalous waste is planned. See response to Comment 37. This checklist has been revised to address this comment and reflect the potential impacts of an undetected Cs-137 cask.	Accept
41	App A	Anomaly detection checklist: • How will WPS be able to identify process equipment?	Any potential process piping and equipment will be preliminarily identified visually. All Project WPSs have experience demolishing buildings that contain(ed) process equipment.	Accept
		• Introduce Cs-137 casks in Anomaly Detection Plan.	See response to Comment 38. They have been included as a separate line-item that references photos.	Accept
		• Add metal shavings and/or turnings as anomalous waste items (experience gained from David Whiterspoon Site).	Added.	Accept
		• Areas associated with S-50 TDP past operations (listed waste).	These areas are outside of the Scrap Yard (not even on the map showing the area to be remediated).	Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		• How will Tc-99 areas be marked/controlled? • What does "high-mass/high-enriched" materials mean? Do you mean high-activity?	See response to Comments 6 and 7. Yes, text revised per comment.	Accept Accept
42	App B	Address the difference between the area that yielded the Cs-137 sources and the rest of the site.	There is no difference. See response to Comment 38.	Accept
43	App B	(bullet list) Define "Class 004" material.	This section contains a reference that contains the detail for the wastes contained on this list (including Class 004 material). Additionally, this term is defined ("too large to shear") on Page 11 of the SAP and in the "Site History" section in Appendix B.	Accept
44	App B	Site History – how have areas that were characterized by DVS that may fail LDRs been addressed?	See response to Comment 3. The waste in this waste lot was characterized in accordance with the approved SAP in Appendix E. As explained in Section 3 and Appendix B, all other historical data and information was used only to support that characterization in a qualitative manner.	Accept
45	App B	K-725 Site History – Define "NEPFA" PK states that a second concrete pad was placed over the original floor. Was the original pad sampled? What were the radionuclides that were found?	Nuclear Energy Propulsion for Aircraft added. See response to Comment 5. Text revised to include "skin coat" and clarify. Based on that response, the original pad was sampled (eight samples of the K-725 pad were collected) and analyzed for radionuclides. The results are in the	Accept Accept

REVIEWED BY: EMWMF WAC Attainment Team	RESPONSE BY: J.M. Davenport

COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			Controlled Dataset.	
		Where were degreasing operations performed? The discussion in Appendix D was not found in Appendix B.	Appendix D states that degreasing operations were not performed in K-725. Appendix B does not normally describe what did not occur in the facilities is describes.	Accept
		Last par. Was the area between K-725 and RR tracks sampled since these areas are suspected to contain high levels of Be powders, chips, and radiological contamination? Could this area be potentially included in this waste lot?	Yes, two samples were collected between the K-725 pad and the railroad tracks. The maximum level of beryllium for these areas (from historic data) is less than one-half the value used by BJC to define beryllium waste. A portion of this area is included in the waste lot (it was sampled).	Accept
		Where is PK on K-725-B?	Pad K-736 was erroneously labeled K-725-B. The map has been revised. There is no K-725-B pad.	Accept
		What about miscellaneous concrete pads that were sampled? Is there any PK on these pads (e.g., size, past operations, etc.) Are these pads marked in the excavation map?	K-726 and one of the small unnamed pads were sampled. With one exception (the pad that supported the K-770 Scrap Removal Project's sort and segregation operation, there is no process knowledge on any of the small, unnamed pads). Project Waste Management and EC&P visually inspected these pads on 4/2/2009 to confirm that there were no EC&P concerns with their inclusion in this waste lot.	Accept
46	App B	Why is a statement made that K-726 slab could be incorrectly concluded as being included in this waste lot?	Concerns with the K-726 slab were raised by Project EC&P, but stated that the slab had been removed during a previous	Accept

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			demolition. The Project visually confirmed that the slab had been removed. Process knowledge did not clearly state this (and this could be misinterpreted). The remaining subsurface "footers" from beneath the slab are in this waste lot.	
47	App B	Building K-770 Site Summary – How were the areas containing > 10,000 pCi/g U-238 addressed in characterization?	Information such as this was considered when the SAP was prepared (and approved by the Core Team).	Accept
48	App B	Are the areas with high Be areas along the SW side of the building slab included in this profile?	See response to the fourth comment in Comment 45.	Accept
49	App B	Residual Misc. Metal – Has a comparison table been developed that shows how WL 4.14 bounds metal from WL 65.1? Since the SAP lists WL 65.2 and WL 65.3, explain why these were not included in the analysis. How does historical data in table with no non-detects support the elimination of strontium and tin?	No, the comparison is detailed in the text. The W.L. 65.2 and 65.3 profiles applied to much smaller (volumetrically) waste lots, segregated materials such as aluminum and waste staged at the site in B-25 containers. It was assumed that W.L. 65.1 was the most representative of the scrap metal at the site. The summary statements at the bottom of the table conclude that historical detections are at levels that do not come close to challenging the EMWMF WAC.	Accept Accept
	App B.3	Page 5, 3rd par. How will newly identified areas found after metal removal address profile conformance? What screening is proposed and how will these data be used to verify removed waste meets profile? General (Figure 3) – what is the screening level criteria used in	This section has been removed from the profile.	Accept

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		the surveys to identify soil contamination (hot spots)? General (Figure 5) – what is excavation criteria? Was this criteria used to eliminate the 225 sq ft of soil around the two Tc-99 samples of 2710 pCi/g and 40,600 pCi/g? Page 7 – How will verification data be used to ensure 100% removal of hot spots from this waste lot? Verification samples need to be compared to profile limits. Page 10 – Are K-725-A and K-726 slabs in or out of this waste lot?		
50	App C	Referring to concrete samples provided in the Controlled Data Set, explain in Appendix G how these samples could have a sample depth of 0 ft to 3 ft which is different from Table E,3 in Appendix E and also different from Table A.1 in the SAP. Why are some XY locations labeled as 1 or 2, respectively	Sample depth in March 2009 version of CDS has been revised to be 0 – 0.25 feet in depth since 3-inch concrete cores were collected. Sample Location IDs in CDS, Table E.3 of Appendix E, and Statistical Summaries in Appendix G have been revised to be consistent with those in the SAP.	Accept Accept
51	App E	Table E.3 – Concrete sample Ids do not match SAP. Concrete sample intervals are not identified in SAP, but they are identified in the Controlled Data Set. Was sample compositing methods assessed by the project? Was there any project or QA oversight during the sampling to verify that composite samples were collected properly? How were VOC samples collected?	Sample Location IDs in CDS, Table E.3 of Appendix E, and Statistical Summaries in Appendix G have been revised to be consistent with those in the SAP. RSI prepared the SAP and RSI performed the sampling SAP (there was project oversight during sampling). Section 4.9 contains this information.	Accept Accept Accept

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
		What is meant by "extraneous…results were rejected due to varying dilution factors?" The SAP does not identify analysis methods. How were these identified and communicated to the laboratory?	The term "extraneous" refers to several reported analytical values for the same sample that were due to differing dilutions based on sample medium. These extra results were assigned a "N" Data Usage flag by the SMO and were not included in the CDS or any statistical summaries. The labs that performed these analyses had been working on this project for several years and had the analysis methods, detection limits, etc. RSI also performed 100% verification and validation on the results of the analyses.	Accept Accept
52	App F	Step 4 – was data subject to 10% or 100% data validation?	100% of the data were validated (verified with RSI). Text revised to clarify.	Accept
53	App G	Provide a table that identifies the manner in which proxy values were applied for the combined validation and laboratory flags; e.g., a Val Q = UJ and Lab Val = J indicates a Proxy value is not required for the result assuming no transformation of units is required. What is the spatial distribution of Tc-99 (X,Y) and how will this be used to determine excavation screening criteria?	Appendix E provides the rationale for selection and transformation of data used in Appendix G. This information is in that appendix. No additional tables are required. See responses to Comments 6 and 7.	Accept Accept
54	App G	The ProUCL runs need to be adjusted for a 10% significance level. NOTE: it is <u>not</u> necessary to re-run all tests; only the ones that concluded that a normal or lognormal distribution was acceptable.	All SRCs have been subjected to 10% signficance testing using Pro-UCL. The U-234, U-235, and U-238 and Total Lead populations remained lognormal even at the 10% significance level due to the homodasticity of the data. Changes were made to Total Aluminum (from normal to	Accept

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COMMENT NO.	SECT/ PAGE	COMMENT	RESPONSE	ACCEPT/REJECT
			Pert-Beta); to Total Arsenic (from normal to lognormal); to Total Mercury (from Pert-Beta to Lognormal); and to Total Sodium (from Pert-Beta to Lognormal). None of these changes involved Analytical WAC or Administrative WAC. UCL95 values for Total Aluminum, Total Arsenic, and Total mercury were adjusted in Table 8 for ASA chemical consideration only.	

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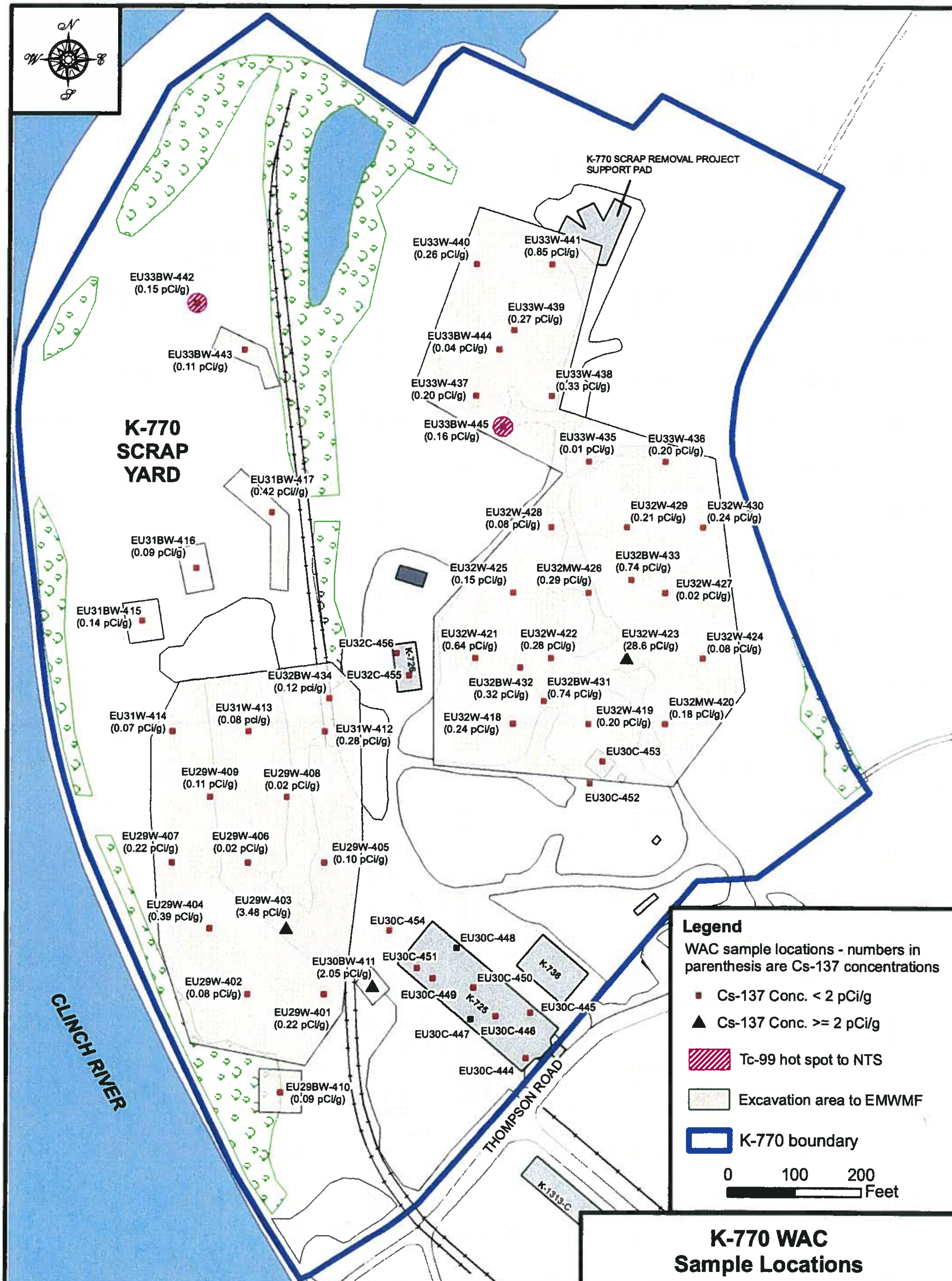
N
W
E
S
K-770 SCRAP REMOVAL PROJECT SUPPORT PAD
EU33W-440 (0.26 pCi/g)
EU33W-441 (0.85 pCi/g)
EU33BW-442 (0.15 pCi/g)
EU33W-439 (0.27 pCi/g)
EU33BW-444 (0.04 pCi/g)
EU33BW-443 (0.11 pCi/g)
EU33W-437 (0.20 pCi/g)
EU33W-438 (0.33 pCi/g)
K-770 SCRAP YARD
EU33BW-445 (0.16 pCi/g)
EU33W-435 (0.01 pCi/g)
EU33W-436 (0.20 pCi/g)
EU31BW-417 (0.42 pCi/g)
EU32W-428 (0.08 pCi/g)
EU32W-429 (0.21 pCi/g)
EU32W-430 (0.24 pCi/g)
EU31BW-416 (0.09 pCi/g)
EU32BW-433 (0.74 pCi/g)
EU32W-425 (0.15 pCi/g)
EU32MW-426 (0.29 pCi/g)
EU32W-427 (0.02 pCi/g)
EU31BW-415 (0.14 pCi/g)
EU32W-421 (0.64 pCi/g)
EU32W-422 (0.28 pCi/g)
EU32W-423 (28.6 pCi/g)
EU32W-424 (0.08 pCi/g)
EU32C-456
EU32C-455
EU32BW-434 (0.12 pci/g)
EU32BW-432 (0.32 pCi/g)
EU32BW-431 (0.74 pCi/g)
EU32MW-420 (0.18 pCi/g)
EU31W-414 (0.07 pCi/g)
EU31W-413 (0.08 pci/g)
EU31W-412 (0.28 pCi/g)
EU32W-418 (0.24 pCi/g)
EU32W-419 (0.20 pCi/g)
EU30C-453
EU29W-409 (0.11 pCi/g)
EU29W-408 (0.02 pCi/g)
EU30C-452
EU29W-407 (0.22 pCi/g)
EU29W-406 (0.02 pCi/g)
EU29W-405 (0.10 pCi/g)
EU29W-404 (0.39 pCi/g)
EU29W-403 (3.48 pCi/g)
EU30C-454
EU30C-448
EU30BW-411 (2.05 pCi/g)
EU30C-451
EU30C-450
K-736
EU29W-402 (0.08 pCi/g)
EU30C-449
K-725
EU30C-445
EU29W-401 (0.22 pCi/g)
EU30C-447
EU30C-446
EU30C-444
EU29BW-410 (0.09 pCi/g)
CLINCH RIVER
THOMPSON ROAD
K-1313-C
Legend
WAC sample locations - numbers in parenthesis are Cs-137 concentrations
Cs-137 Conc. < 2 pCi/g
Cs-137 Conc. >= 2 pCi/g
Tc-99 hot spot to NTS
Excavation area to EMWMF
K-770 boundary
0
100
200
Feet
K-770 WAC
Sample Locations

APPENDIX C
WASTE LOT 4.12 CONTROLLED DATA SET

Davenport, John M (MDN)

From: Redus, Kenneth S (3KR)
ent: Tuesday, April 14, 2009 10:11 AM
o: Davenport, John M (MDN); Hampshire, G John (O57)
Cc: Hanahan, Douglas W. (HGG); Hopper Jr, James Guy (HPZ)
Subject: RE: K-770 Scrap Yard Soils and Misc Debris

Received and acknowledged

From: Davenport, John M (MDN)
Sent: Monday, April 13, 2009 5:01 PM
To: Redus, Kenneth S (3KR); Hampshire, G John (O57)
Cc: Hanahan, Douglas W. (HGG)
Subject: K-770 Scrap Yard Soils and Misc Debris

Attached are the controlled data set and WACFACS input for the subject profile.
Thank you
Marshall

<< File: WL 4 12_Controlled Data Set (Final 032909).xls >> << File: WL 4 12_Appendix H_WACFACS Input Sheet (041309 Revision).xls >>

APPENDIX D
ENVIRONMENTAL COMPLIANCE ASSESSMENT

APPENDIX D: ENVIRONMENTAL COMPLIANCE ASSESSMENT FOR K-770 SCRAP YARD

Waste Acceptance Criteria Attainment Team Project Execution Plan (BJC/OR-1091-R3) states that project environmental personnel should be consulted for RCRA and TSCA compliance determinations, and calculations that are performed to support regulatory compliance shall be reviewed and approved by project environmental compliance staff. The purpose of this assessment is to provide clear and succinct documentation that all aspects of the RCRA and TSCA compliance for the waste from the remedial action performed at the K-770 Scrap Yard (including the removal of the K-725, K-726, and other small concrete foundations) was reviewed by the Environmental Compliance and Protection (EC&P) organization and the EC&P organization concurs with these determinations. It also provides documentation that the EC&P organization has reviewed the process knowledge used to characterize the waste in this waste lot, concurs that it is accurate, and no significant gaps exist.

Excluded from EMWMF Disposal

Two distinct soil areas within the K-770 Scrap Yard have been identified as anomalous waste due to elevated Tc-99 pCi/g concentrations (see Appendix A). Soils in these areas are excluded from this EMWMF waste lot. These soils are expected to be excavated, packaged in ST-90s, segregated, and managed in accordance with BJC-WM-2001 prior to waste in this waste lot being generated. This anomalous waste is expected to be included in off-site commercial or DOE waste profiles for disposal.

The S-50 Site (which is not in the K-770 Scrap Yard area) will not be remediated during this action.

RCRA Characteristic Waste Compliance

The RCRA waste characteristic determination was documented in Sections 2.4 through 2.4.4 of this profile. A review of the information in this section indicates that this waste lot was determined to not be hazardous waste based up a review of the criteria for ignitability, corrosivity, reactivity, and toxicity in accordance with 40 CFR 261.21-261.24 requirements.

The toxicity characteristic TCLP sampling results for the controlled data set are documented in Table 1 of Section 2.4.4. The results of this data set indicate that all parameters for waste lot soils are less than levels that would trigger hazardous waste determinations.

The EC&P organization has reviewed the hazardous waste determination in Sections 2.4 through 2.4.4 of this profile and concurs that this waste lot is not a hazardous waste stream.

RCRA Listed Waste Compliance

The RCRA listed waste determination was documented in Section 2.4.5 of this profile. A review of the information in this section indicates that this waste lot was determined to not be a listed hazardous waste.

The Project EC&P representative conducted a due diligence RCRA listed waste review for the K-770 Soils and concrete in 2008. A review of this listed waste determination indicates that records of operations indicated RCRA listed wastes could have been spilled, managed, or dispositioned at the former S-50 Liquid Media Thermal Diffusion Plant (LMTDP). This plant was located to the south of the K-770 area near where soils will be removed for this profile. Operating records indicate the columns and lines were degreased with tetrachloroethylene or carbon tetrachloride. An operations manual for the facility states that solvents were drained and captured in a drain tank at the F-01 building but no disposal records for the organic solvents were located during this listed waste review. Organic data for the soils show no contamination for listed constituents and therefore are deemed to not be a RCRA listed waste for this waste lot.

Records on Building K-725 state that "degreasing was not performed in the F-10 Machine Shop," therefore, there are no associated RCRA listed uses identified in the building.

The K-726 Concrete and the asphalt K-736 pad were deemed to not be RCRA listed waste since no additional records or information are available that would indicate listed wastes were spilled, managed, or dispositioned associated with the concrete and pad.

The due diligence good faith review questions that were asked of the project team and the consensus responses provided for the Waste Lot 4.12 are noted in the following discussion.

- Are you aware of any RCRA listed wastes located in the subject waste streams?
  - No

- Are there operational waste disposal records (manifests, vouchers, bills of lading, waste storage records) or investigation reports that provide specific information on the industry processes that generated the waste in Waste Lot 4.12?
  - No

- Are there operational records or investigation reports for the K-770 Scrap Yard where the waste stream is being excavated that provide information on spills or releases of listed hazardous waste?
  - No

- Are there project records that indicate a specific industrial operation with the potential to generate RCRA listed hazardous waste was ever located on this site (i.e. F code degreasing operations, plating shop treatment sludge, P and U waste discarded commercial chemicals)?
  - Yes – see explanation above.

- Does the chemical analysis provide any definitive waste fingerprint that would provide strong evidence on the waste generation processes that were the likely sources of the waste stream?
  - No

Based upon the historical listed waste due diligence reviews for the soil and concrete area addressed in this profile, the EC&P organization concurs with the waste determination documented in Section 2.4.5 that this is not a listed RCRA hazardous waste stream.

TSCA PCB Compliance

The TSCA PCB waste characteristic determination was documented in Section 2.5 of this profile. A review of the information in this section indicates that this waste lot was not determined to be Bulk PCB remediation waste in accordance with 40 CFR 761.61 requirements. The PCB sampling results for the controlled data set are documented in Table 2 of Section 2.5

The EC&P organization has reviewed the TSCA PCB waste determination in Section 2.5 this profile, and concurs that Waste Lot 4.12 is not being characterized and managed as a Bulk PCB remediation waste stream.

Asbestos NESHAP Compliance

The National Emission Standard for Hazardous Air Pollutants (NESHAP) for asbestos waste determination was documented in Section 5.7 of this profile. A review of the information in this section indicates that this waste lot was determined to not be an asbestos waste stream in accordance with 40 CFR 61 requirements.

If any asbestos suspect material is discovered, a project asbestos inspector (who has the commensurate training) would conduct an evaluation to determine if the waste contains asbestos material and the waste would be handled appropriately.

The waste included in this waste lot does not include any transite or any suspect asbestos material and does not include material that would potentially be characterized as friable or non-friable asbestos containing material. The Anomaly Detection Plan includes criteria to review and identify any asbestos waste that might be uncovered during the waste loading steps. In the event asbestos waste is discovered during the waste loading steps, the asbestos waste would be segregated and disposed in accordance with asbestos packaging and waste transport regulations per the EMWMF Physical WAC guidelines.

The EC&P organization has reviewed the asbestos waste determination in Section 5.7 and concurs that this waste lot is not an asbestos waste stream.

BECHTEL JACOBS
Bechtel Jacobs Company LLC

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Statistical Summary for Th-232 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	1.36		=	0.12	1.36	0.3074847
Z1-EU29W-401	S	REG	0.36		=	0.13	0.36	-1.021651248
Z1-EU29W-402	S	REG	1.4		=	0.17	1.4	0.336472237
Z1-EU29W-403	S	REG	1.27		=	0.08	1.27	0.2390169
Z1-EU29W-404	S	REG	1.19		=	0.09	1.19	0.173953307
Z1-EU29W-405 + Dup	S	FR	3.33		J	0.05	3.33	1.202972304
Z1-EU29W-406	S	REG	1.57		=	0.04	1.57	0.451075619
Z1-EU29W-407	S	REG	1.6		=	0.19	1.6	0.470003629
Z1-EU29W-408	S	REG	1.7		=	0.12	1.7	0.530628251
Z1-EU29W-409	S	REG	1.2		=	0.11	1.2	0.182321557
Z1-EU30BW-411	B	REG	0.87		=	0.11	0.87	-0.139262067
Z1-EU30C-444	C	REG	0.42		=	0.12	0.42	-0.867500568
Z1-EU30C-445	C	REG	0.2		=	0.06	0.2	-1.609437912
Z1-EU30C-446	C	REG	0.3		=	0.11	0.3	-1.203972804
Z1-EU30C-447	C	REG	0.49		=	0.07	0.49	-0.713349888
Z1-EU30C-448 + Dup	C	REG	0.4		=	0.06	0.4	-0.916290732
Z1-EU30C-449	C	REG	0.39		=	0.08	0.39	-0.94160854
Z1-EU30C-450	C	REG	0.29		=	0.06	0.29	-1.237874356
Z1-EU30C-451	C	REG	0.3		=	0.07	0.3	-1.203972804
Z1-EU30C-452	C	REG	0.65		=	0.1	0.65	-0.430782916
Z1-EU30C-453	C	REG	0.33		=	0.11	0.33	-1.108662625
Z1-EU30C-454	C	REG	0.35		=	0.09	0.35	-1.049822124
Z1-EU31BW-415	B	REG	1.15		=	0.11	1.15	0.139761942
Z1-EU31BW-416	B	REG	1.16		=	0.06	1.16	0.148420005
Z1-EU31BW-417	B	REG	1.23		=	0.09	1.23	0.207014169
Z1-EU31W-412	S	REG	0.97		=	0.07	0.97	-0.030459207
Z1-EU31W-413	S	REG	0.53		=	0.1	0.53	-0.634878272
Z1-EU31W-414	S	REG	1.77		=	0.11	1.77	0.570979547
Z1-EU32BW-431	B	REG	0.78		=	0.08	0.78	-0.248461359
Z1-EU32BW-432	B	REG	0.57		=	0.09	0.57	-0.562118918
Z1-EU32BW-433 + Dup	B	FR	2.39		=	0.21	2.39	0.871293366
Z1-EU32BW-434	B	REG	0.73		=	0.07	0.73	-0.314710745
Z1-EU32C-455	C	REG	0.33		=	0.04	0.33	-1.108662625
Z1-EU32C-456	C	REG	0.25		=	0.04	0.25	-1.386294361
Z1-EU32MW-420	S	REG	0.98		=	0.09	0.98	-0.020202707
Z1-EU32MW-426	S	REG	1.04		=	0.14	1.04	0.039220713
Z1-EU32W-418	S	REG	1.64		=	0.09	1.64	0.494696242
Z1-EU32W-419 + Dup	S	FR	1.51		=	0.1	1.51	0.412109651
Z1-EU32W-421	S	REG	1.33		=	0.14	1.33	0.285178942
Z1-EU32W-422	S	REG	0.99		=	0.18	0.99	-0.010050336
Z1-EU32W-423	S	REG	1.08		=	0.19	1.08	0.076961041
Z1-EU32W-424	S	REG	1.42		=	0.12	1.42	0.350656872
Z1-EU32W-425	S	REG	1		=	0.12	1	0
Z1-EU32W-427	S	REG	1.49		=	0.06	1.49	0.39877612
Z1-EU32W-428	S	REG	1.17		=	0.17	1.17	0.157003749
Z1-EU32W-429	S	REG	1.34		=	0.1	1.34	0.292669614
Z1-EU32W-430	S	REG	1.24		=	0.05	1.24	0.21511138
Z1-EU33BW-443	B	REG	1		=	0.06	1	0
Z1-EU33BW-444	B	REG	0.73		=	0.07	0.73	-0.314710745
Z1-EU33C-457	C	REG	0.29		=	0.1	0.29	-1.237874356
Z1-EU33W-435	S	REG	1.49		=	0.08	1.49	0.39877612
Z1-EU33W-436	S	REG	0.92		=	0.04	0.92	-0.083381609
Z1-EU33W-437	S	REG	0.8		=	0.08	0.8	-0.223143551
Z1-EU33W-438	S	REG	0.86		=	0.09	0.86	-0.15082289
Z1-EU33W-439	S	REG	0.93		=	0.11	0.93	-0.072570693
Z1-EU33W-440	S	REG	0.83		=	0.03	0.83	-0.186329578
Z1-EU33W-441	S	REG	1.19		=	0.12	1.19	0.173953307

Number of Samples	57
Number of Detects	57
Minimum	0.2
Median	0.99
Maximum	3.33
Average	1.0017544
Standard Deviation	0.5738253
PERT-Beta Mean	1.2483333
Lognormal Mean	-0.173725
Lognormal Standard Deviation	0.6329407

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Th-232 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	50

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.2	Minimum of Log Data	-1.609
Maximum	3.33	Maximum of Log Data	1.203
Mean	1.002	Mean of log Data	-0.174
Median	0.99	SD of log Data	0.633
SD	0.574		
Coefficient of Variation	0.573		
Skewness	1.26		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.0812	Lilliefors Test Statistic	0.136
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data appear Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	1.129	95% H-UCL	1.212
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	1.426
95% Adjusted-CLT UCL	1.14	97.5% Chebyshev (MVUE) UCL	1.601
95% Modified-t UCL	1.131	99% Chebyshev (MVUE) UCL	1.944
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	2.859	Data appear Normal at 5% Significance Level	
Theta Star	0.35		
nu star	325.9		
Approximate Chi Square Value (.05)	285.1	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	1.127
Adjusted Chi Square Value	284.1	95% Jackknife UCL	1.129
		95% Standard Bootstrap UCL	1.124
Anderson-Darling Test Statistic	0.961	95% Bootstrap-t UCL	1.145
Anderson-Darling 5% Critical Value	0.758	95% Hall's Bootstrap UCL	1.152
Kolmogorov-Smirnov Test Statistic	0.0989	95% Percentile Bootstrap UCL	1.128
Kolmogorov-Smirnov 5% Critical Value	0.119	95% BCA Bootstrap UCL	1.127
D 'ollow Appr. Gamma Distribution at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	1.333
		97.5% Chebyshev(Mean, Sd) UCL	1.476
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1.758
95% Approximate Gamma UCL	1.145		
95% Adjusted Gamma UCL	1.149		

		Potential UCL to Use							Use 95% Student's-t UCL		1.129

Statistical Summary for U-234 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	17.7		=	0.16	17.7	2.87356464
Z1-EU29W-401	S	REG	9.78		J	0.11	9.78	2.280339484
Z1-EU29W-402	S	REG	36		J	0.29	36	3.583518938
Z1-EU29W-403	S	REG	6.62		=	0.11	6.62	1.89009537
Z1-EU29W-404	S	REG	18.5		=	0.11	18.5	2.917770732
Z1-EU29W-405 + Dup	S	FR	10.2		=	0.15	10.2	2.32238772
Z1-EU29W-406	S	REG	2.67		=	0.07	2.67	0.982078472
Z1-EU29W-407	S	REG	23.5		=	0.19	23.5	3.157000421
Z1-EU29W-408	S	REG	5.59		=	0.06	5.59	1.720979287
Z1-EU29W-409	S	REG	23.1		=	0.11	23.1	3.139832618
Z1-EU30BW-411	B	REG	29		J	0.16	29	3.36729583
Z1-EU30C-444	C	REG	0.39		U	0.11	0.11	-2.207274913
Z1-EU30C-445	C	REG	1.19		=	0.12	1.19	0.173953307
Z1-EU30C-446	C	REG	0.85		J	0.14	0.85	-0.162518929
Z1-EU30C-447	C	REG	25.8		=	0.16	25.8	3.250374492
Z1-EU30C-448 + Dup	C	REG	1.25		=	0.09	1.25	0.223143551
Z1-EU30C-449	C	REG	0.82		J	0.12	0.82	-0.198450939
Z1-EU30C-450	C	REG	0.79		J	0.12	0.79	-0.235722334
Z1-EU30C-451	C	REG	0.74		J	0.11	0.74	-0.301105093
Z1-EU30C-452	C	REG	1.45		=	0.12	1.45	0.371563556
Z1-EU30C-453	C	REG	1.72		=	0.14	1.72	0.542324291
Z1-EU30C-454	C	REG	1.34		=	0.16	1.34	0.292669614
Z1-EU31BW-415	B	REG	51.8		J	0.47	51.8	3.947390149
Z1-EU31BW-416	B	REG	68.3		J	0.24	68.3	4.223909767
Z1-EU31BW-417	B	REG	36		=	0.14	36	3.583518938
Z1-EU31W-412	S	REG	3.18		=	0.1	3.18	1.156881197
Z1-EU31W-413	S	REG	37.4		J	0.34	37.4	3.621670704
Z1-EU31W-414	S	REG	26.2		J	0.15	26.2	3.265759411
Z1-EU32BW-431	B	REG	42.9		J	0.11	42.9	3.758871826
Z1-EU32BW-432	B	REG	14.5		=	0.07	14.5	2.674148649
Z1-EU32BW-433 + Dup	B	FR	1360		=	21.5	1360	7.215239979
Z1-EU32BW-434	B	REG	2.94		=	0.16	2.94	1.078409581
Z1-EU32C-455	C	REG	1.26		=	0.14	1.26	0.231111721
Z1-EU32C-456	C	REG	0.83		J	0.16	0.83	-0.186329578
Z1-EU32MW-420	S	REG	10.2		=	0.19	10.2	2.32238772
Z1-EU32MW-426	S	REG	19.8		=	0.14	19.8	2.985681938
Z1-EU32W-418	S	REG	17.1		J	0.46	17.1	2.839078464
Z1-EU32W-419 + Dup	S	REG	23.9		=	0.15	23.9	3.173878459
Z1-EU32W-421	S	REG	46.7		J	0.42	46.7	3.843744165
Z1-EU32W-422	S	REG	22.5		=	0.13	22.5	3.113515309
Z1-EU32W-423	S	REG	64.3		J	0.3	64.3	4.163559631
Z1-EU32W-424	S	REG	7.87		=	0.05	7.87	2.063058062
Z1-EU32W-425	S	REG	10.4		=	0.05	10.4	2.341805806
Z1-EU32W-427	S	REG	2.81		=	0.07	2.81	1.033184483
Z1-EU32W-428	S	REG	2.65		=	0.05	2.65	0.97455964
Z1-EU32W-429	S	REG	5.42		=	0.16	5.42	1.690095815
Z1-EU32W-430	S	REG	4.64		=	0.09	4.64	1.534714366
Z1-EU33BW-443	B	REG	19.7		=	0.15	19.7	2.980618636
Z1-EU33BW-444	B	REG	50.5		J	0.24	50.5	3.921973336
Z1-EU33C-457	C	REG	1.1		=	0.11	1.1	0.09531018
Z1-EU33W-435	S	REG	1.72		=	0.09	1.72	0.542324291
Z1-EU33W-436	S	REG	2.16		=	0.1	2.16	0.770108222
Z1-EU33W-437	S	REG	11.2		=	0.07	11.2	2.415913778
Z1-EU33W-438	S	REG	31.2		=	0.11	31.2	3.440418095
Z1-EU33W-439	S	REG	6.38		=	0.09	6.38	1.853168097
Z1-EU33W-440	S	REG	11.5		=	0.21	11.5	2.442347035
Z1-EU33W-441	S	REG	10.8		=	0.07	10.8	2.379546134

Number of Samples	57
Number of Detects	56
Minimum	0.1 t
Median	10.2
Maximum	1360
Average	39.448772
Standard Deviation	t78.84992
PERT-Beta Mean	233.485
Lognormal Mean	2.0609718
Lognormal Standard Deviation	1.6261761

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

U-234 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	54

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.11	Minimum of Log Data	-2.207
Maximum	1360	Maximum of Log Data	7.215
Mean	39.45	Mean of log Data	2.061
Median	10.2	SD of log Data	1.626
SD	178.8		
Coefficient of Variation	4.534		
Skewness	7.445		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.42	Lilliefors Test Statistic	0.0975
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	79.07	95% H-UCL	54.43
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	64.3
95% Adjusted-CLT UCL	103.4	97.5% Chebyshev (MVUE) UCL	80
95% Modified-t UCL	82.96	99% Chebyshev (MVUE) UCL	110.8

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.397	Data appear Lognormal at 5% Significance Level	
Theta Star	99.39		
nu star	45.25		
Approximate Chi Square Value (.05)	30.82	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	78.41
Adjusted Chi Square Value	30.51	95% Jackknife UCL	79.07
		95% Standard Bootstrap UCL	78.69
Anderson-Darling Test Statistic	3.838	95% Bootstrap-t UCL	350.3
Anderson-Darling 5% Critical Value	0.838	95% Hall's Bootstrap UCL	236.5
Kolmogorov-Smirnov Test Statistic	0.19	95% Percentile Bootstrap UCL	86.15
Kolmogorov-Smirnov 5% Critical Value	0.126	95% BCA Bootstrap UCL	132.6
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	142.7
		97.5% Chebyshev(Mean, Sd) UCL	187.4
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	275.2
95% Approximate Gamma UCL	57.92		
95% Adjusted Gamma UCL	58.51		

		Potential UCL to Use								Use 95% H-UCL	54.43

Statistical Summary for U-235 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	2.45		=	0.71	2.45	0.896088025
Z1-EU29W-401	S	REG	0.96		=	0.13	0.96	-0.040821995
Z1-EU29W-402	S	REG	3.21		J	0.27	3.21	1.166270937
Z1-EU29W-403	S	REG	0.59		=	0.1	0.59	-0.527632742
Z1-EU29W-404	S	REG	2.09		=	0.14	2.09	0.737164066
Z1-EU29W-405 + Dup	S	FR	1.44		=	0.46	1.44	0.364643114
Z1-EU29W-406	S	REG	0.38		=	0.09	0.38	-0.967584026
Z1-EU29W-407	S	REG	2.38		=	0.09	2.38	0.867100488
Z1-EU29W-408	S	REG	0.64		=	0.05	0.64	-0.446287103
Z1-EU29W-409	S	REG	2.37		=	0.14	2.37	0.862889955
Z1-EU30BW-411	B	REG	2.86		=	0.1	2.86	1.050821625
Z1-EU30C-444	C	REG	0.1	J	U	0.05	0.05	-2.995732274
Z1-EU30C-445	C	REG	0.22		U	0.06	0.06	-2.813410717
Z1-EU30C-446	C	REG	0.11	J	U	0.11	0.11	-2.207274913
Z1-EU30C-447	C	REG	6.48		=	0.12	6.48	1.86872051
Z1-EU30C-448 + Dup	C	REG	0.51		U	0.1	0.1	-2.302585093
Z1-EU30C-449	C	REG	0.14	J	U	0.06	0.06	-2.813410717
Z1-EU30C-450	C	REG	0.13	J	U	0.15	0.15	-1.897119985
Z1-EU30C-451	C	REG	0.14	J	U	0.14	0.14	-1.966112856
Z1-EU30C-452	C	REG	0.5		U	0.06	0.06	-2.813410717
Z1-EU30C-453	C	REG	0.26		U	0.06	0.06	-2.813410717
Z1-EU30C-454	C	REG	0.41		U	0.14	0.14	-1.966112856
Z1-EU31BW-415	B	REG	6.95		=	0.79	6.95	1.93874166
Z1-EU31BW-416	B	REG	8.57		J	0.3	8.57	2.148267733
Z1-EU31BW-417	B	REG	4.15		=	0.66	4.15	1.423108334
Z1-EU31W-412	S	REG	0.32	J	J	0.17	0.32	-1.139434283
Z1-EU31W-413	S	REG	3.78		=	0.53	3.78	1.32972401
Z1-EU31W-414	S	REG	3.1		J	0.11	3.1	1.131402111
Z1-EU32BW-431	B	REG	4.97		J	0.13	4.97	1.60341984
Z1-EU32BW-432	B	REG	1.08		J	0.1	1.08	0.076961041
Z1-EU32BW-433 + Dup	B	REG	185	J	J	97	185	5.220355825
Z1-EU32BW-434	B	REG	0.2	J	U	0.21	0.21	-1.560647748
Z1-EU32C-455	C	REG	0.54		J	0.1	0.54	-0.616186139
Z1-EU32C-456	C	REG	0.08	U	U	0.12	0.12	-2.120263536
Z1-EU32MW-420	S	REG	1.22		=	0.14	1.22	0.198850859
Z1-EU32MW-426	S	REG	1.77		=	0.48	1.77	0.570979547
Z1-EU32W-418	S	REG	2.83		J	0.32	2.83	1.040276712
Z1-EU32W-419 + Dup	S	REG	2.58		=	0.15	2.58	0.947789399
Z1-EU32W-421	S	REG	5.86		J	0.39	5.86	1.768149604
Z1-EU32W-422	S	REG	2.22		=	0.19	2.22	0.797507196
Z1-EU32W-423	S	REG	7.25		J	0.34	7.25	1.981001469
Z1-EU32W-424	S	REG	0.6		=	0.14	0.6	-0.510825624
Z1-EU32W-425	S	REG	0.92		=	0.06	0.92	-0.083381609
Z1-EU32W-427	S	REG	0.25		=	0.08	0.25	-1.386294361
Z1-EU32W-428	S	REG	0.25	J	J	0.13	0.25	-1.386294361
Z1-EU32W-429	S	REG	0.94		=	0.08	0.94	-0.061875404
Z1-EU32W-430	S	REG	0.78		=	0.09	0.78	-0.248461359
Z1-EU33BW-443	B	REG	2.51		=	0.53	2.51	0.920282753
Z1-EU33BW-444	B	REG	4.66		J	0.3	4.66	1.539015448
Z1-EU33C-457	C	REG	0.27	J	U	0.15	0.15	-1.897119985
Z1-EU33W-435	S	REG	0.16	J	J	0.08	0.16	-1.832581464
Z1-EU33W-436	S	REG	0.3		=	0.13	0.3	-1.203972804
Z1-EU33W-437	S	REG	1.13		=	0.62	1.13	0.122217633
Z1-EU33W-438	S	REG	4.02		=	0.86	4.02	1.391281903
Z1-EU33W-439	S	REG	0.5	J	J	0.56	0.5	-0.693147181
Z1-EU33W-440	S	REG	1.26		=	0.15	1.26	0.231111721
Z1-EU33W-441	S	REG	1.32	J	J	0.47	1.32	0.277631737

Number of Samples	57
Number of Detects	44
Minimum	0.05
Median	1.08
Maximum	185
Average	5.0710526
Standard Deviation	24.347791
PERT-Beta Mean	31.561667
Lognormal Mean	-0.119993
Lognormal Standard Deviation	1.6472166

General UCL Statistics for Full Data Sets

User Selected Options

From File	P:\Waste Generator Services\EMWMF Profiles\WL 4.12\March 2009 revision\revised rad to test distributio
Full Precision	OFF
Confidence Coefficient	95%
Nu...er of Bootstrap Operations	2000

U-235 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	51
Raw Statistics		**Log-transformed Statistics**	
Minimum	0.05	Minimum of Log Data	-2.996
Maximum	185	Maximum of Log Data	5.22
Mean	5.071	Mean of log Data	-0.12
Median	1.08	SD of log Data	1.647
SD	24.35		
Coefficient of Variation	4.801		
Skewness	7.464		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.429	Lilliefors Test Statistic	0.0846
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	10.46	95% H-UCL	6.449
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	7.575
95% Adjusted-CLT UCL	13.78	97.5% Chebyshev (MVUE) UCL	9.44
95% Modified-t UCL	11	99% Chebyshev (MVUE) UCL	13.1
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.372	Data appear Lognormal at 5% Significance Level	
Theta Star	13.63		
nu star	42.42		
Approximate Chi Square Value (.05)	28.49	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	10.38
Adjusted Chi Square Value	28.2	95% Jackknife UCL	10.46
		95% Standard Bootstrap UCL	10.34
Anderson-Darling Test Statistic	4.231	95% Bootstrap-t UCL	52.33
Anderson-Darling 5% Critical Value	0.844	95% Hall's Bootstrap UCL	31.62
Kolmogorov-Smirnov Test Statistic	0.194	95% Percentile Bootstrap UCL	11.52
Kolmogorov-Smirnov 5% Critical Value	0.127	95% BCA Bootstrap UCL	15.01
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	19.13
		97.5% Chebyshev(Mean, Sd) UCL	25.21
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	37.16
95% Approximate Gamma UCL	7.551		
95% Adjusted Gamma UCL	7.63		

Potential UCL to Use	Use 95% H-UCL	6.449

Statistical Summary for U-238 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	15		=	0.16	15	2.708050201
Z1-EU29W-401	S	REG	9.4		J	0.1	9.4	2.240709689
Z1-EU29W-402	S	REG	35.7		J	0.26	35.7	3.575150689
Z1-EU29W-403	S	REG	5.82		=	0.11	5.82	1.761300262
Z1-EU29W-404	S	REG	22.1		=	0.13	22.1	3.095577609
Z1-EU29W-405 + Dup	S	FR	10.4		=	0.11	10.4	2.341805806
Z1-EU29W-406	S	REG	2.35		=	0.06	2.35	0.854415328
Z1-EU29W-407	S	REG	16.4		=	0.13	16.4	2.797281335
Z1-EU29W-408	S	REG	4.09		=	0.07	4.09	1.40854497
Z1-EU29W-409	S	REG	13.5		=	0.11	13.5	2.602689685
Z1-EU30BW-411	B	REG	18.7		J	0.08	18.7	2.928523524
Z1-EU30C-444	C	REG	0.43		=	0.08	0.43	-0.84397007
Z1-EU30C-445	C	REG	0.87		=	0.05	0.87	-0.139262067
Z1-EU30C-446	C	REG	0.46		=	0.07	0.46	-0.776528789
Z1-EU30C-447	C	REG	28.8		=	0.12	28.8	3.360375387
Z1-EU30C-448 + Dup	C	REG	1.29		=	0.08	1.29	0.254642218
Z1-EU30C-449	C	REG	0.48		=	0.1	0.48	-0.733969175
Z1-EU30C-450	C	REG	0.51		=	0.11	0.51	-0.673344553
Z1-EU30C-451	C	REG	0.43		=	0.09	0.43	-0.84397007
Z1-EU30C-452	C	REG	1.11		=	0.14	1.11	0.104360015
Z1-EU30C-453	C	REG	1.03		=	0.09	1.03	0.029558802
Z1-EU30C-454	C	REG	1.13		=	0.14	1.13	0.122217633
Z1-EU31BW-415	B	REG	38.8		J	0.3	38.8	3.658420247
Z1-EU31BW-416	B	REG	47.3		J	0.24	47.3	3.856510295
Z1-EU31BW-417	B	REG	28.4		=	0.08	28.4	3.346389145
Z1-EU31W-412	S	REG	1.59		=	0.06	1.59	0.463734016
Z1-EU31W-413	S	REG	40.1		J	0.29	40.1	3.691376334
Z1-EU31W-414	S	REG	18.4		J	0.15	18.4	2.912350665
Z1-EU32BW-431	B	REG	38.2		J	0.11	38.2	3.642835516
Z1-EU32BW-432	B	REG	11.4		=	0.08	11.4	2.433613355
Z1-EU32BW-433 + Dup	B	FR	1150		=	25.1	1150	7.047517221
Z1-EU32BW-434	B	REG	2.6		=	0.16	2.6	0.955511445
Z1-EU32C-455	C	REG	0.46		=	0.11	0.46	-0.776528789
Z1-EU32C-456	C	REG	0.69		=	0.11	0.69	-0.371063681
Z1-EU32MW-420	S	REG	6.88		=	0.13	6.88	1.928618652
Z1-EU32MW-426	S	REG	14.4		=	0.12	14.4	2.667228207
Z1-EU32W-418	S	REG	42.4		J	0.39	42.4	3.747148362
Z1-EU32W-419 + Dup	S	REG	17.5		J	0.11	17.5	2.862200881
Z1-EU32W-421	S	REG	55.4		J	0.24	55.4	4.014579594
Z1-EU32W-422	S	REG	17		=	0.13	17	2.833213344
Z1-EU32W-423	S	REG	46		J	0.21	46	3.828641396
Z1-EU32W-424	S	REG	6.75		=	0.08	6.75	1.909542505
Z1-EU32W-425	S	REG	7.65		=	0.08	7.65	2.034705648
Z1-EU32W-427	S	REG	1.62		=	0.04	1.62	0.482426149
Z1-EU32W-428	S	REG	1.47		=	0.05	1.47	0.385262401
Z1-EU32W-429	S	REG	6.6		=	0.15	6.6	1.887069649
Z1-EU32W-430	S	REG	3.64		=	0.07	3.64	1.291983682
Z1-EU33BW-443	B	REG	16.2		=	0.12	16.2	2.785011242
Z1-EU33BW-444	B	REG	44.4		J	0.14	44.4	3.793239469
Z1-EU33C-457	C	REG	0.92		=	0.05	0.92	-0.083381609
Z1-EU33W-435	S	REG	1.53		=	0.07	1.53	0.425267735
Z1-EU33W-436	S	REG	1.66		=	0.09	1.66	0.506817602
Z1-EU33W-437	S	REG	7.75		=	0.08	7.75	2.047692843
Z1-EU33W-438	S	REG	18.8		=	0.06	18.8	2.93385687
Z1-EU33W-439	S	REG	4.41		=	0.08	4.41	1.483874689
Z1-EU33W-440	S	REG	8.35		=	0.14	8.35	2.122261539
Z1-EU33W-441	S	REG	7.39		=	0.07	7.39	2.000127735

Number of Samples	57
Number of Detects	57
Minimum	0.43
Median	7.65
Maximum	1150
Average	33.450175
Standard Deviation	151.27378
PERT-Beta Mean	196.83833
Lognormal Mean	1.8407406
Lognormal Standard Deviation	1.6590547

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

U-238 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	55

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.43	Minimum of Log Data	-0.844
Maximum	1150	Maximum of Log Data	7.048
Mean	33.45	Mean of log Data	1.841
Median	7.65	SD of log Data	1.659
SD	151.3		
Coefficient of Variation	4.522		
Skewness	7.436		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.428	Lilliefors Test Statistic	0.105
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	66.96	95% H-UCL	47.09
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	55.13
95% Adjusted-CLT UCL	87.5	97.5% Chebyshev (MVUE) UCL	68.75
95% Modified-t UCL	70.25	99% Chebyshev (MVUE) UCL	95.51

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.386	Data appear Lognormal at 5% Significance Level	
Theta Star	86.68		
nu star	43.99		
Approximate Chi Square Value (.05)	29.78	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	66.41
Adjusted Chi Square Value	29.48	95% Jackknife UCL	66.96
		95% Standard Bootstrap UCL	65.97
Anderson-Darling Test Statistic	3.71	95% Bootstrap-t UCL	281.4
Anderson-Darling 5% Critical Value	0.84	95% Hall's Bootstrap UCL	199.4
Kolmogorov-Smirnov Test Statistic	0.191	95% Percentile Bootstrap UCL	73.57
Kolmogorov-Smirnov 5% Critical Value	0.126	95% BCA Bootstrap UCL	98.27
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	120.8
		97.5% Chebyshev(Mean, Sd) UCL	158.6
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	232.8
95% Approximate Gamma UCL	49.41		
95% Adjusted Gamma UCL	49.92		

		Potential UCL to Use							Use 95% H-UCL		47.09

Statistical Summary for Aluminum mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	16000	N	=	10.8	16000	9.680344001
Z1-EU29W-401	S	REG	4400	N	=	9.4	4400	8.38935982
Z1-EU29W-402	S	REG	19200	N	=	11.5	19200	9.862665558
Z1-EU29W-403	S	REG	15400	N	=	9.6	15400	9.642122788
Z1-EU29W-404	S	REG	15500	N	=	10.8	15500	9.648595303
Z1-EU29W-405 + Dup	S	REG	12900	N	=	10.2	12900	9.46498259
Z1-EU29W-406	S	REG	15800	N	=	9.5	15800	9.667765219
Z1-EU29W-407	S	REG	20100	N	=	11	20100	9.908475094
Z1-EU29W-408	S	REG	17700	N	=	10.5	17700	9.781319919
Z1-EU29W-409	S	REG	16300	N	=	10.3	16300	9.698920387
Z1-EU30BW-411	B	REG	7910	N	=	10.4	7910	8.975883061
Z1-EU30C-444	C	REG	6520	N	=	3.9	6520	8.782629655
Z1-EU30C-445	C	REG	4510	N	=	3.5	4510	8.414052432
Z1-EU30C-446	C	REG	5320	N	=	4.1	5320	8.579228582
Z1-EU30C-447	C	REG	6810	N	=	4.2	6810	8.826147399
Z1-EU30C-448 + Dup	C	FR	8190	N	=	3.8	8190	9.010669177
Z1-EU30C-449	C	REG	7420	N	=	4	7420	8.911934336
Z1-EU30C-450	C	REG	5670	N	=	4	5670	8.642944397
Z1-EU30C-451	C	REG	7150	N	=	4	7150	8.874867636
Z1-EU30C-452	C	REG	7140	N	=	4	7140	8.873468055
Z1-EU30C-453	C	REG	7250	N	=	4.2	7250	8.888756748
Z1-EU30C-454	C	REG	6880	N	=	4.1	6880	8.836373931
Z1-EU31BW-415	B	REG	14800	N	=	10.8	14800	9.60238246
Z1-EU31BW-416	B	REG	18400	N	=	11.2	18400	9.820105944
Z1-EU31BW-417	B	REG	18100	N	=	9.7	18100	9.803667217
Z1-EU31W-412	S	REG	8350	N	=	10.7	8350	9.030016818
Z1-EU31W-413	S	REG	8380	N	=	9.3	8380	9.033603193
Z1-EU31W-414	S	REG	16400	N	=	11	16400	9.705036614
Z1-EU32BW-431	B	REG	10600	N	=	3.4	10600	9.26860928
Z1-EU32BW-432	B	REG	12300	N	=	3.1	12300	9.417354541
Z1-EU32BW-433 + Dup	B	REG	19800	N	=	3.5	19800	9.893437217
Z1-EU32BW-434	B	REG	8800	N	=	9.5	8800	9.082507
Z1-EU32C-455	C	REG	6520	N	=	4.1	6520	8.782629655
Z1-EU32C-456	C	REG	6400	N	=	4.3	6400	8.764053269
Z1-EU32MW-420	S	REG	12500	N	=	3.4	12500	9.433483923
Z1-EU32MW-426	S	REG	11300	N	=	3.6	11300	9.332558005
Z1-EU32W-418	S	REG	14400	N	=	4.2	14400	9.574983486
Z1-EU32W-419 + Dup	S	REG	20400	N	=	3.4	20400	9.92329018
Z1-EU32W-421	S	REG	13000	N	=	3.6	13000	9.472704636
Z1-EU32W-422	S	REG	9690	N	=	3.3	9690	9.178849705
Z1-EU32W-423	S	REG	12100	N	=	3.3	12100	9.400960732
Z1-EU32W-424	S	REG	12800	N	=	3.6	12800	9.45720045
Z1-EU32W-425	S	REG	11100	N	=	3.7	11100	9.314700387
Z1-EU32W-427	S	REG	16200	N	=	3.4	16200	9.692766521
Z1-EU32W-428	S	REG	11400	N	=	3.8	11400	9.341368634
Z1-EU32W-429	S	REG	13900	N	=	3.4	13900	9.539644119
Z1-EU32W-430	S	REG	11600	N	=	3	11600	9.358760377
Z1-EU33BW-443	B	REG	17900	N	=	10.1	17900	9.792555992
Z1-EU33BW-444	B	REG	11900	N	=	3.5	11900	9.384293679
Z1-EU33C-457	C	REG	7570	N	=	3.9	7570	8.931948346
Z1-EU33W-435	S	REG	21400	N	=	3.5	21400	9.971146201
Z1-EU33W-436	S	REG	13700	N	=	3.6	13700	9.525151112
Z1-EU33W-437	S	REG	16700	N	=	4	16700	9.723163998
Z1-EU33W-438	S	REG	15300	N	=	3.5	15300	9.635608107
Z1-EU33W-439	S	REG	15400	N	=	3.3	15400	9.642122788
Z1-EU33W-440	S	REG	11100	N	=	3.4	11100	9.314700387
Z1-EU33W-441	S	REG	14600	N	=	3.2	14600	9.588776808

Number of Samples	57
Number of Detects	57
Minimum	4400
Median	12300
Maximum	21400
Average	12261.053
Standard Deviation	4617.5352
PERT-Beta Mean	12500
Lognormal Mean	9.3350114
Lognormal Standard Deviation	0.4172184

Goodness-of-Fit Test Statistics for Full Data Sets without Non-Detects

User Selected Options

From File	P:\Waste Generator Services\EMWMF Profiles\WL 4.12\March 2009 revision\revised total metals to test c
Full Precision	OFF
Confidence Coefficient	0.9

Al mg/kg

Raw Statistics

Number of Valid Observations	57
Number of Distinct Observations	54
Minimum	4400
Maximum	21400
Mean of Raw Data	12261
Standard Deviation of Raw Data	4618
Kstar	6.148
Mean of Log Transformed Data	9.335
Standard Deviation of Log Transformed Data	0.417

Normal Distribution Test Results

Correlation Coefficient R	0.985
Lilliefors Test Statistic	0.115
Lilliefors Critical (0.9) Value	0.107

Data not Normal at (0.1) Significance Level

Gamma Distribution Test Results

Correlation Coefficient R	0.974
A-D Test Statistic	0.862
A-D Critical (0.9) Value	0.632
K-S Test Statistic	0.0968
K-S Critical(0.9) Value	0.108

Data follow Appr. Gamma Distribution at (0.1) Significance Level

Lognormal Distribution Test Results

Correlation Coefficient R	0.976
Lilliefors Test Statistic	0.112
Lilliefors Critical (0.9) Value	0.107

Data not Lognormal at (0.1) Significance Level

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005 | R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Aluminum (mg/kg)	4400.0000	1.23E+04	2.14E+04	12500.00	17857.28	1.43	17857.28	2.86	3.14	###########	17000.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ *is the Beta Function and* $B_z(\alpha_1, \alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95 α_1 α_2 MIN MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Antimony mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	1.7	N	=	0.27	1.7	0.530628251
Z1-EU29W-401	S	REG	0.82	B N	J	0.23	0.82	-0.198450939
Z1-EU29W-402	S	REG	0.56	B N	=	0.29	0.56	-0.579818495
Z1-EU29W-403	S	REG	0.5	B N	=	0.24	0.5	-0.693147181
Z1-EU29W-404	S	REG	0.84	B N	=	0.27	0.84	-0.174353387
Z1-EU29W-405 + Dup	S	FR	1.3	N	=	0.25	1.3	0.262364264
Z1-EU29W-406	S	REG	0.84	B N	=	0.24	0.84	-0.174353387
Z1-EU29W-407	S	REG	2.8	N	=	0.27	2.8	1.029619417
Z1-EU29W-408	S	REG	0.28	B N	=	0.26	0.28	-1.272965676
Z1-EU29W-409	S	REG	1.1	B N	=	0.26	1.1	0.09531018
Z1-EU30BW-411	B	REG	1.3	B N	=	0.26	1.3	0.262364264
Z1-EU30C-444	C	REG	0.3	U N	UJ	0.3	0.15	-1.897119985
Z1-EU30C-445	C	REG	0.26	U N	U	0.26	0.13	-2.040220829
Z1-EU30C-446	C	REG	0.31	U N	U	0.31	0.155	-1.864330162
Z1-EU30C-447	C	REG	0.31	U N	U	0.31	0.155	-1.864330162
Z1-EU30C-448 + Dup	C	REG	0.29	U N	U	0.29	0.145	-1.931021537
Z1-EU30C-449	C	REG	0.3	U N	U	0.3	0.15	-1.897119985
Z1-EU30C-450	C	REG	0.3	U N	U	0.3	0.15	-1.897119985
Z1-EU30C-451	C	REG	0.3	U N	U	0.3	0.15	-1.897119985
Z1-EU30C-452	C	REG	0.3	U N	U	0.3	0.15	-1.897119985
Z1-EU30C-453	C	REG	0.32	U N	U	0.32	0.16	-1.832581464
Z1-EU30C-454	C	REG	0.3	U N	U	0.3	0.15	-1.897119985
Z1-EU31BW-415	B	REG	0.85	B N	=	0.27	0.85	-0.162518929
Z1-EU31BW-416	B	REG	0.74	B N	=	0.28	0.74	-0.301105093
Z1-EU31BW-417	B	REG	11.3	B N	=	0.24	11.3	2.424802726
Z1-EU31W-412	S	REG	0.42	B N	=	0.27	0.42	-0.867500568
Z1-EU31W-413	S	REG	2.1	N	=	0.23	2.1	0.741937345
Z1-EU31W-414	S	REG	0.51	B N	=	0.27	0.51	-0.673344553
Z1-EU32BW-431	B	REG	65.1	N	=	0.26	65.1	4.175924549
Z1-EU32BW-432	B	REG	1.6	N	=	0.23	1.6	0.470003629
Z1-EU32BW-433 + Dup	B	REG	0.27	B N	=	0.26	0.27	-1.30933332
Z1-EU32BW-434	B	REG	0.56	B N	=	0.24	0.56	-0.579818495
Z1-EU32C-455	C	REG	0.31	U N	U	0.31	0.155	-1.864330162
Z1-EU32C-456	C	REG	0.32	N U	U	0.32	0.16	-1.832581464
Z1-EU32MW-420	S	REG	0.26	U N	U	0.26	0.13	-2.040220829
Z1-EU32MW-426	S	REG	1.4	N	=	0.27	1.4	0.336472237
Z1-EU32W-418	S	REG	0.32	U N	UJ	0.32	0.16	-1.832581464
Z1-EU32W-419 + Dup	S	REG	1.4	N	=	0.26	1.4	0.336472237
Z1-EU32W-421	S	REG	0.83	B N	=	0.27	0.83	-0.186329578
Z1-EU32W-422	S	REG	0.69	B N	=	0.25	0.69	-0.371063681
Z1-EU32W-423	S	REG	0.96	B N	=	0.25	0.96	-0.040821995
Z1-EU32W-424	S	REG	0.27	U N	U	0.27	0.135	-2.002480501
Z1-EU32W-425	S	REG	0.52	B N	=	0.28	0.52	-0.653926467
Z1-EU32W-427	S	REG	0.26	U N	U	0.26	0.13	-2.040220829
Z1-EU32W-428	S	REG	0.28	U N	U	0.28	0.14	-1.966112856
Z1-EU32W-429	S	REG	0.26	U N	U	0.26	0.13	-2.040220829
Z1-EU32W-430	S	REG	0.23	U N	UJ	0.23	0.115	-2.162823151
Z1-EU33BW-443	B	REG	1.9	N	=	0.25	1.9	0.641853886
Z1-EU33BW-444	B	REG	0.29	B N	=	0.26	0.29	-1.237874356
Z1-EU33C-457	C	REG	0.29	U N	U	0.29	0.145	-1.931021537
Z1-EU33W-435	S	REG	0.27	U N	U	0.27	0.135	-2.002480501
Z1-EU33W-436	S	REG	0.31	B N	=	0.27	0.31	-1.171182982
Z1-EU33W-437	S	REG	0.93	B N	=	0.3	0.93	-0.072570693
Z1-EU33W-438	S	REG	2.9	N	=	0.26	2.9	1.064710737
Z1-EU33W-439	S	REG	0.46	B N	=	0.25	0.46	-0.776528789
Z1-EU33W-440	S	REG	2.5	N	=	0.25	2.5	0.916290732
Z1-EU33W-441	S	REG	0.68	B N	=	0.24	0.68	-0.385662481

Number of Samples	57
Number of Detects	35
Minimum	0.115
Median	0.5
Maximum	65.1
Average	2.0077193
Standard Deviation	8.649705
PERT-Beta Mean	11.2025
Lognormal Mean	-0.723231
Lognormal Standard Deviation	1.2769656

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Sb mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	39

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.115	Minimum of Log Data	-2.163
Maximum	65.1	Maximum of Log Data	4.176
Mean	2.008	Mean of log Data	-0.723
Median	0.5	SD of log Data	1.277
SD	8.65		
Coefficient of Variation	4.308		
Skewness	7.199		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.424	Lilliefors Test Statistic	0.193
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	3.924	95% H-UCL	1.601
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	2.07
95% Adjusted-CLT UCL	5.06	97.5% Chebyshev (MVUE) UCL	2.503
95% Modified-t UCL	4.106	99% Chebyshev (MVUE) UCL	3.354
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.442	Data do not follow a Discernable Distribution (0.05)	
Theta Star	4.544		
nu star	50.37		
Approximate Chi Square Value (.05)	35.07	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	3.892
Adjusted Chi Square Value	34.74	95% Jackknife UCL	3.924
		95% Standard Bootstrap UCL	3.886
Anderson-Darling Test Statistic	6.604	95% Bootstrap-t UCL	19.05
Anderson-Darling 5% Critical Value	0.826	95% Hall's Bootstrap UCL	11.42
Kolmogorov-Smirnov Test Statistic	0.233	95% Percentile Bootstrap UCL	4.186
Kolmogorov-Smirnov 5% Critical Value	0.125	95% BCA Bootstrap UCL	6.246
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	7.002
		97.5% Chebyshev(Mean, Sd) UCL	9.162
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	13.41
95% Approximate Gamma UCL	2.883		
95% Adjusted Gamma UCL	2.911		

		Potential UCL to Use						Use 97.5% Chebyshev (Mean, Sd) UCL			9.162

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells	
Report OUTPUT UCL-95	

SRC	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Antimony (mg/kg)	0.1150	0.5000	65.1000	11.20	29.79	2.66	29.79	1.02	4.98	102.9316	65.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as *f(x)* for the random variable, *x*. The Cumulative Distribution Function (CDF) is denoted as *F(x)*. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ *is the Beta Function and* $B_z(\alpha_1,\alpha_2)$ *is the Incomplete Beta Function*
α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95 α_1 α_2 MIN MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Arsenic mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	8.4		=	0.45	8.4	2.128231706
Z1-EU29W-401	S	REG	3.4		=	0.39	3.4	1.223775432
Z1-EU29W-402	S	REG	10.2		=	0.48	10.2	2.32238772
Z1-EU29W-403	S	REG	7.6		=	0.4	7.6	2.028148247
Z1-EU29W-404	S	REG	7.6		=	0.45	7.6	2.028148247
Z1-EU29W-405 + Dup	S	REG	6.2		=	0.43	6.2	1.824549292
Z1-EU29W-406	S	REG	8		=	0.39	8	2.079441542
Z1-EU29W-407	S	REG	9.6		=	0.46	9.6	2.261763098
Z1-EU29W-408	S	REG	8.4		=	0.44	8.4	2.128231706
Z1-EU29W-409	S	REG	8.7		=	0.43	8.7	2.163323026
Z1-EU30BW-411	B	REG	8		=	0.43	8	2.079441542
Z1-EU30C-444	C	REG	2.9		=	0.49	2.9	1.064710737
Z1-EU30C-445	C	REG	3.3		=	0.43	3.3	1.193922468
Z1-EU30C-446	C	REG	5		=	0.51	5	1.609437912
Z1-EU30C-447	C	REG	3.8		=	0.52	3.8	1.335001067
Z1-EU30C-448 + Dup	C	REG	3.1		=	0.48	3.1	1.131402111
Z1-EU30C-449	C	REG	3.4		=	0.5	3.4	1.223775432
Z1-EU30C-450	C	REG	4.8		=	0.5	4.8	1.568615918
Z1-EU30C-451	C	REG	3.2		=	0.5	3.2	1.16315081
Z1-EU30C-452	C	REG	4.1		=	0.5	4.1	1.410986974
Z1-EU30C-453	C	REG	4.3		=	0.53	4.3	1.458615023
Z1-EU30C-454	C	REG	4		=	0.51	4	1.386294361
Z1-EU31BW-415	B	REG	11		=	0.45	11	2.397895273
Z1-EU31BW-416	B	REG	9.5		=	0.47	9.5	2.251291799
Z1-EU31BW-417	B	REG	7.6		=	0.41	7.6	2.028148247
Z1-EU31W-412	S	REG	5.8		=	0.44	5.8	1.757857918
Z1-EU31W-413	S	REG	5.9		=	0.39	5.9	1.774952351
Z1-EU31W-414	S	REG	9		=	0.46	9	2.197224577
Z1-EU32BW-431	B	REG	9.5		=	0.43	9.5	2.251291799
Z1-EU32BW-432	B	REG	9.1		=	0.39	9.1	2.208274414
Z1-EU32BW-433 + Dup	B	FR	6.6		=	0.44	6.6	1.887069649
Z1-EU32BW-434	B	REG	5.2		=	0.4	5.2	1.648658626
Z1-EU32C-455	C	REG	4.9		=	0.51	4.9	1.589235205
Z1-EU32C-456	C	REG	3.8		=	0.54	3.8	1.335001067
Z1-EU32MW-420	S	REG	6.2		=	0.43	6.2	1.824549292
Z1-EU32MW-426	S	REG	10.2		=	0.45	10.2	2.32238772
Z1-EU32W-418	S	REG	4.4		=	0.53	4.4	1.481604541
Z1-EU32W-419 + Dup	S	REG	14.1		=	0.43	14.1	2.646174797
Z1-EU32W-421	S	REG	7.2		=	0.45	7.2	1.974081026
Z1-EU32W-422	S	REG	9.8		=	0.41	9.8	2.282382386
Z1-EU32W-423	S	REG	7.6		=	0.42	7.6	2.028148247
Z1-EU32W-424	S	REG	6		=	0.45	6	1.791759469
Z1-EU32W-425	S	REG	6.6		=	0.46	6.6	1.887069649
Z1-EU32W-427	S	REG	5.9		=	0.43	5.9	1.774952351
Z1-EU32W-428	S	REG	7.7		=	0.47	7.7	2.041220329
Z1-EU32W-429	S	REG	5.9		=	0.43	5.9	1.774952351
Z1-EU32W-430	S	REG	5.3		=	0.38	5.3	1.667706821
Z1-EU33BW-443	B	REG	16.8		=	0.42	16.8	2.821378886
Z1-EU33BW-444	B	REG	5.8		=	0.44	5.8	1.757857918
Z1-EU33C-457	C	REG	4.8		=	0.49	4.8	1.568615918
Z1-EU33W-435	S	REG	5.8		=	0.44	5.8	1.757857918
Z1-EU33W-436	S	REG	5.5		=	0.44	5.5	1.704748092
Z1-EU33W-437	S	REG	15.5		=	0.5	15.5	2.740840024
Z1-EU33W-438	S	REG	11.1		=	0.44	11.1	2.406945108
Z1-EU33W-439	S	REG	10.3		=	0.41	10.3	2.332143895
Z1-EU33W-440	S	REG	18.4		=	0.42	18.4	2.912350665
Z1-EU33W-441	S	REG	7.8		=	0.4	7.8	2.054123734

Number of Samples	57
Number of Detects	57
Minimum	2.9
Median	6.6
Maximum	18.4
Average	7.2736842
Standard Deviation	3.3555139
PERT-Beta Mean	7.95
Lognormal Mean	1.8893703
Lognormal Standard Deviation	0.436757

Goodness-of-Fit Test Statistics for Full Data Sets without Non-Detects

User Selected Options

From File	P:\Waste Generator Services\EMWMF Profiles\WL 4.12\March 2009 revision\revised total metals to test c
Full Precision	OFF
Confidence Coefficient	0.9

As mg/kg

Raw Statistics

Number of Valid Observations	57
Number of Distinct Observations	41
Minimum	2.9
Maximum	18.4
Mean of Raw Data	7.274
Standard Deviation of Raw Data	3.356
Kstar	5.156
Mean of Log Transformed Data	1.889
Standard Deviation of Log Transformed Data	0.437

Normal Distribution Test Results

Correlation Coefficient R	0.947
Lilliefors Test Statistic	0.117
Lilliefors Critical (0.9) Value	0.107

Data not Normal at (0.1) Significance Level

Gamma Distribution Test Results

Correlation Coefficient R	0.985
A-D Test Statistic	0.374
A-D Critical (0.9) Value	0.632
K-S Test Statistic	0.0772
K-S Critical(0.9) Value	0.108

Data appear Gamma Distributed at (0.1) Significance Level

Lognormal Distribution Test Results

Correlation Coefficient R	0.993
Lilliefors Test Statistic	0.0808
Lilliefors Critical (0.9) Value	0.107

Data appear Lognormal at (0.1) Significance Level

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Ba mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	52

Raw Statistics		**Log-transformed Statistics**	
Minimum	31.3	Minimum of Log Data	3.444
Maximum	395	Maximum of Log Data	5.979
Mean	80.37	Mean of log Data	4.264
Median	71.5	SD of log Data	0.462
SD	52.88		
Coefficient of Variation	0.658		
Skewness	4.032		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.264	Lilliefors Test Statistic	0.14
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	92.09	95% H-UCL	88.6
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	100.9
95% Adjusted-CLT UCL	95.89	97.5% Chebyshev (MVUE) UCL	110.4
95% Modified-t UCL	92.71	99% Chebyshev (MVUE) UCL	129.1

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	4.008	Data do not follow a Discernable Distribution (0.05)	
Theta Star	20.05		
nu star	456.9		
Approximate Chi Square Value (.05)	408.4	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	91.9
Adjusted Chi Square Value	407.2	95% Jackknife UCL	92.09
		95% Standard Bootstrap UCL	92.12
Anderson-Darling Test Statistic	1.51	95% Bootstrap-t UCL	99.21
Anderson-Darling 5% Critical Value	0.754	95% Hall's Bootstrap UCL	145
Kolmogorov-Smirnov Test Statistic	0.18	95% Percentile Bootstrap UCL	93.52
Kolmogorov-Smirnov 5% Critical Value	0.118	95% BCA Bootstrap UCL	97.26
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	110.9
		97.5% Chebyshev(Mean, Sd) UCL	124.1
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	150.1
95% Approximate Gamma UCL	89.93		
95% Adjusted Gamma UCL	90.19		

		Potential UCL to Use							Use 95% Student's-t UCL		92.09
									or 95% Modified-t UCL		92.71

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12				Beta PDF inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Barium (mg/kg)	31.3000	71.5000	395.0000	118.72	231.67	1.95	231.67	1.44	4.56	4541.9202	363.7

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \qquad MIN < Most\,likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\,Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ is the Beta Function and $B_z(\alpha_1,\alpha_2)$ is the Incomplete Beta Function

α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Barium mg/L

Location ID	Sample Lot	Sample Type	Result (ug/L)	Result Qualifier	Validation	Detection Limit (ug/L)	Proxy Value (mg/L)	LN Proxy Value
Z1-EU29BW-410		REG	363		=	3.1	0.363	-1.013352445
Z1-EU29W-401		REG	742		=	3.1	0.742	-0.298406036
Z1-EU29W-402		REG	270		=	3.1	0.27	-1.30933332
Z1-EU29W-403		REG	369		=	3.1	0.369	-0.996958635
Z1-EU29W-404		REG	358		=	3.1	0.358	-1.027222293
Z1-EU29W-405 + Dup		REG	311		=	3.1	0.311	-1.167962367
Z1-EU29W-406		REG	279		=	3.1	0.279	-1.276543497
Z1-EU29W-407		REG	360		=	3.1	0.36	-1.021651248
Z1-EU29W-408		REG	223		=	3.1	0.223	-1.500583508
Z1-EU29W-409		REG	672		=	3.1	0.672	-0.397496938
Z1-EU30BW-411		REG	638		=	3.1	0.638	-0.449416996
Z1-EU31BW-415		REG	305		=	3.1	0.305	-1.187443502
Z1-EU31BW-416		REG	244		=	3.1	0.244	-1.410587054
Z1-EU31BW-417		REG	276		=	3.1	0.276	-1.287354413
Z1-EU31W-412		REG	235		=	3.1	0.235	-1.448169765
Z1-EU31W-413		REG	470		=	3.1	0.47	-0.755022584
Z1-EU31W-414		REG	285		=	3.1	0.285	-1.255266099
Z1-EU32BW-431		REG	846		=	6	0.846	-0.167235919
Z1-EU32BW-432		REG	792		=	6	0.792	-0.233193887
Z1-EU32BW-433 + Dup		REG	474		=	6	0.474	-0.746547957
Z1-EU32BW-434		REG	674		=	3.1	0.674	-0.394525168
Z1-EU32MW-420		REG	1570		=	6	1.57	0.451075619
Z1-EU32MW-426		REG	862		=	6	0.862	-0.148500008
Z1-EU32W-418		REG	436		=	6	0.436	-0.830113036
Z1-EU32W-419 + Dup		REG	795		=	6	0.795	-0.229413164
Z1-EU32W-421		REG	1090		=	6	1.09	0.086177696
Z1-EU32W-422		REG	1400		=	6	1.4	0.336472237
Z1-EU32W-423		REG	1240		=	6	1.24	0.21511138
Z1-EU32W-424		REG	584		=	6	0.584	-0.537854296
Z1-EU32W-425		REG	933		=	6	0.933	-0.069350078
Z1-EU32W-427		REG	495		=	6	0.495	-0.703197516
Z1-EU32W-428		REG	492		=	6	0.492	-0.709276562
Z1-EU32W-429		REG	438		=	6	0.438	-0.825536369
Z1-EU32W-430		REG	603		=	6	0.603	-0.505838082
Z1-EU33BW-443		REG	499		=	3.1	0.499	-0.695149183
Z1-EU33BW-444		REG	511		=	6	0.511	-0.671385689
Z1-EU33W-435		REG	531		=	6	0.531	-0.632993258
Z1-EU33W-436		REG	626		=	6	0.626	-0.468404908
Z1-EU33W-437		REG	1770		=	6	1.77	0.570979547
Z1-EU33W-438		REG	593		=	6	0.593	-0.52256088
Z1-EU33W-439		REG	631		=	6	0.631	-0.460449416
Z1-EU33W-440		REG	583		=	6	0.583	-0.539568093
Z1-EU33W-441		REG	1740		=	6	1.74	0.553885113

Number of Samples	43
Number of Detects	43
Minimum	0.223
Median	0.531
Maximum	1.77
Average	0.6420465
Standard Deviation	0.3939569
PERT-Beta Mean	0.6861667
Lognormal Mean	-0.597213
Lognormal Standard Deviation	0.5480201

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Ba mg/L

General Statistics

Number of Valid Observations	43	Number of Distinct Observations	43

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.223	Minimum of Log Data	-1.501
Maximum	1.77	Maximum of Log Data	0.571
Mean	0.642	Mean of log Data	-0.597
Median	0.531	SD of log Data	0.548
SD	0.394		
Coefficient of Variation	0.614		
Skewness	1.531		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.829	Shapiro Wilk Test Statistic	0.959
Shapiro Wilk Critical Value	0.943	Shapiro Wilk Critical Value	0.943
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.743	95% H-UCL	0.753
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.882
95% Adjusted-CLT UCL	0.756	97.5% Chebyshev (MVUE) UCL	0.989
95% Modified-t UCL	0.745	99% Chebyshev (MVUE) UCL	1.197
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	3.18	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	0.202		
nu star	273.5		
Approximate Chi Square Value (.05)	236.2	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0444	95% CLT UCL	0.741
Adjusted Chi Square Value	235	95% Jackknife UCL	0.743
		95% Standard Bootstrap UCL	0.741
Anderson-Darling Test Statistic	0.73	95% Bootstrap-t UCL	0.758
Anderson-Darling 5% Critical Value	0.754	95% Hall's Bootstrap UCL	0.764
Kolmogorov-Smirnov Test Statistic	0.114	95% Percentile Bootstrap UCL	0.743
Kolmogorov-Smirnov 5% Critical Value	0.136	95% BCA Bootstrap UCL	0.755
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.904
		97.5% Chebyshev(Mean, Sd) UCL	1.017
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1.24
95% Approximate Gamma UCL	0.743		
95% Adjusted Gamma UCL	0.747		

		Potential UCL to Use						Use 95% Approximate Gamma UCL			0.743

Statistical Summary for Beryllium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	0.14	B	=	0.05	0.14	-1.966112856
Z1-EU29W-401	S	REG	0.31		=	0.04	0.31	-1.171182982
Z1-EU29W-402	S	REG	0.44		=	0.05	0.44	-0.820980552
Z1-EU29W-403	S	REG	0.47		=	0.04	0.47	-0.755022584
Z1-EU29W-404	S	REG	0.44		=	0.05	0.44	-0.820980552
Z1-EU29W-405 + Dup	S	FR	1.8		=	0.04	1.8	0.587786665
Z1-EU29W-406	S	REG	0.44		=	0.04	0.44	-0.820980552
Z1-EU29W-407	S	REG	0.97		=	0.05	0.97	-0.030459207
Z1-EU29W-408	S	REG	0.37		=	0.04	0.37	-0.994252273
Z1-EU29W-409	S	REG	0.58		=	0.04	0.58	-0.544727175
Z1-EU30BW-411	B	REG	0.43		=	0.04	0.43	-0.84397007
Z1-EU30C-444	C	REG	0.26		=	0.05	0.26	-1.347073648
Z1-EU30C-445	C	REG	0.19		=	0.04	0.19	-1.660731207
Z1-EU30C-446	C	REG	0.2	B	=	0.05	0.2	-1.609437912
Z1-EU30C-447	C	REG	0.29		=	0.05	0.29	-1.237874356
Z1-EU30C-448 + Dup	C	FR	0.33		=	0.05	0.33	-1.108662625
Z1-EU30C-449	C	REG	0.32		=	0.05	0.32	-1.139434283
Z1-EU30C-450	C	REG	0.2		=	0.05	0.2	-1.609437912
Z1-EU30C-451	C	REG	0.31		=	0.05	0.31	-1.171182982
Z1-EU30C-452	C	REG	0.55		=	0.05	0.55	-0.597837001
Z1-EU30C-453	C	REG	0.69		=	0.05	0.69	-0.371063681
Z1-EU30C-454	C	REG	0.29		=	0.05	0.29	-1.237874356
Z1-EU31BW-415	B	REG	0.35		=	0.04	0.35	-1.049822124
Z1-EU31BW-416	B	REG	0.38		=	0.05	0.38	-0.967584026
Z1-EU31BW-417	B	REG	0.36		=	0.04	0.36	-1.021651248
Z1-EU31W-412	S	REG	0.42		=	0.04	0.42	-0.867500568
Z1-EU31W-413	S	REG	0.39		=	0.04	0.39	-0.94160854
Z1-EU31W-414	S	REG	0.37		=	0.05	0.37	-0.994252273
Z1-EU32BW-431	B	REG	0.42		=	0.04	0.42	-0.867500568
Z1-EU32BW-432	B	REG	0.3		=	0.04	0.3	-1.203972804
Z1-EU32BW-433 + Dup	B	FR	0.44		=	0.04	0.44	-0.820980552
Z1-EU32BW-434	B	REG	0.61		=	0.04	0.61	-0.494296322
Z1-EU32C-455	C	REG	0.26		=	0.05	0.26	-1.347073648
Z1-EU32C-456	C	REG	0.25		=	0.05	0.25	-1.386294361
Z1-EU32MW-420	S	REG	0.34		=	0.04	0.34	-1.078809661
Z1-EU32MW-426	S	REG	0.44		=	0.05	0.44	-0.820980552
Z1-EU32W-418	S	REG	0.37		=	0.05	0.37	-0.994252273
Z1-EU32W-419 + Dup	S	REG	0.42		=	0.04	0.42	-0.867500568
Z1-EU32W-421	S	REG	0.4		=	0.05	0.4	-0.916290732
Z1-EU32W-422	S	REG	0.38		=	0.04	0.38	-0.967584026
Z1-EU32W-423	S	REG	0.33		=	0.04	0.33	-1.108662625
Z1-EU32W-424	S	REG	0.41		=	0.05	0.41	-0.891598119
Z1-EU32W-425	S	REG	0.39		=	0.05	0.39	-0.94160854
Z1-EU32W-427	S	REG	0.53		=	0.04	0.53	-0.634878272
Z1-EU32W-428	S	REG	0.42		=	0.05	0.42	-0.867500568
Z1-EU32W-429	S	REG	0.39		=	0.04	0.39	-0.94160854
Z1-EU32W-430	S	REG	0.37		=	0.04	0.37	-0.994252273
Z1-EU33BW-443	B	REG	0.47		=	0.04	0.47	-0.755022584
Z1-EU33BW-444	B	REG	0.48		=	0.04	0.48	-0.733969175
Z1-EU33C-457	C	REG	0.44		=	0.05	0.44	-0.820980552
Z1-EU33W-435	S	REG	0.83		=	0.04	0.83	-0.186329578
Z1-EU33W-436	S	REG	0.46		=	0.04	0.46	-0.776528789
Z1-EU33W-437	S	REG	0.54		=	0.05	0.54	-0.616186139
Z1-EU33W-438	S	REG	0.4		=	0.04	0.4	-0.916290732
Z1-EU33W-439	S	REG	0.49		=	0.04	0.49	-0.713349888
Z1-EU33W-440	S	REG	0.29		=	0.04	0.29	-1.237874356
Z1-EU33W-441	S	REG	0.46		=	0.04	0.46	-0.776528789

Number of Samples	57
Number of Detects	57
Minimum	0.14
Median	0.4
Maximum	1.8
Average	0.4319298
Standard Deviation	0.2322056
PERT-Beta Mean	0.59
Lognormal Mean	-0.926186
Lognormal Standard Deviation	0.3927134

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Be mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	34
Raw Statistics		**Log-transformed Statistics**	
Minimum	0.14	Minimum of Log Data	-1.966
Maximum	1.8	Maximum of Log Data	0.588
Mean	0.432	Mean of log Data	-0.926
Median	0.4	SD of log Data	0.393
SD	0.232		
Coefficient of Variation	0.538		
Skewness	4.003		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.243	Lilliefors Test Statistic	0.138
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.483	95% H-UCL	0.47
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.527
95% Adjusted-CLT UCL	0.5	97.5% Chebyshev (MVUE) UCL	0.57
95% Modified-t UCL	0.486	99% Chebyshev (MVUE) UCL	0.655
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	5.629	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.0767		
nu star	641.7		
Approximate Chi Square Value (.05)	583.9	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	0.483
Adjusted Chi Square Value	582.5	95% Jackknife UCL	0.483
		95% Standard Bootstrap UCL	0.481
Anderson-Darling Test Statistic	2.011	95% Bootstrap-t UCL	0.522
Anderson-Darling 5% Critical Value	0.753	95% Hall's Bootstrap UCL	0.727
Kolmogorov-Smirnov Test Statistic	0.172	95% Percentile Bootstrap UCL	0.487
Kolmogorov-Smirnov 5% Critical Value	0.118	95% BCA Bootstrap UCL	0.504
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.566
		97.5% Chebyshev(Mean, Sd) UCL	0.624
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	0.738
95% Approximate Gamma UCL	0.475		
95% Adjusted Gamma UCL	0.476		

		Potential UCL to Use							Use 95% Student's-t UCL		0.483
									or 95% Modified-t UCL		0.486

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Beryllium (mg/kg)	0.1400	0.4000	1.8000	0.59	1.12	1.89	1.12	1.63	4.37	0.1067	1.7

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ *is the Beta Function and* $B_z(\alpha_1, \alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Boron mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	3		=	0.45	3	1.098612289
Z1-EU29W-401	S	REG	5.2		=	0.39	5.2	1.648658626
Z1-EU29W-402	S	REG	3.4		=	0.48	3.4	1.223775432
Z1-EU29W-403	S	REG	3.5		=	0.4	3.5	1.252762968
Z1-EU29W-404	S	REG	4.5		=	0.45	4.5	1.504077397
Z1-EU29W-405 + Dup	S	FR	16.8		=	0.41	16.8	2.821378886
Z1-EU29W-406	S	REG	3.2		=	0.39	3.2	1.16315081
Z1-EU29W-407	S	REG	5.4		=	0.46	5.4	1.686398954
Z1-EU29W-408	S	REG	2.9		=	0.44	2.9	1.064710737
Z1-EU29W-409	S	REG	4.3		=	0.43	4.3	1.458615023
Z1-EU30BW-411	B	REG	15.4		=	0.43	15.4	2.734367509
Z1-EU30C-444	C	REG	9 *		=	0.49	9	2.197224577
Z1-EU30C-445	C	REG	5.9 *		=	0.43	5.9	1.774952351
Z1-EU30C-446	C	REG	10.9 *		=	0.51	10.9	2.388762789
Z1-EU30C-447	C	REG	10.8 *		=	0.52	10.8	2.379546134
Z1-EU30C-448 + Dup	C	FR	10.7 *		=	0.47	10.7	2.370243741
Z1-EU30C-449	C	REG	9.8 *		=	0.5	9.8	2.282382386
Z1-EU30C-450	C	REG	9.8 *		=	0.5	9.8	2.282382386
Z1-EU30C-451	C	REG	9.2 *		=	0.5	9.2	2.219203484
Z1-EU30C-452	C	REG	6.7 *		=	0.5	6.7	1.902107526
Z1-EU30C-453	C	REG	7.8 *		=	0.53	7.8	2.054123734
Z1-EU30C-454	C	REG	13.3 *		=	0.51	13.3	2.587764035
Z1-EU31BW-415	B	REG	3.5		=	0.45	3.5	1.252762968
Z1-EU31BW-416	B	REG	3		=	0.47	3	1.098612289
Z1-EU31BW-417	B	REG	3		=	0.41	3	1.098612289
Z1-EU31W-412	S	REG	21.2		=	0.44	21.2	3.054001182
Z1-EU31W-413	S	REG	7.9		=	0.39	7.9	2.066862759
Z1-EU31W-414	S	REG	3.2		=	0.46	3.2	1.16315081
Z1-EU32BW-431	B	REG	8.5		=	0.43	8.5	2.140066163
Z1-EU32BW-432	B	REG	7.2		=	0.39	7.2	1.974081026
Z1-EU32BW-433 + Dup	B	REG	4.2		=	0.44	4.2	1.435084525
Z1-EU32BW-434	B	REG	7.7		=	0.4	7.7	2.041220329
Z1-EU32C-455	C	REG	8.6 *		=	0.51	8.6	2.151762203
Z1-EU32C-456	C	REG	8.3 *		=	0.54	8.3	2.116255515
Z1-EU32MW-420	S	REG	5 N		=	0.43	5	1.609437912
Z1-EU32MW-426	S	REG	5.9 N		=	0.45	5.9	1.774952351
Z1-EU32W-418	S	REG	5.3 N		J	0.53	5.3	1.667706821
Z1-EU32W-419 + Dup	S	REG	11.4 N		=	0.43	11.4	2.433613355
Z1-EU32W-421	S	REG	7.7 N		=	0.45	7.7	2.041220329
Z1-EU32W-422	S	REG	8.4 N		=	0.41	8.4	2.128231706
Z1-EU32W-423	S	REG	16.3 N		=	0.42	16.3	2.791165108
Z1-EU32W-424	S	REG	2 N		=	0.45	2	0.693147181
Z1-EU32W-425	S	REG	5.8 N		=	0.46	5.8	1.757857918
Z1-EU32W-427	S	REG	2.2 N		=	0.43	2.2	0.78845736
Z1-EU32W-428	S	REG	4.5 N		=	0.47	4.5	1.504077397
Z1-EU32W-429	S	REG	3 N		=	0.43	3	1.098612289
Z1-EU32W-430	S	REG	1.9		=	0.38	1.9	0.641853886
Z1-EU33BW-443	B	REG	8.5		=	0.42	8.5	2.140066163
Z1-EU33BW-444	B	REG	3.2		=	0.44	3.2	1.16315081
Z1-EU33C-457	C	REG	39.1 *		=	0.49	39.1	3.666122467
Z1-EU33W-435	S	REG	3		=	0.44	3	1.098612289
Z1-EU33W-436	S	REG	2.6		=	0.44	2.6	0.955511445
Z1-EU33W-437	S	REG	7.9		=	0.5	7.9	2.066862759
Z1-EU33W-438	S	REG	6.8		=	0.44	6.8	1.916922612
Z1-EU33W-439	S	REG	4.2		=	0.41	4.2	1.435084525
Z1-EU33W-440	S	REG	5.9		=	0.42	5.9	1.774952351
Z1-EU33W-441	S	REG	5.1		=	0.4	5.1	1.62924054

Number of Samples	57
Number of Detects	57
Minimum	1.9
Median	5.9
Maximum	39.1
Average	7.4298246
Standard Deviation	5.8910939
PERT-Beta Mean	10.766667
Lognormal Mean	1.7976234
Lognormal Standard Deviation	0.6246972

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

B mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	42
Raw Statistics		**Log-transformed Statistics**	
Minimum	1.9	Minimum of Log Data	0.642
Maximum	39.1	Maximum of Log Data	3.666
Mean	7.43	Mean of log Data	1.798
Median	5.9	SD of log Data	0.625
SD	5.891		
Coefficient of Variation	0.793		
Skewness	3.175		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.176	Lilliefors Test Statistic	0.0892
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	8.735	95% H-UCL	8.635
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	10.15
95% Adjusted-CLT UCL	9.064	97.5% Chebyshev (MVUE) UCL	11.38
95% Modified-t UCL	8.79	99% Chebyshev (MVUE) UCL	13.79
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	2.437	Data Follow Appr. Gamma Distribution at 5% Significance Level	
Theta Star	3.049		
nu star	277.8		
Approximate Chi Square Value (.05)	240.2	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	8.713
Adjusted Chi Square Value	239.3	95% Jackknife UCL	8.735
		95% Standard Bootstrap UCL	8.663
Anderson-Darling Test Statistic	0.795	95% Bootstrap-t UCL	9.326
Anderson-Darling 5% Critical Value	0.76	95% Hall's Bootstrap UCL	10.33
Kolmogorov-Smirnov Test Statistic	0.083	95% Percentile Bootstrap UCL	8.798
Kolmogorov-Smirnov 5% Critical Value	0.119	95% BCA Bootstrap UCL	9.196
follow Appr. Gamma Distribution at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	10.83
		97.5% Chebyshev(Mean, Sd) UCL	12.3
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	15.19
95% Approximate Gamma UCL	8.593		
95% Adjusted Gamma UCL	8.625		

		Potential UCL to Use						Use 95% Approximate Gamma UCL			8.593

Statistical Summary for Cadmium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	0.99 *		=	0.05	0.99	-0.010050336
Z1-EU29W-401	S	REG	3.1 *		J	0.04	3.1	1.131402111
Z1-EU29W-402	S	REG	0.66 *		=	0.05	0.66	-0.415515444
Z1-EU29W-403	S	REG	0.36 B *		=	0.04	0.36	-1.021651248
Z1-EU29W-404	S	REG	2.8 *		=	0.05	2.8	1.029619417
Z1-EU29W-405 + Dup	S	REG	0.97 *		=	0.04	0.97	-0.030459207
Z1-EU29W-406	S	REG	0.14 B *		=	0.04	0.14	-1.966112856
Z1-EU29W-407	S	REG	2.8 *		=	0.05	2.8	1.029619417
Z1-EU29W-408	S	REG	0.04 U *		U	0.04	0.02	-3.912023005
Z1-EU29W-409	S	REG	1.1 *		=	0.04	1.1	0.09531018
Z1-EU30BW-411	B	REG	2.7 *		=	0.04	2.7	0.993251773
Z1-EU30C-444	C	REG	0.05 U		U	0.05	0.025	-3.688879454
Z1-EU30C-445	C	REG	0.05 B		=	0.04	0.05	-2.995732274
Z1-EU30C-446	C	REG	0.18 B		=	0.05	0.18	-1.714798428
Z1-EU30C-447	C	REG	0.07 B		=	0.05	0.07	-2.659260037
Z1-EU30C-448 + Dup	C	FR	0.06 B		=	0.05	0.06	-2.813410717
Z1-EU30C-449	C	REG	0.06 B		=	0.05	0.06	-2.813410717
Z1-EU30C-450	C	REG	0.12 B		=	0.05	0.12	-2.120263536
Z1-EU30C-451	C	REG	0.06 B		=	0.05	0.06	-2.813410717
Z1-EU30C-452	C	REG	0.26 B		=	0.05	0.26	-1.347073648
Z1-EU30C-453	C	REG	0.38 B		=	0.05	0.38	-0.967584026
Z1-EU30C-454	C	REG	0.09 B		=	0.05	0.09	-2.407945609
Z1-EU31BW-415	B	REG	0.35 B *		=	0.04	0.35	-1.049822124
Z1-EU31BW-416	B	REG	1 *		=	0.05	1	0
Z1-EU31BW-417	B	REG	0.77 *		=	0.04	0.77	-0.261364764
Z1-EU31W-412	S	REG	0.57 *		=	0.04	0.57	-0.562118918
Z1-EU31W-413	S	REG	1.1 *		=	0.04	1.1	0.09531018
Z1-EU31W-414	S	REG	0.42 B *		=	0.05	0.42	-0.867500568
Z1-EU32BW-431	B	REG	3.3 N *		=	0.04	3.3	1.193922468
Z1-EU32BW-432	B	REG	3 N *		=	0.04	3	1.098612289
Z1-EU32BW-433 + Dup	B	REG	0.83 N *		=	0.04	0.83	-0.186329578
Z1-EU32BW-434	B	REG	0.45 *		=	0.04	0.45	-0.798507696
Z1-EU32C-455	C	REG	0.15 B		=	0.05	0.15	-1.897119985
Z1-EU32C-456	C	REG	0.05 U		U	0.05	0.025	-3.688879454
Z1-EU32MW-420	S	REG	1		=	0.04	1	0
Z1-EU32MW-426	S	REG	2.2		=	0.05	2.2	0.78845736
Z1-EU32W-418	S	REG	0.75		=	0.05	0.75	-0.287682072
Z1-EU32W-419 + Dup	S	REG	7.2		=	0.04	7.2	1.974081026
Z1-EU32W-421	S	REG	3.8		=	0.05	3.8	1.335001067
Z1-EU32W-422	S	REG	2.9		=	0.04	2.9	1.064710737
Z1-EU32W-423	S	REG	2.5		=	0.04	2.5	0.916290732
Z1-EU32W-424	S	REG	0.16 B		=	0.05	0.16	-1.832581464
Z1-EU32W-425	S	REG	2.5		=	0.05	2.5	0.916290732
Z1-EU32W-427	S	REG	0.25 B		=	0.04	0.25	-1.386294361
Z1-EU32W-428	S	REG	0.38 B		=	0.05	0.38	-0.967584026
Z1-EU32W-429	S	REG	0.23 B		=	0.04	0.23	-1.46967597
Z1-EU32W-430	S	REG	1.8 N *		J	0.04	1.8	0.587786665
Z1-EU33BW-443	B	REG	2.5 *		=	0.04	2.5	0.916290732
Z1-EU33BW-444	B	REG	1.3 N *		=	0.04	1.3	0.262364264
Z1-EU33C-457	C	REG	0.31 B		=	0.05	0.31	-1.171182982
Z1-EU33W-435	S	REG	0.2 B N *		=	0.04	0.2	-1.609437912
Z1-EU33W-436	S	REG	0.53 N *		=	0.04	0.53	-0.634878272
Z1-EU33W-437	S	REG	3.5 N *		=	0.05	3.5	1.252762968
Z1-EU33W-438	S	REG	4.9 N *		=	0.04	4.9	1.589235205
Z1-EU33W-439	S	REG	1.9 N *		=	0.04	1.9	0.641853886
Z1-EU33W-440	S	REG	14.2 N *		=	0.04	14.2	2.653241965
Z1-EU33W-441	S	REG	2.4 N *		=	0.04	2.4	0.875468737

Number of Samples	57
Number of Detects	54
Minimum	0.02
Median	0.75
Maximum	14.2
Average	1.5152632
Standard Deviation	2.2467626
PERT-Beta Mean	2.87
Lognormal Mean	-0.525047
Lognormal Standard Deviation	1.562501

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Cd mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	48

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.02	Minimum of Log Data	-3.912
Maximum	14.2	Maximum of Log Data	2.653
Mean	1.515	Mean of log Data	-0.525
Median	0.75	SD of log Data	1.563
SD	2.247		
Coefficient of Variation	1.483		
Skewness	3.663		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.253	Lilliefors Test Statistic	0.098
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	2.013	95% H-UCL	3.559
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	4.269
95% Adjusted-CLT UCL	2.159	97.5% Chebyshev (MVUE) UCL	5.287
95% Modified-t UCL	2.037	99% Chebyshev (MVUE) UCL	7.287

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.627	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	2.417		
nu star	71.46		
Approximate Chi Square Value (.05)	53	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	2.005
Adjusted Chi Square Value	52.59	95% Jackknife UCL	2.013
		95% Standard Bootstrap UCL	2.01
Anderson-Darling Test Statistic	0.582	95% Bootstrap-t UCL	2.301
Anderson-Darling 5% Critical Value	0.802	95% Hall's Bootstrap UCL	4.161
Kolmogorov-Smirnov Test Statistic	0.0843	95% Percentile Bootstrap UCL	2.036
Kolmogorov-Smirnov 5% Critical Value	0.123	95% BCA Bootstrap UCL	2.257
ta appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	2.812
		97.5% Chebyshev(Mean, Sd) UCL	3.374
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	4.476
95% Approximate Gamma UCL	2.043		
95% Adjusted Gamma UCL	2.059		

		Potential UCL to Use					Use 95% Approximate Gamma UCL				2.043

Statistical Summary for Cadmium mg/L

Location ID	Sample Lot	Sample Type	Result (ug/L)	Result Qualifier	Validation	Detection Limit (ug/L)	Proxy Value (mg/L)	LN Proxy Value
Z1-EU29BW-410		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU29W-401		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU29W-402		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU29W-403		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU29W-404		REG	11.1		=	5.6	0.0111	-4.500810171
Z1-EU29W-405 + Dup		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU29W-406		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU29W-407		REG	26.4		=	5.6	0.0264	-3.634391269
Z1-EU29W-408		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU29W-409		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU30BW-411		REG	16.7		=	5.6	0.0167	-4.09234656
Z1-EU31BW-415		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU31BW-416		REG	7.5		=	5.6	0.0075	-4.892852258
Z1-EU31BW-417		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU31W-412		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU31W-413		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU31W-414		REG	12.4		=	5.6	0.0124	-4.390058806
Z1-EU32BW-431		REG	43.6		=	3	0.0436	-3.132698129
Z1-EU32BW-432		REG	21.7	B	=	3	0.0217	-3.830443018
Z1-EU32BW-433 + Dup		REG	10.4	B	=	3	0.0104	-4.565949473
Z1-EU32BW-434		REG	5.6	U	U	5.6	0.0028	-5.878135862
Z1-EU32MW-420		REG	7.8	B	=	3	0.0078	-4.853631545
Z1-EU32MW-426		REG	28.8	B	=	3	0.0288	-3.547379892
Z1-EU32W-418		REG	17.7	B	=	3	0.0177	-4.034190639
Z1-EU32W-419 + Dup		FR	30.8		=	3	0.0308	-3.480240589
Z1-EU32W-421		REG	58.6		=	3	0.0586	-2.837020582
Z1-EU32W-422		REG	25.1	B	=	3	0.0251	-3.684887433
Z1-EU32W-423		REG	48.5		=	3	0.0485	-3.026191481
Z1-EU32W-424		REG	3	U	U	3	0.0015	-6.502290171
Z1-EU32W-425		REG	7.6	B	=	3	0.0076	-4.879607032
Z1-EU32W-427		REG	3.7	B	=	3	0.0037	-5.599422459
Z1-EU32W-428		REG	3	U	U	3	0.0015	-6.502290171
Z1-EU32W-429		REG	3	U	U	3	0.0015	-6.502290171
Z1-EU32W-430		REG	7.7	B	=	3	0.0077	-4.86653495
Z1-EU33BW-443		REG	9.8		=	5.6	0.0098	-4.625372893
Z1-EU33BW-444		REG	12.6	B	=	3	0.0126	-4.374058465
Z1-EU33W-435		REG	3	U	U	3	0.0015	-6.502290171
Z1-EU33W-436		REG	3	U	U	3	0.0015	-6.502290171
Z1-EU33W-437		REG	19.1	B	=	3	0.0191	-3.958066944
Z1-EU33W-438		REG	17.7	B	=	3	0.0177	-4.034190639
Z1-EU33W-439		REG	16.4	B	=	3	0.0164	-4.110473944
Z1-EU33W-440		REG	96.1		=	3	0.0961	-2.342365963
Z1-EU33W-441		REG	22.2	B	=	3	0.0222	-3.80766299

Number of Samples	43
Number of Detects	25
Minimum	0.0015
Median	0.0077
Maximum	0.0961
Average	0.0145093
Standard Deviation	0.0185671
PERT-Beta Mean	0.0214
Lognormal Mean	-4.884374
Lognormal Standard Deviation	1.1649097

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Cd mg/L

General Statistics

Number of Valid Observations	43	Number of Distinct Observations	26

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.0015	Minimum of Log Data	-6.502
Maximum	0.0961	Maximum of Log Data	-2.342
Mean	0.0145	Mean of log Data	-4.884
Median	0.0077	SD of log Data	1.165
SD	0.0186		
Coefficient of Variation	1.28		
Skewness	2.611		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.702	Shapiro Wilk Test Statistic	0.915
Shapiro Wilk Critical Value	0.943	Shapiro Wilk Critical Value	0.943
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.0193	95% H-UCL	0.0235
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.0282
95% Adjusted-CLT UCL	0.0204	97.5% Chebyshev (MVUE) UCL	0.0341
95% Modified-t UCL	0.0195	99% Chebyshev (MVUE) UCL	0.0458
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.851	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.0171		
nu star	73.15		
Approximate Chi Square Value (.05)	54.46	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0444	95% CLT UCL	0.0192
Adjusted Chi Square Value	53.9	95% Jackknife UCL	0.0193
		95% Standard Bootstrap UCL	0.0192
Anderson-Darling Test Statistic	1.533	95% Bootstrap-t UCL	0.021
Anderson-Darling 5% Critical Value	0.782	95% Hall's Bootstrap UCL	0.0222
Kolmogorov-Smirnov Test Statistic	0.22	95% Percentile Bootstrap UCL	0.0192
Kolmogorov-Smirnov 5% Critical Value	0.139	95% BCA Bootstrap UCL	0.0209
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.0269
		97.5% Chebyshev(Mean, Sd) UCL	0.0322
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	0.0427
95% Approximate Gamma UCL	0.0195		
95% Adjusted Gamma UCL	0.0197		

		Potential UCL to Use						Use 99% Chebyshev (Mean, Sd) UCL			0.0427

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

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Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Cadmium (mg/L)	0.0015	0.0077	0.0961	0.02	0.05	2.33	0.05	1.26	4.74	0.0003	0.1

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as *f(x)* for the random variable, *x*. The Cumulative Distribution Function (CDF) is denoted as *F(x)*. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \quad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ is the Beta Function and $B_z(\alpha_1,\alpha_2)$ is the Incomplete Beta Function
α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate *x* such that *F(x)* = 0.95. The result is

Statistical Summary for Calcium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	12700	N	=	10.8	12700	9.449357272
Z1-EU29W-401	S	REG	254000	N	=	37.5	254000	12.44508955
Z1-EU29W-402	S	REG	10300	N	=	11.5	10300	9.239899174
Z1-EU29W-403	S	REG	58200	N	=	9.6	58200	10.97164063
Z1-EU29W-404	S	REG	23700	N	=	10.8	23700	10.07323033
Z1-EU29W-405 + Dup	S	FR	233000	N	=	39.4	233000	12.35879373
Z1-EU29W-406	S	REG	26200	N	=	9.5	26200	10.17351469
Z1-EU29W-407	S	REG	26900	N	=	11	26900	10.19988157
Z1-EU29W-408	S	REG	7180	N	=	10.5	7180	8.879054662
Z1-EU29W-409	S	REG	66000	N	=	10.3	66000	11.09741002
Z1-EU30BW-411	B	REG	155000	N	=	41.5	155000	11.9511804
Z1-EU30C-444	C	REG	167000	N	=	23.7	167000	12.02574909
Z1-EU30C-445	C	REG	143000	N	=	20.8	143000	11.87059991
Z1-EU30C-446	C	REG	148000	N	=	24.6	148000	11.90496755
Z1-EU30C-447	C	REG	134000	N	=	25	134000	11.80559508
Z1-EU30C-448 + Dup	C	REG	184000	N	=	22.9	184000	12.12269104
Z1-EU30C-449	C	REG	177000	N	=	24	177000	12.08390501
Z1-EU30C-450	C	REG	144000	N	=	24.1	144000	11.87756858
Z1-EU30C-451	C	REG	207000	N	=	23.8	207000	12.24047407
Z1-EU30C-452	C	REG	197000	N	=	24.2	197000	12.19095901
Z1-EU30C-453	C	REG	202000	N	=	25.5	202000	12.21602298
Z1-EU30C-454	C	REG	141000	N	=	24.4	141000	11.85651517
Z1-EU31BW-415	B	REG	62600	N	=	10.8	62600	11.04452056
Z1-EU31BW-416	B	REG	5990	N	=	11.2	5990	8.697846691
Z1-EU31BW-417	B	REG	20100	N	=	9.7	20100	9.908475094
Z1-EU31W-412	S	REG	96600	N	=	10.7	96600	11.47833402
Z1-EU31W-413	S	REG	64700	N	=	9.3	64700	11.07751648
Z1-EU31W-414	S	REG	26600	N	=	11	26600	10.18866649
Z1-EU32BW-431	B	REG	95000	N *	=	10.2	95000	11.46163217
Z1-EU32BW-432	B	REG	23100	N *	=	3.1	23100	10.0475879
Z1-EU32BW-433 + Dup	B	FR	11300	N *	=	3.5	11300	9.332558005
Z1-EU32BW-434	B	REG	98900	N	=	9.5	98900	11.50186452
Z1-EU32C-455	C	REG	148000	N	=	24.5	148000	11.90496755
Z1-EU32C-456	C	REG	132000	N	=	25.8	132000	11.7905572
Z1-EU32MW-420	S	REG	41500	N *	=	3.4	41500	10.63344871
Z1-EU32MW-426	S	REG	22600	N *	=	10.9	22600	10.02570519
Z1-EU32W-418	S	REG	34900	N *	J	4.2	34900	10.46024211
Z1-EU32W-419 + Dup	S	REG	86800	N *	=	10.2	86800	11.3713619
Z1-EU32W-421	S	REG	44000	N *	=	10.9	44000	10.69194491
Z1-EU32W-422	S	REG	84700	N *	=	19.8	84700	11.34687088
Z1-EU32W-423	S	REG	110000	N *	=	20	110000	11.60823564
Z1-EU32W-424	S	REG	9980	N *	=	3.6	9980	9.208338369
Z1-EU32W-425	S	REG	45000	N *	=	3.7	45000	10.71441777
Z1-EU32W-427	S	REG	5520	N *	=	3.4	5520	8.616133139
Z1-EU32W-428	S	REG	25700	N *	=	3.8	25700	10.15424627
Z1-EU32W-429	S	REG	18400	N *	=	3.4	18400	9.820105944
Z1-EU32W-430	S	REG	7170	N *	J	3	7170	8.877660934
Z1-EU33BW-443	B	REG	85000	N	=	10.1	85000	11.35040654
Z1-EU33BW-444	B	REG	6250	N *	=	3.5	6250	8.740336743
Z1-EU33C-457	C	REG	210000	N	=	23.5	210000	12.25486281
Z1-EU33W-435	S	REG	1860	N *	=	3.5	1860	7.528331767
Z1-EU33W-436	S	REG	6620	N *	=	3.6	6620	8.797850649
Z1-EU33W-437	S	REG	26700	N *	=	4	26700	10.19241884
Z1-EU33W-438	S	REG	42800	N *	=	3.5	42800	10.66429338
Z1-EU33W-439	S	REG	13900	N *	=	3.3	13900	9.539644119
Z1-EU33W-440	S	REG	70400	N *	=	10.1	70400	11.16194854
Z1-EU33W-441	S	REG	18000	N *	=	3.2	18000	9.798127037

Number of Samples	57
Number of Detects	57
Minimum	1860
Median	58200
Maximum	254000
Average	79295.965
Standard Deviation	71104.57
PERT-Beta Mean	81443.333
Lognormal Mean	10.719747
Lognormal Standard Deviation	1.2170622

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Ca mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	56

Raw Statistics

Minimum	1860
Maximum	254000
Mean	79296
Median	58200
SD	71105
Coefficient of Variation	0.897
Skewness	0.78

Log-transformed Statistics

Minimum of Log Data	7.528
Maximum of Log Data	12.45
Mean of log Data	10.72
SD of log Data	1.217

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic	0.176
Lilliefors Critical Value	0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic	0.118
Lilliefors Critical Value	0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	95048

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	95827
95% Modified-t UCL	95210

Assuming Lognormal Distribution

95% H-UCL	185727
95% Chebyshev (MVUE) UCL	174371
97.5% Chebyshev (MVUE) UCL	209654
99% Chebyshev (MVUE) UCL	278960

Gamma Distribution Test

k star (bias corrected)	0.983
Theta Star	80647
nu star	112.1
Approximate Chi Square Value (.05)	88.65
Adjusted Level of Significance	0.0458
Adjusted Chi Square Value	88.11
Anderson-Darling Test Statistic	0.814
Anderson-Darling 5% Critical Value	0.779
Kolmogorov-Smirnov Test Statistic	0.121
Kolmogorov-Smirnov 5% Critical Value	0.121

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Assuming Gamma Distribution

95% Approximate Gamma UCL	100262
95% Adjusted Gamma UCL	100876

Nonparametric Statistics

95% CLT UCL	94787
95% Jackknife UCL	95048
95% Standard Bootstrap UCL	95140
95% Bootstrap-t UCL	95581
95% Hall's Bootstrap UCL	95808
95% Percentile Bootstrap UCL	95406
95% BCA Bootstrap UCL	94742
95% Chebyshev(Mean, Sd) UCL	120348
97.5% Chebyshev(Mean, Sd) UCL	138112
99% Chebyshev(Mean, Sd) UCL	173004

		Potential UCL to Use					Use 97.5% Chebyshev (Mean, Sd) UCL				138112

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Calcium (mg/kg)	1860.0000	5.82E+04	2.54E+05	81443.33	162846.39	2.00	162846.39	1.89	4.11	###########	252140.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < Most\,likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ *is the Beta Function and* $B_z(\alpha_1, \alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Chromium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	117 *		=	0.18	117	4.762173935
Z1-EU29W-401	S	REG	19.3 *		=	0.16	19.3	2.960105096
Z1-EU29W-402	S	REG	28.7 *		=	0.19	28.7	3.356897123
Z1-EU29W-403	S	REG	21.1 *		=	0.16	21.1	3.04927304
Z1-EU29W-404	S	REG	41.2 *		=	0.18	41.2	3.718438256
Z1-EU29W-405 + Dup	S	REG	26 *		=	0.17	26	3.258096538
Z1-EU29W-406	S	REG	23.6 *		=	0.16	23.6	3.161246712
Z1-EU29W-407	S	REG	38.3 *		=	0.18	38.3	3.645449896
Z1-EU29W-408	S	REG	24.6 *		=	0.18	24.6	3.202746443
Z1-EU29W-409	S	REG	30.5 *		=	0.17	30.5	3.417726684
Z1-EU30BW-411	B	REG	179 *		=	0.17	179	5.187385806
Z1-EU30C-444	C	REG	9.7		=	0.2	9.7	2.272125886
Z1-EU30C-445	C	REG	10.8		=	0.17	10.8	2.379546134
Z1-EU30C-446	C	REG	11.9		=	0.21	11.9	2.4765384
Z1-EU30C-447	C	REG	16.9		=	0.21	16.9	2.827313622
Z1-EU30C-448 + Dup	C	FR	11.3		=	0.19	11.3	2.424802726
Z1-EU30C-449	C	REG	10.8		=	0.2	10.8	2.379546134
Z1-EU30C-450	C	REG	12.2		=	0.2	12.2	2.501435952
Z1-EU30C-451	C	REG	9.9		=	0.2	9.9	2.292534757
Z1-EU30C-452	C	REG	9.9		=	0.2	9.9	2.292534757
Z1-EU30C-453	C	REG	11.5		=	0.21	11.5	2.442347035
Z1-EU30C-454	C	REG	12.6		=	0.2	12.6	2.533696814
Z1-EU31BW-415	B	REG	46.6 *		=	0.18	46.6	3.841600541
Z1-EU31BW-416	B	REG	32.5 *		=	0.19	32.5	3.481240089
Z1-EU31BW-417	B	REG	2880 *		=	0.16	2880	7.965545573
Z1-EU31W-412	S	REG	12.9 *		=	0.18	12.9	2.557227311
Z1-EU31W-413	S	REG	402 *		=	0.15	402	5.996452089
Z1-EU31W-414	S	REG	35.1 *		=	0.18	35.1	3.55820113
Z1-EU32BW-431	B	REG	68.5	N *	=	0.17	68.5	4.226833745
Z1-EU32BW-432	B	REG	53.6	N *	=	0.16	53.6	3.981549068
Z1-EU32BW-433 + Dup	B	FR	22.5	N *	=	0.18	22.5	3.113515309
Z1-EU32BW-434	B	REG	20.5 *		=	0.16	20.5	3.020424886
Z1-EU32C-455	C	REG	12.1		=	0.2	12.1	2.493205453
Z1-EU32C-456	C	REG	10		=	0.21	10	2.302585093
Z1-EU32MW-420	S	REG	33.2		=	0.17	33.2	3.502549876
Z1-EU32MW-426	S	REG	54.4		=	0.18	54.4	3.996364154
Z1-EU32W-418	S	REG	21.9		=	0.21	21.9	3.086486637
Z1-EU32W-419 + Dup	S	REG	85		=	0.17	85	4.442651256
Z1-EU32W-421	S	REG	45.8		=	0.18	45.8	3.824284091
Z1-EU32W-422	S	REG	91		=	0.16	91	4.510859507
Z1-EU32W-423	S	REG	329		=	0.17	329	5.796057751
Z1-EU32W-424	S	REG	15.6		=	0.18	15.6	2.747270914
Z1-EU32W-425	S	REG	36.9		=	0.18	36.9	3.608211551
Z1-EU32W-427	S	REG	16		=	0.17	16	2.772588722
Z1-EU32W-428	S	REG	19.7		=	0.19	19.7	2.980618636
Z1-EU32W-429	S	REG	13.7		=	0.17	13.7	2.617395833
Z1-EU32W-430	S	REG	27.8	N *	J	0.15	27.8	3.325036021
Z1-EU33BW-443	B	REG	102 *		=	0.17	102	4.624972813
Z1-EU33BW-444	B	REG	23.2	N *	=	0.17	23.2	3.144152279
Z1-EU33C-457	C	REG	27.8		=	0.2	27.8	3.325036021
Z1-EU33W-435	S	REG	19.8	N *	=	0.18	19.8	2.985681938
Z1-EU33W-436	S	REG	16	N *	=	0.18	16	2.772588722
Z1-EU33W-437	S	REG	123	N *	=	0.2	123	4.812184355
Z1-EU33W-438	S	REG	106	N *	=	0.18	106	4.663439094
Z1-EU33W-439	S	REG	70.4	N *	=	0.16	70.4	4.254193263
Z1-EU33W-440	S	REG	228	N *	=	0.17	228	5.429345629
Z1-EU33W-441	S	REG	76.6	N *	=	0.16	76.6	4.338597077

Number of Samples	57
Number of Detects	57
Minimum	9.7
Median	26
Maximum	2880
Average	102.73509
Standard Deviation	381.67197
PERT-Beta Mean	498.95
Lognormal Mean	3.5200159
Lognormal Standard Deviation	1.108872

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Cr mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	53

Raw Statistics		**Log-transformed Statistics**	
Minimum	9.7	Minimum of Log Data	2.272
Maximum	2880	Maximum of Log Data	7.966
Mean	102.7	Mean of log Data	3.52
Median	26	SD of log Data	1.109
SD	381.7		
Coefficient of Variation	3.715		
Skewness	7.136		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.404	Lilliefors Test Statistic	0.13
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	187.3	95% H-UCL	183.2
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	109.2
95% Adjusted-CLT UCL	236.9	97.5% Chebyshev (MVUE) UCL	129.9
95% Modified-t UCL	195.3	99% Chebyshev (MVUE) UCL	170.6

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.543	Data do not follow a Discernable Distribution (0.05)	
Theta Star	189.1		
nu star	61.94		
Approximate Chi Square Value (.05)	44.84	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	185.9
Adjusted Chi Square Value	44.46	95% Jackknife UCL	187.3
		95% Standard Bootstrap UCL	184.8
Anderson-Darling Test Statistic	6.481	95% Bootstrap-t UCL	530.4
Anderson-Darling 5% Critical Value	0.81	95% Hall's Bootstrap UCL	454.9
Kolmogorov-Smirnov Test Statistic	0.242	95% Percentile Bootstrap UCL	202.7
Kolmogorov-Smirnov 5% Critical Value	0.124	95% BCA Bootstrap UCL	263.2
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	323.1
		97.5% Chebyshev(Mean, Sd) UCL	418.4
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	605.7
95% Approximate Gamma UCL	141.9		
95% Adjusted Gamma UCL	143.1		

		Potential UCL to Use						Use 97.5% Chebyshev (Mean, Sd) UCL			418.4

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Chromium (mg/kg)	9.7000	26	2880	498.95	1319.51	2.64	1319.51	1.02	4.98	200613.4679	2870.3

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ is the Beta Function and $B_z(\alpha_1,\alpha_2)$ is the Incomplete Beta Function

α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Chromium mg/L

Location ID	Sample Lot	Sample Type	Result (ug/L)	Result Qualifier	Validation	Detection Limit (ug/L)	Proxy Value (mg/L)	LN Proxy Value
Z1-EU29BW-410		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU29W-401		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU29W-402		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU29W-403		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU29W-404		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU29W-405 + Dup		FR	7.3	B	=	4.6	0.0073	-4.919880931
Z1-EU29W-406		REG	6.8	B	=	4.6	0.0068	-4.990832667
Z1-EU29W-407		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU29W-408		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU29W-409		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU30BW-411		REG	4.9	B	=	4.6	0.0049	-5.318520074
Z1-EU31BW-415		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU31BW-416		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU31BW-417		REG	6	B	=	4.6	0.006	-5.11599581
Z1-EU31W-412		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU31W-413		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU31W-414		REG	7.7	B	=	4.6	0.0077	-4.86653495
Z1-EU32BW-431		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32BW-432		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32BW-433 + Dup		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32BW-434		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU32MW-420		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32MW-426		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32W-418		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32W-419 + Dup		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32W-421		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32W-422		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32W-423		REG	12.3	B	=	12	0.0123	-4.398156017
Z1-EU32W-424		REG	30.1	B	=	12	0.0301	-3.503230107
Z1-EU32W-425		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32W-427		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32W-428		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32W-429		REG	12	U	U	12	0.006	-5.11599581
Z1-EU32W-430		REG	12	U	U	12	0.006	-5.11599581
Z1-EU33BW-443		REG	4.6	U	U	4.6	0.0023	-6.074846156
Z1-EU33BW-444		REG	12	U	U	12	0.006	-5.11599581
Z1-EU33W-435		REG	12	U	U	12	0.006	-5.11599581
Z1-EU33W-436		REG	12	U	U	12	0.006	-5.11599581
Z1-EU33W-437		REG	12	U	U	12	0.006	-5.11599581
Z1-EU33W-438		REG	12	U	U	12	0.006	-5.11599581
Z1-EU33W-439		REG	12	U	U	12	0.006	-5.11599581
Z1-EU33W-440		REG	12	U	U	12	0.006	-5.11599581
Z1-EU33W-441		REG	12	U	U	12	0.006	-5.11599581

Number of Samples	43
Number of Detects	7
Minimum	0.0023
Median	0.006
Maximum	0.0301
Average	0.0055651
Standard Deviation	0.0043928
PERT-Beta Mean	0.0094
Lognormal Mean	-5.365416
Lognormal Standard Deviation	0.5663194

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Cr mg/L

General Statistics

Number of Valid Observations	43	Number of Distinct Observations	8

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.0023	Minimum of Log Data	-6.075
Maximum	0.0301	Maximum of Log Data	-3.503
Mean	0.00557	Mean of log Data	-5.365
Median	0.006	SD of log Data	0.566
SD	0.00439		
Coefficient of Variation	0.789		
Skewness	4.303		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.526	Shapiro Wilk Test Statistic	0.763
Shapiro Wilk Critical Value	0.943	Shapiro Wilk Critical Value	0.943
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.00669	95% H-UCL	0.0065
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.00765
95% Adjusted-CLT UCL	0.00714	97.5% Chebyshev (MVUE) UCL	0.00859
95% Modified-t UCL	0.00677	99% Chebyshev (MVUE) UCL	0.0105
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	2.831	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.00197		
nu star	243.5		
Approximate Chi Square Value (.05)	208.4	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0444	95% CLT UCL	0.00667
Adjusted Chi Square Value	207.2	95% Jackknife UCL	0.00669
		95% Standard Bootstrap UCL	0.00665
Anderson-Darling Test Statistic	4.425	95% Bootstrap-t UCL	0.00767
Anderson-Darling 5% Critical Value	0.755	95% Hall's Bootstrap UCL	0.0118
Kolmogorov-Smirnov Test Statistic	0.278	95% Percentile Bootstrap UCL	0.00672
Kolmogorov-Smirnov 5% Critical Value	0.136	95% BCA Bootstrap UCL	0.00727
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.00849
		97.5% Chebyshev(Mean, Sd) UCL	0.00975
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	0.0122
95% Approximate Gamma UCL	0.0065		
95% Adjusted Gamma UCL	0.00654		

		Potential UCL to Use						Use 95% Chebyshev (Mean, Sd) UCL			0.00849

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT							Calculations				
	STEP 10	STEP 11	STEP 12		OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)		0.95	α_1	α_2	Variance	Max - Min
Chromium (mg/L)	0.0023	0.006	0.0301	0.01	0.02	1.93		0.02	1.53	4.47	0.0000	0.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_z(\alpha_1, \alpha_2)$ is the Incomplete Beta Function

α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Cobalt mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	15.4		=	0.18	15.4	2.734367509
Z1-EU29W-401	S	REG	5.3		=	0.16	5.3	1.667706821
Z1-EU29W-402	S	REG	9.1		=	0.19	9.1	2.208274414
Z1-EU29W-403	S	REG	5.7		=	0.16	5.7	1.740466175
Z1-EU29W-404	S	REG	9.5		=	0.18	9.5	2.251291799
Z1-EU29W-405 + Dup	S	REG	7.2		=	0.17	7.2	1.974081026
Z1-EU29W-406	S	REG	4.4		=	0.16	4.4	1.481604541
Z1-EU29W-407	S	REG	14.9		=	0.18	14.9	2.701361213
Z1-EU29W-408	S	REG	4.5		=	0.18	4.5	1.504077397
Z1-EU29W-409	S	REG	9.5		=	0.17	9.5	2.251291799
Z1-EU30BW-411	B	REG	11.3		=	0.17	11.3	2.424802726
Z1-EU30C-444	C	REG	3.1		=	0.2	3.1	1.131402111
Z1-EU30C-445	C	REG	1.5		=	0.17	1.5	0.405465108
Z1-EU30C-446	C	REG	5.2		=	0.21	5.2	1.648658626
Z1-EU30C-447	C	REG	2.5		=	0.21	2.5	0.916290732
Z1-EU30C-448 + Dup	C	FR	3.7		=	0.19	3.7	1.30833282
Z1-EU30C-449	C	REG	3.9		=	0.2	3.9	1.360976553
Z1-EU30C-450	C	REG	2.2		=	0.2	2.2	0.78845736
Z1-EU30C-451	C	REG	3.5		=	0.2	3.5	1.252762968
Z1-EU30C-452	C	REG	2.2		=	0.2	2.2	0.78845736
Z1-EU30C-453	C	REG	2.8		=	0.21	2.8	1.029619417
Z1-EU30C-454	C	REG	2.6		=	0.2	2.6	0.955511445
Z1-EU31BW-415	B	REG	9.1		=	0.18	9.1	2.208274414
Z1-EU31BW-416	B	REG	7.7		=	0.19	7.7	2.041220329
Z1-EU31BW-417	B	REG	11.7		=	0.16	11.7	2.459588842
Z1-EU31W-412	S	REG	3.9		=	0.18	3.9	1.360976553
Z1-EU31W-413	S	REG	15.2		=	0.15	15.2	2.721295428
Z1-EU31W-414	S	REG	9.7		=	0.18	9.7	2.272125886
Z1-EU32BW-431	B	REG	12.5		=	0.17	12.5	2.525728644
Z1-EU32BW-432	B	REG	10.4		=	0.16	10.4	2.341805806
Z1-EU32BW-433 + Dup	B	REG	14.7		=	0.17	14.7	2.687847494
Z1-EU32BW-434	B	REG	5.8		=	0.16	5.8	1.757857918
Z1-EU32C-455	C	REG	2.2		=	0.2	2.2	0.78845736
Z1-EU32C-456	C	REG	2		=	0.21	2	0.693147181
Z1-EU32MW-420	S	REG	8.5		=	0.17	8.5	2.140066163
Z1-EU32MW-426	S	REG	9.3		=	0.18	9.3	2.2300144
Z1-EU32W-418	S	REG	4		=	0.21	4	1.386294361
Z1-EU32W-419 + Dup	S	FR	11.3		=	0.17	11.3	2.424802726
Z1-EU32W-421	S	REG	10.1		=	0.18	10.1	2.312535424
Z1-EU32W-422	S	REG	9.1		=	0.16	9.1	2.208274414
Z1-EU32W-423	S	REG	9.1		=	0.17	9.1	2.208274414
Z1-EU32W-424	S	REG	10.2		=	0.18	10.2	2.32238772
Z1-EU32W-425	S	REG	6.7		=	0.18	6.7	1.902107526
Z1-EU32W-427	S	REG	13.6		=	0.17	13.6	2.610069793
Z1-EU32W-428	S	REG	5.9		=	0.19	5.9	1.774952351
Z1-EU32W-429	S	REG	8.5		=	0.17	8.5	2.140066163
Z1-EU32W-430	S	REG	9		=	0.15	9	2.197224577
Z1-EU33BW-443	B	REG	20.9		=	0.17	20.9	3.039749159
Z1-EU33BW-444	B	REG	9.2		=	0.17	9.2	2.219203484
Z1-EU33C-457	C	REG	3.3		=	0.2	3.3	1.193922468
Z1-EU33W-435	S	REG	11.2		=	0.18	11.2	2.415913778
Z1-EU33W-436	S	REG	8		=	0.18	8	2.079441542
Z1-EU33W-437	S	REG	16.6		=	0.2	16.6	2.809402695
Z1-EU33W-438	S	REG	41.9		=	0.18	41.9	3.735285827
Z1-EU33W-439	S	REG	12.1		=	0.16	12.1	2.493205453
Z1-EU33W-440	S	REG	30.3		=	0.17	30.3	3.411147713
Z1-EU33W-441	S	REG	11.8		=	0.16	11.8	2.468099531

Number of Samples	57
Number of Detects	57
Minimum	1.5
Median	9
Maximum	41.9
Average	9.0438596
Standard Deviation	6.8682504
PERT-Beta Mean	13.233333
Lognormal Mean	1.9667724
Lognormal Standard Deviation	0.7054203

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Co mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	48

Raw Statistics		**Log-transformed Statistics**	
Minimum	1.5	Minimum of Log Data	0.405
Maximum	41.9	Maximum of Log Data	3.735
Mean	9.044	Mean of log Data	1.967
Median	9	SD of log Data	0.705
SD	6.868		
Coefficient of Variation	0.759		
Skewness	2.525		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.153	Lilliefors Test Statistic	0.141
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	10.57	95% H-UCL	11.09
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	13.2
95% Adjusted-CLT UCL	10.87	97.5% Chebyshev (MVUE) UCL	14.96
95% Modified-t UCL	10.62	99% Chebyshev (MVUE) UCL	18.43

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	2.169	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	4.169		
nu star	247.3		
Approximate Chi Square Value (.05)	211.9	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	10.54
Adjusted Chi Square Value	211.1	95% Jackknife UCL	10.57
		95% Standard Bootstrap UCL	10.53
Anderson-Darling Test Statistic	0.641	95% Bootstrap-t UCL	11.08
Anderson-Darling 5% Critical Value	0.761	95% Hall's Bootstrap UCL	11.71
Kolmogorov-Smirnov Test Statistic	0.096	95% Percentile Bootstrap UCL	10.52
Kolmogorov-Smirnov 5% Critical Value	0.119	95% BCA Bootstrap UCL	10.86
·ta appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	13.01
		97.5% Chebyshev(Mean, Sd) UCL	14.73
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	18.1
95% Approximate Gamma UCL	10.56		
95% Adjusted Gamma UCL	10.6		

		Potential UCL to Use						Use 95% Approximate Gamma UCL			10.56

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Cobalt (mg/kg)	1.5000	9	41.9	13.23	26.16	1.98	26.16	1.74	4.26	67.7181	40.4

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \qquad MIN < Most\,likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_z(\alpha_1, \alpha_2)$ is the Incomplete Beta Function
α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®™ function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Copper mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	135	N *	=	0.18	135	4.905274778
Z1-EU29W-401	S	REG	270	N *	J	0.16	270	5.598421959
Z1-EU29W-402	S	REG	73.8	N *	=	0.19	73.8	4.301358732
Z1-EU29W-403	S	REG	36.7	N *	=	0.16	36.7	3.602776755
Z1-EU29W-404	S	REG	218	N *	=	0.17	218	5.384495063
Z1-EU29W-405 + Dup	S	FR	155	N *	=	0.16	155	5.043425117
Z1-EU29W-406	S	REG	19.9	N *	=	0.16	19.9	2.990719732
Z1-EU29W-407	S	REG	313	N *	=	0.18	313	5.746203191
Z1-EU29W-408	S	REG	13.7	N *	=	0.18	13.7	2.617395833
Z1-EU29W-409	S	REG	162	N *	=	0.17	162	5.087596335
Z1-EU30BW-411	B	REG	222	N *	=	0.17	222	5.402677382
Z1-EU30C-444	C	REG	14.2		=	0.2	14.2	2.653241965
Z1-EU30C-445	C	REG	3.5		=	0.17	3.5	1.252762968
Z1-EU30C-446	C	REG	5		=	0.21	5	1.609437912
Z1-EU30C-447	C	REG	5.6		=	0.21	5.6	1.722766598
Z1-EU30C-448 + Dup	C	REG	14.9		=	0.19	14.9	2.701361213
Z1-EU30C-449	C	REG	20.2		=	0.2	20.2	3.005682604
Z1-EU30C-450	C	REG	5.3		=	0.2	5.3	1.667706821
Z1-EU30C-451	C	REG	16.6		=	0.2	16.6	2.809402695
Z1-EU30C-452	C	REG	8.3		=	0.2	8.3	2.116255515
Z1-EU30C-453	C	REG	14.5		=	0.21	14.5	2.674148649
Z1-EU30C-454	C	REG	6		=	0.2	6	1.791759469
Z1-EU31BW-415	B	REG	96.6	N *	=	0.18	96.6	4.570578741
Z1-EU31BW-416	B	REG	172	N *	=	0.19	172	5.147494477
Z1-EU31BW-417	B	REG	189	N *	=	0.16	189	5.241747015
Z1-EU31W-412	S	REG	87.8	N *	=	0.18	87.8	4.475061501
Z1-EU31W-413	S	REG	381	N *	=	0.15	381	5.942799375
Z1-EU31W-414	S	REG	97.1	N *	=	0.18	97.1	4.575741375
Z1-EU32BW-431	B	REG	584	*	=	0.17	584	6.369900983
Z1-EU32BW-432	B	REG	365	*	=	0.16	365	5.899897354
Z1-EU32BW-433 + Dup	B	REG	110	*	=	0.17	110	4.700480366
Z1-EU32BW-434	B	REG	23.2	N *	=	0.16	23.2	3.144152279
Z1-EU32C-455	C	REG	5		=	0.2	5	1.609437912
Z1-EU32C-456	C	REG	4.4		=	0.21	4.4	1.481604541
Z1-EU32MW-420	S	REG	78.7	N *	=	0.17	78.7	4.365643155
Z1-EU32MW-426	S	REG	83	N *	=	0.18	83	4.418840608
Z1-EU32W-418	S	REG	36.1	N *	J	0.21	36.1	3.586292865
Z1-EU32W-419 + Dup	S	FR	270	N *	=	0.17	270	5.598421959
Z1-EU32W-421	S	REG	4780	N *	=	0.18	4780	8.472195825
Z1-EU32W-422	S	REG	150	N *	=	0.16	150	5.010635294
Z1-EU32W-423	S	REG	294	N *	=	0.17	294	5.683579767
Z1-EU32W-424	S	REG	38.7	N *	=	0.18	38.7	3.6558396
Z1-EU32W-425	S	REG	1260	N *	=	0.18	1260	7.138867
Z1-EU32W-427	S	REG	19.7	N *	=	0.17	19.7	2.980618636
Z1-EU32W-428	S	REG	36.9	N *	=	0.19	36.9	3.608211551
Z1-EU32W-429	S	REG	29.5	N *	=	0.17	29.5	3.384390263
Z1-EU32W-430	S	REG	29.3	*	=	0.15	29.3	3.377587516
Z1-EU33BW-443	B	REG	937	N *	=	0.17	937	6.842683282
Z1-EU33BW-444	B	REG	106	*	=	0.17	106	4.663439094
Z1-EU33C-457	C	REG	11		=	0.2	11	2.397895273
Z1-EU33W-435	S	REG	16.7	*	=	0.18	16.7	2.815408719
Z1-EU33W-436	S	REG	30	*	=	0.18	30	3.401197382
Z1-EU33W-437	S	REG	1250	*	=	0.2	1250	7.13089883
Z1-EU33W-438	S	REG	1970	*	=	0.18	1970	7.585788822
Z1-EU33W-439	S	REG	352	*	=	0.16	352	5.863631176
Z1-EU33W-440	S	REG	455	*	=	0.17	455	6.120297419
Z1-EU33W-441	S	REG	136	*	=	0.16	136	4.912654886

Number of Samples	57
Number of Detects	57
Minimum	3.5
Median	83
Maximum	4780
Average	284.52456
Standard Deviation	704.2613
PERT-Beta Mean	852.58333
Lognormal Mean	4.2255927
Lognormal Standard Deviation	1.7216562

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Cu mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	55

Raw Statistics		**Log-transformed Statistics**	
Minimum	3.5	Minimum of Log Data	1.253
Maximum	4780	Maximum of Log Data	8.472
Mean	284.5	Mean of log Data	4.226
Median	83	SD of log Data	1.722
SD	704.3		
Coefficient of Variation	2.475		
Skewness	5.15		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.345	Lilliefors Test Statistic	0.0858
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	440.5	95% H-UCL	592.5
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	680.6
95% Adjusted-CLT UCL	506	97.5% Chebyshev (MVUE) UCL	852.4
95% Modified-t UCL	451.1	99% Chebyshev (MVUE) UCL	1190
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.441	Data appear Lognormal at 5% Significance Level	
Theta Star	645.9		
nu star	50.22		
Approximate Chi Square Value (.05)	34.95	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	438
Adjusted Chi Square Value	34.62	95% Jackknife UCL	440.5
		95% Standard Bootstrap UCL	438.1
Anderson-Darling Test Statistic	2.057	95% Bootstrap-t UCL	633.5
Anderson-Darling 5% Critical Value	0.827	95% Hall's Bootstrap UCL	1014
Kolmogorov-Smirnov Test Statistic	0.142	95% Percentile Bootstrap UCL	447.6
Kolmogorov-Smirnov 5% Critical Value	0.125	95% BCA Bootstrap UCL	546.4
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	691.1
		97.5% Chebyshev(Mean, Sd) UCL	867.1
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1213
95% Approximate Gamma UCL	408.9		
95% Adjusted Gamma UCL	412.8		

		Potential UCL to Use								Use 95% H-UCL	592.5

Statistical Summary for Iron mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	30700	N *	=	10.8	30700	10.33201793
Z1-EU29W-401	S	REG	22000	N *	J	9.4	22000	9.998797732
Z1-EU29W-402	S	REG	35600	N *	=	11.5	35600	10.48010092
Z1-EU29W-403	S	REG	28400	N *	=	9.6	28400	10.25414442
Z1-EU29W-404	S	REG	30800	N *	=	10.8	30800	10.33526997
Z1-EU29W-405 + Dup	S	REG	18900	N *	=	10.2	18900	9.846917201
Z1-EU29W-406	S	REG	31800	N *	=	9.5	31800	10.36722157
Z1-EU29W-407	S	REG	40800	N *	=	11	40800	10.61643736
Z1-EU29W-408	S	REG	31000	N *	=	10.5	31000	10.34174248
Z1-EU29W-409	S	REG	35800	N *	=	10.3	35800	10.48570317
Z1-EU30BW-411	B	REG	26400	N *	=	10.4	26400	10.18111929
Z1-EU30C-444	C	REG	7990	N	=	4.4	7990	8.985946039
Z1-EU30C-445	C	REG	5310	N	=	3.9	5310	8.577347114
Z1-EU30C-446	C	REG	5690	N	=	4.6	5690	8.646465527
Z1-EU30C-447	C	REG	8090	N	=	4.7	8090	8.99838401
Z1-EU30C-448 + Dup	C	FR	10100	N	=	4.3	10100	9.220290703
Z1-EU30C-449	C	REG	9930	N	=	4.5	9930	9.203315757
Z1-EU30C-450	C	REG	5950	N	=	4.5	5950	8.691146499
Z1-EU30C-451	C	REG	9710	N	=	4.5	9710	9.180911561
Z1-EU30C-452	C	REG	4630	N	=	4.5	4630	8.440312147
Z1-EU30C-453	C	REG	7630	N	=	4.8	7630	8.939843124
Z1-EU30C-454	C	REG	8290	N	=	4.6	8290	9.022805248
Z1-EU31BW-415	B	REG	42600	N *	=	10.8	42600	10.65960953
Z1-EU31BW-416	B	REG	35300	N *	=	11.2	35300	10.47163824
Z1-EU31BW-417	B	REG	49400	N *	=	9.7	49400	10.8077057
Z1-EU31W-412	S	REG	17800	N *	=	10.7	17800	9.786953736
Z1-EU31W-413	S	REG	25700	N *	=	9.3	25700	10.15424627
Z1-EU31W-414	S	REG	34300	N *	=	11	34300	10.44290063
Z1-EU32BW-431	B	REG	35100	N	=	3.8	35100	10.46595641
Z1-EU32BW-432	B	REG	48600	N	=	10.6	48600	10.79137881
Z1-EU32BW-433 + Dup	B	REG	26900	N	=	3.9	26900	10.19988157
Z1-EU32BW-434	B	REG	20100	N *	=	9.5	20100	9.908475094
Z1-EU32C-455	C	REG	7780	N	=	4.6	7780	8.959311617
Z1-EU32C-456	C	REG	6210	N	=	4.8	6210	8.733916175
Z1-EU32MW-420	S	REG	18800	N	=	3.4	18800	9.841612149
Z1-EU32MW-426	S	REG	60900	N	=	10.9	60900	11.01698845
Z1-EU32W-418	S	REG	18400	N	=	4.2	18400	9.820105944
Z1-EU32W-419 + Dup	S	REG	51200	N	=	10.2	51200	10.84349481
Z1-EU32W-421	S	REG	49100		=	10.9	49100	10.80161431
Z1-EU32W-422	S	REG	41100	N	=	3.3	41100	10.6237634
Z1-EU32W-423	S	REG	27600	N	=	3.3	27600	10.22557105
Z1-EU32W-424	S	REG	18500	N	=	3.6	18500	9.825526011
Z1-EU32W-425	S	REG	34100	N	=	3.7	34100	10.43705266
Z1-EU32W-427	S	REG	19300	N	=	3.4	19300	9.867860375
Z1-EU32W-428	S	REG	24700	N	=	3.8	24700	10.11455852
Z1-EU32W-429	S	REG	18700	N	=	3.4	18700	9.836278803
Z1-EU32W-430	S	REG	15500	N	=	3.4	15500	9.648595303
Z1-EU33BW-443	B	REG	49100	N *	=	10.1	49100	10.80161431
Z1-EU33BW-444	B	REG	20400	N	=	3.9	20400	9.92329018
Z1-EU33C-457	C	REG	8120	N	=	4.4	8120	9.002085433
Z1-EU33W-435	S	REG	20800	N	=	4	20800	9.942708266
Z1-EU33W-436	S	REG	17600	N	=	4	17600	9.775654181
Z1-EU33W-437	S	REG	30000	N	=	4.5	30000	10.30895266
Z1-EU33W-438	S	REG	68600	N	=	11.9	68600	11.13604781
Z1-EU33W-439	S	REG	22500	N	=	3.7	22500	10.02127059
Z1-EU33W-440	S	REG	155000	N	=	22.8	155000	11.9511804
Z1-EU33W-441	S	REG	28900	N	=	3.6	28900	10.27159687

Number of Samples	57
Number of Detects	57
Minimum	4630
Median	24700
Maximum	155000
Average	27793.509
Standard Deviation	22797.249
PERT-Beta Mean	43071.667
Lognormal Mean	9.9748357
Lognormal Standard Deviation	0.7420704

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Fe mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	56

Raw Statistics

Minimum	4630
Maximum	155000
Mean	27794
Median	24700
SD	22797
Coefficient of Variation	0.82
Skewness	3.273

Log-transformed Statistics

Minimum of Log Data	8.44
Maximum of Log Data	11.95
Mean of log Data	9.975
SD of log Data	0.742

Relevant UCL Statistics

Normal Distribution Test

Lilliefors Test Statistic	0.17
Lilliefors Critical Value	0.117

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Lilliefors Test Statistic	0.131
Lilliefors Critical Value	0.117

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	32844

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	34159
95% Modified-t UCL	33062

Assuming Lognormal Distribution

95% H-UCL	34656
95% Chebyshev (MVUE) UCL	41459
97.5% Chebyshev (MVUE) UCL	47232
99% Chebyshev (MVUE) UCL	58573

Gamma Distribution Test

k star (bias corrected)	1.993
Theta Star	13945
nu star	227.2
Approximate Chi Square Value (.05)	193.3
Adjusted Level of Significance	0.0458
Adjusted Chi Square Value	192.5
Anderson-Darling Test Statistic	0.612
Anderson-Darling 5% Critical Value	0.762
Kolmogorov-Smirnov Test Statistic	0.091
Kolmogorov-Smirnov 5% Critical Value	0.119

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	32760
95% Jackknife UCL	32844
95% Standard Bootstrap UCL	32642
95% Bootstrap-t UCL	35204
95% Hall's Bootstrap UCL	53949
95% Percentile Bootstrap UCL	33051
95% BCA Bootstrap UCL	34674
95% Chebyshev(Mean, Sd) UCL	40956
97.5% Chebyshev(Mean, Sd) UCL	46651
99% Chebyshev(Mean, Sd) UCL	57838

Assuming Gamma Distribution

95% Approximate Gamma UCL	32666
95% Adjusted Gamma UCL	32803

		Potential UCL to Use						Use 95% Approximate Gamma UCL			32666

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter Input values in yellow shaded cells
Report OUTPUT UCL-95

SRC	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Iron (mg/kg)	4630.0000	24700	155000	43071.67	90299.55	2.10	90299.55	1.53	4.47	###########	150370.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ *is the Beta Function and* $B_z(\alpha_1,\alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95 α_1 α_2 MIN MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Lead mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	54.2 *		=	0.27	54.2	3.992680908
Z1-EU29W-401	S	REG	50.2 *		=	0.23	50.2	3.916015027
Z1-EU29W-402	S	REG	52.2 *		=	0.29	52.2	3.955082495
Z1-EU29W-403	S	REG	22.7 *		=	0.24	22.7	3.122364924
Z1-EU29W-404	S	REG	148 *		=	0.27	148	4.997212274
Z1-EU29W-405 + Dup	S	REG	54.2 *		=	0.26	54.2	3.992680908
Z1-EU29W-406	S	REG	17.8 *		=	0.24	17.8	2.879198457
Z1-EU29W-407	S	REG	161 *		=	0.27	161	5.081404365
Z1-EU29W-408	S	REG	14.1 *		=	0.26	14.1	2.646174797
Z1-EU29W-409	S	REG	36.6 *		=	0.26	36.6	3.60004824
Z1-EU30BW-411	B	REG	84 *		=	0.26	84	4.430816799
Z1-EU30C-444	C	REG	3.5		=	0.3	3.5	1.252762968
Z1-EU30C-445	C	REG	3		=	0.26	3	1.098612289
Z1-EU30C-446	C	REG	8.2		=	0.31	8.2	2.104134154
Z1-EU30C-447	C	REG	3.5		=	0.31	3.5	1.252762968
Z1-EU30C-448 + Dup	C	FR	3.2		=	0.28	3.2	1.16315081
Z1-EU30C-449	C	REG	3.8		=	0.3	3.8	1.335001067
Z1-EU30C-450	C	REG	5.3		=	0.3	5.3	1.667706821
Z1-EU30C-451	C	REG	3.2		=	0.3	3.2	1.16315081
Z1-EU30C-452	C	REG	5.3		=	0.3	5.3	1.667706821
Z1-EU30C-453	C	REG	9.4		=	0.32	9.4	2.240709689
Z1-EU30C-454	C	REG	4		=	0.3	4	1.386294361
Z1-EU31BW-415	B	REG	27.5 *		=	0.27	27.5	3.314186005
Z1-EU31BW-416	B	REG	30.7 *		=	0.28	30.7	3.424262655
Z1-EU31BW-417	B	REG	30.4 *		=	0.24	30.4	3.414442608
Z1-EU31W-412	S	REG	17.8 *		=	0.27	17.8	2.879198457
Z1-EU31W-413	S	REG	76.9 *		=	0.23	76.9	4.342505877
Z1-EU31W-414	S	REG	23.7 *		=	0.27	23.7	3.165475048
Z1-EU32BW-431	B	REG	733 *		=	0.26	733	6.597145702
Z1-EU32BW-432	B	REG	78.4 *		=	0.23	78.4	4.361823927
Z1-EU32BW-433 + Dup	B	REG	49.5 *		=	0.26	49.5	3.90197267
Z1-EU32BW-434	B	REG	18.6 *		=	0.24	18.6	2.923161581
Z1-EU32C-455	C	REG	5.6		=	0.31	5.6	1.722766598
Z1-EU32C-456	C	REG	2.9		=	0.32	2.9	1.064710737
Z1-EU32MW-420	S	REG	84.3		=	0.26	84.3	4.434381865
Z1-EU32MW-426	S	REG	59.4		=	0.27	59.4	4.084294226
Z1-EU32W-418	S	REG	41.8		=	0.32	41.8	3.73289634
Z1-EU32W-419 + Dup	S	REG	137		=	0.26	137	4.919980926
Z1-EU32W-421	S	REG	99.3		=	0.27	99.3	4.598145571
Z1-EU32W-422	S	REG	98		=	0.25	98	4.584967479
Z1-EU32W-423	S	REG	57.6		=	0.25	57.6	4.053522568
Z1-EU32W-424	S	REG	23.1		=	0.27	23.1	3.139832618
Z1-EU32W-425	S	REG	62.9		=	0.28	62.9	4.141546164
Z1-EU32W-427	S	REG	31.6		=	0.26	31.6	3.453157121
Z1-EU32W-428	S	REG	26.1		=	0.28	26.1	3.261935314
Z1-EU32W-429	S	REG	58		=	0.26	58	4.060443011
Z1-EU32W-430	S	REG	40.6 *		J	0.23	40.6	3.703768067
Z1-EU33BW-443	B	REG	175 *		=	0.25	175	5.164785974
Z1-EU33BW-444	B	REG	29.5 *		=	0.26	29.5	3.384390263
Z1-EU33C-457	C	REG	11.3		=	0.29	11.3	2.424802726
Z1-EU33W-435	S	REG	24.3 *		=	0.27	24.3	3.19047635
Z1-EU33W-436	S	REG	37.7 *		=	0.27	37.7	3.629660094
Z1-EU33W-437	S	REG	88.6 *		=	0.3	88.6	4.484131858
Z1-EU33W-438	S	REG	187 *		=	0.26	187	5.231108617
Z1-EU33W-439	S	REG	44.5 *		=	0.25	44.5	3.795489189
Z1-EU33W-440	S	REG	93.4 *		=	0.25	93.4	4.536891345
Z1-EU33W-441	S	REG	101 *		=	0.24	101	4.615120517

Number of Samples	57
Number of Detects	57
Minimum	2.9
Median	36.6
Maximum	733
Average	60.603509
Standard Deviation	101.54869
PERT-Beta Mean	147.05
Lognormal Mean	3.3804044
Lognormal Standard Deviation	1.2792784

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Pb mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	52

Raw Statistics		**Log-transformed Statistics**	
Minimum	2.9	Minimum of Log Data	1.065
Maximum	733	Maximum of Log Data	6.597
Mean	60.6	Mean of log Data	3.38
Median	36.6	SD of log Data	1.279
SD	101.5		
Coefficient of Variation	1.676		
Skewness	5.421		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.285	Lilliefors Test Statistic	0.104
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	83.1	95% H-UCL	97.11
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	125.9
95% Adjusted-CLT UCL	93.05	97.5% Chebyshev (MVUE) UCL	152.2
95% Modified-t UCL	84.71	99% Chebyshev (MVUE) UCL	204

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.786	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	77.09		
nu star	89.62		
Approximate Chi Square Value (.05)	68.79	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	82.73
Adjusted Chi Square Value	68.32	95% Jackknife UCL	83.1
		95% Standard Bootstrap UCL	82.3
Anderson-Darling Test Statistic	0.684	95% Bootstrap-t UCL	106.9
Anderson-Darling 5% Critical Value	0.789	95% Hall's Bootstrap UCL	172.7
Kolmogorov-Smirnov Test Statistic	0.0887	95% Percentile Bootstrap UCL	84.54
Kolmogorov-Smirnov 5% Critical Value	0.122	95% BCA Bootstrap UCL	95.98
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	119.2
		97.5% Chebyshev(Mean, Sd) UCL	144.6
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	194.4
95% Approximate Gamma UCL	78.95		
95% Adjusted Gamma UCL	79.5		

		Potential UCL to Use						Use 95% Approximate Gamma UCL			78.95

Statistical Summary for Lead mg/L

Location ID	Sample Lot	Sample Type	Result (ug/L)	Result Qualifier	Validation	Detection Limit (ug/L)	Proxy Value (mg/L)	LN Proxy Value
Z1-EU29BW-410		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU29W-401		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU29W-402		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU29W-403		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU29W-404		REG	66.2		=	34.8	0.0662	-2.715074816
Z1-EU29W-405 + Dup		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU29W-406		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU29W-407		REG	83.4		=	34.8	0.0834	-2.48410697
Z1-EU29W-408		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU29W-409		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU30BW-411		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU31BW-415		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU31BW-416		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU31BW-417		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU31W-412		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU31W-413		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU31W-414		REG	37.7		=	34.8	0.0377	-3.278095185
Z1-EU32BW-431		REG	599		=	18	0.599	-0.512493681
Z1-EU32BW-432		REG	18	U	U	18	0.009	-4.710530702
Z1-EU32BW-433 + Dup		REG	249		=	18	0.249	-1.390302383
Z1-EU32BW-434		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU32MW-420		REG	18	U	U	18	0.009	-4.710530702
Z1-EU32MW-426		REG	18	U	U	18	0.009	-4.710530702
Z1-EU32W-418		REG	56.5	B	=	18	0.0565	-2.873514641
Z1-EU32W-419 + Dup		FR	26.1	B	=	18	0.0261	-3.645819965
Z1-EU32W-421		REG	273		=	18	0.273	-1.298283484
Z1-EU32W-422		REG	18	U	U	18	0.009	-4.710530702
Z1-EU32W-423		REG	18	U	U	18	0.009	-4.710530702
Z1-EU32W-424		REG	18	U	U	18	0.009	-4.710530702
Z1-EU32W-425		REG	18	U	U	18	0.009	-4.710530702
Z1-EU32W-427		REG	18	U	U	18	0.009	-4.710530702
Z1-EU32W-428		REG	18	U	U	18	0.009	-4.710530702
Z1-EU32W-429		REG	18	U	U	18	0.009	-4.710530702
Z1-EU32W-430		REG	34.2	B	=	18	0.0342	-3.375529635
Z1-EU33BW-443		REG	34.8	U	U	34.8	0.0174	-4.051285073
Z1-EU33BW-444		REG	18	U	U	18	0.009	-4.710530702
Z1-EU33W-435		REG	21.2	B	=	18	0.0212	-3.853754097
Z1-EU33W-436		REG	18	U	U	18	0.009	-4.710530702
Z1-EU33W-437		REG	18	U	U	18	0.009	-4.710530702
Z1-EU33W-438		REG	18	U	U	18	0.009	-4.710530702
Z1-EU33W-439		REG	18	U	U	18	0.009	-4.710530702
Z1-EU33W-440		REG	18	U	U	18	0.009	-4.710530702
Z1-EU33W-441		REG	21.1	B	=	18	0.0211	-3.858482239

Number of Samples	43
Number of Detects	11
Minimum	0.009
Median	0.0174
Maximum	0.599
Average	0.0439488
Standard Deviation	0.102017
PERT-Beta Mean	0.1129333
Lognormal Mean	-3.941268
Lognormal Standard Deviation	0.982463

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Pb mg/L

General Statistics

Number of Valid Observations	43	Number of Distinct Observations	13

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.009	Minimum of Log Data	-4.711
Maximum	0.599	Maximum of Log Data	-0.512
Mean	0.0439	Mean of log Data	-3.941
Median	0.0174	SD of log Data	0.982
SD	0.102		
Coefficient of Variation	2.321		
Skewness	4.485		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.378	Shapiro Wilk Test Statistic	0.731
Shapiro Wilk Critical Value	0.943	Shapiro Wilk Critical Value	0.943
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.0701	95% H-UCL	0.0448
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.0545
95% Adjusted-CLT UCL	0.0809	97.5% Chebyshev (MVUE) UCL	0.0647
95% Modified-t UCL	0.0719	99% Chebyshev (MVUE) UCL	0.0847

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.699	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.0628		
nu star	60.14		
Approximate Chi Square Value (.05)	43.31	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0444	95% CLT UCL	0.0695
Adjusted Chi Square Value	42.81	95% Jackknife UCL	0.0701
		95% Standard Bootstrap UCL	0.0687
Anderson-Darling Test Statistic	6.851	95% Bootstrap-t UCL	0.107
Anderson-Darling 5% Critical Value	0.791	95% Hall's Bootstrap UCL	0.0832
Kolmogorov-Smirnov Test Statistic	0.353	95% Percentile Bootstrap UCL	0.0728
Kolmogorov-Smirnov 5% Critical Value	0.14	95% BCA Bootstrap UCL	0.0844
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.112
		97.5% Chebyshev(Mean, Sd) UCL	0.141
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	0.199
95% Approximate Gamma UCL	0.061		
95% Adjusted Gamma UCL	0.0617		

		Potential UCL to Use						Use 95% Chebyshev (Mean, Sd) UCL			0.112

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Lead (mg/L)	0.0090	0.0174	0.599	0.11	**0.28**	2.51	0.28	1.06	4.94	0.0088	0.6

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ is the Beta Function and $B_z(\alpha_1,\alpha_2)$ is the Incomplete Beta Function
α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95 α_1 α_2 MIN MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Lithium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	8.1	E N	=	0.04	8.1	2.091864062
Z1-EU29W-401	S	REG	15.5	E N	J	0.03	15.5	2.740840024
Z1-EU29W-402	S	REG	12.1	E N	=	0.04	12.1	2.493205453
Z1-EU29W-403	S	REG	12	E N	=	0.03	12	2.48490665
Z1-EU29W-404	S	REG	13.6	E N	=	0.04	13.6	2.610069793
Z1-EU29W-405 + Dup	S	FR	45.7	E N	=	0.03	45.7	3.822098298
Z1-EU29W-406	S	REG	9.2	E N	=	0.03	9.2	2.219203484
Z1-EU29W-407	S	REG	13.8	E N	=	0.04	13.8	2.624668592
Z1-EU29W-408	S	REG	9.4	E N	=	0.04	9.4	2.240709689
Z1-EU29W-409	S	REG	13.3	E N	=	0.03	13.3	2.587764035
Z1-EU30BW-411	B	REG	35.1	E N	=	0.03	35.1	3.55820113
Z1-EU30C-444	C	REG	10.7	E N	J	0.04	10.7	2.370243741
Z1-EU30C-445	C	REG	5.3	E N	=	0.03	5.3	1.667706821
Z1-EU30C-446	C	REG	11.5	E N	=	0.04	11.5	2.442347035
Z1-EU30C-447	C	REG	8.2	E N	=	0.04	8.2	2.104134154
Z1-EU30C-448 + Dup	C	FR	13.2	E N	=	0.04	13.2	2.58021683
Z1-EU30C-449	C	REG	11.3	E N	=	0.04	11.3	2.424802726
Z1-EU30C-450	C	REG	8.5	E N	=	0.04	8.5	2.140066163
Z1-EU30C-451	C	REG	12.3	E N	=	0.04	12.3	2.509599262
Z1-EU30C-452	C	REG	13.8	E N	=	0.04	13.8	2.624668592
Z1-EU30C-453	C	REG	15.4	E N	=	0.04	15.4	2.734367509
Z1-EU30C-454	C	REG	8.1	E N	=	0.04	8.1	2.091864062
Z1-EU31BW-415	B	REG	10.4	E N	=	0.04	10.4	2.341805806
Z1-EU31BW-416	B	REG	11.3	E N	=	0.04	11.3	2.424802726
Z1-EU31BW-417	B	REG	11.5	E N	=	0.03	11.5	2.442347035
Z1-EU31W-412	S	REG	19.8	E N	=	0.04	19.8	2.985681938
Z1-EU31W-413	S	REG	11.1	E N	=	0.03	11.1	2.406945108
Z1-EU31W-414	S	REG	10.2	E N	=	0.04	10.2	2.32238772
Z1-EU32BW-431	B	REG	17.5		=	0.03	17.5	2.862200881
Z1-EU32BW-432	B	REG	14		=	0.03	14	2.63905733
Z1-EU32BW-433 + Dup	B	REG	18.4		=	0.03	18.4	2.912350665
Z1-EU32BW-434	B	REG	12.3	E N	=	0.03	12.3	2.509599262
Z1-EU32C-455	C	REG	7	E N	=	0.04	7	1.945910149
Z1-EU32C-456	C	REG	7.1	E N	=	0.04	7.1	1.960094784
Z1-EU32MW-420	S	REG	22.4	E *	=	0.03	22.4	3.109060959
Z1-EU32MW-426	S	REG	11.4	E *	=	0.04	11.4	2.433613355
Z1-EU32W-418	S	REG	15.4	E *	J	0.04	15.4	2.734367509
Z1-EU32W-419 + Dup	S	REG	23.4	E *	=	0.03	23.4	3.152736022
Z1-EU32W-421	S	REG	16	E *	=	0.04	16	2.772588722
Z1-EU32W-422	S	REG	19.6	E *	=	0.03	19.6	2.975529566
Z1-EU32W-423	S	REG	68	E *	=	0.03	68	4.219507705
Z1-EU32W-424	S	REG	7.7	E *	=	0.04	7.7	2.041220329
Z1-EU32W-425	S	REG	15.5	E *	=	0.04	15.5	2.740840024
Z1-EU32W-427	S	REG	10.6	E *	=	0.03	10.6	2.360854001
Z1-EU32W-428	S	REG	10.3	E *	=	0.04	10.3	2.332143895
Z1-EU32W-429	S	REG	11	E *	=	0.03	11	2.397895273
Z1-EU32W-430	S	REG	8.1		=	0.03	8.1	2.091864062
Z1-EU33BW-443	B	REG	13	E N	=	0.03	13	2.564949357
Z1-EU33BW-444	B	REG	9.6		=	0.03	9.6	2.261763098
Z1-EU33C-457	C	REG	14.7	E N	=	0.04	14.7	2.687847494
Z1-EU33W-435	S	REG	16.4		=	0.04	16.4	2.797281335
Z1-EU33W-436	S	REG	10.4		=	0.04	10.4	2.341805806
Z1-EU33W-437	S	REG	14.3		=	0.04	14.3	2.660259537
Z1-EU33W-438	S	REG	23.7		=	0.04	23.7	3.165475048
Z1-EU33W-439	S	REG	13.7		=	0.03	13.7	2.617395833
Z1-EU33W-440	S	REG	11.2		=	0.03	11.2	2.415913778
Z1-EU33W-441	S	REG	14.1		=	0.03	14.1	2.646174797

Number of Samples	57
Number of Detects	57
Minimum	5.3
Median	12.3
Maximum	68
Average	14.687719
Standard Deviation	9.7310635
PERT-Beta Mean	20.416667
Lognormal Mean	2.5690845
Lognormal Standard Deviation	0.439288

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Li mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	48

Raw Statistics		**Log-transformed Statistics**	
Minimum	5.3	Minimum of Log Data	1.668
Maximum	68	Maximum of Log Data	4.22
Mean	14.69	Mean of log Data	2.569
Median	12.3	SD of log Data	0.439
SD	9.731		
Coefficient of Variation	0.663		
Skewness	3.762		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.256	Lilliefors Test Statistic	0.137
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	16.84	95% H-UCL	16.01
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	18.14
95% Adjusted-CLT UCL	17.49	97.5% Chebyshev (MVUE) UCL	19.77
95% Modified-t UCL	16.95	99% Chebyshev (MVUE) UCL	22.99
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	4.18	Data do not follow a Discernable Distribution (0.05)	
Theta Star	3.514		
nu star	476.5		
Approximate Chi Square Value (.05)	426.9	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	16.81
Adjusted Chi Square Value	425.7	95% Jackknife UCL	16.84
		95% Standard Bootstrap UCL	16.85
Anderson-Darling Test Statistic	2.611	95% Bootstrap-t UCL	18.41
Anderson-Darling 5% Critical Value	0.754	95% Hall's Bootstrap UCL	26.36
Kolmogorov-Smirnov Test Statistic	0.182	95% Percentile Bootstrap UCL	16.91
Kolmogorov-Smirnov 5% Critical Value	0.118	95% BCA Bootstrap UCL	17.58
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	20.31
		97.5% Chebyshev(Mean, Sd) UCL	22.74
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	27.51
95% Approximate Gamma UCL	16.39		
95% Adjusted Gamma UCL	16.44		

		Potential UCL to Use							Use 95% Student's-t UCL		16.84
									or 95% Modified-t UCL		16.95

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Lithium (mg/kg)	5.3000	12.3	68	20.42	39.90	1.95	39.90	1.45	4.55	135.4021	62.7

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \qquad MIN < Most\,likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ *is the Beta Function and* $B_z(\alpha_1, \alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95 α_1 α_2 MIN MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Magnesium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	2340		=	10	2340	7.757906208
Z1-EU29W-401	S	REG	13100		=	8.7	13100	9.480367509
Z1-EU29W-402	S	REG	3250		=	10.6	3250	8.086410275
Z1-EU29W-403	S	REG	4970		=	8.8	4970	8.511175119
Z1-EU29W-404	S	REG	3290		=	10	3290	8.098642844
Z1-EU29W-405 + Dup	S	FR	25200		=	9.1	25200	10.13459927
Z1-EU29W-406	S	REG	2810		=	8.7	2810	7.940939762
Z1-EU29W-407	S	REG	3770		=	10.1	3770	8.23483028
Z1-EU29W-408	S	REG	1060		=	9.7	1060	6.966024187
Z1-EU29W-409	S	REG	6250		=	9.5	6250	8.740336743
Z1-EU30BW-411	B	REG	35300		=	9.6	35300	10.47163824
Z1-EU30C-444	C	REG	6350	N *	J	21.8	6350	8.756210092
Z1-EU30C-445	C	REG	55200	N *	=	19.2	55200	10.91871823
Z1-EU30C-446	C	REG	58900	N *	=	22.7	58900	10.98359637
Z1-EU30C-447	C	REG	27600	N *	=	23.1	27600	10.22557105
Z1-EU30C-448 + Dup	C	FR	6310	N *	=	21	6310	8.749890956
Z1-EU30C-449	C	REG	5440	N *	=	22.1	5440	8.60153434
Z1-EU30C-450	C	REG	51000	N *	=	22.2	51000	10.83958091
Z1-EU30C-451	C	REG	5880	N *	=	22	5880	8.679312041
Z1-EU30C-452	C	REG	6950	N *	=	22.3	6950	8.846496939
Z1-EU30C-453	C	REG	7020	N *	=	23.5	7020	8.856518497
Z1-EU30C-454	C	REG	42900	N *	=	22.5	42900	10.6666271
Z1-EU31BW-415	B	REG	1790		=	10	1790	7.489970899
Z1-EU31BW-416	B	REG	1250		=	10.3	1250	7.13089883
Z1-EU31BW-417	B	REG	1750		=	9	1750	7.467371067
Z1-EU31W-412	S	REG	17800		=	9.8	17800	9.786953736
Z1-EU31W-413	S	REG	7050		=	8.6	7050	8.860782896
Z1-EU31W-414	S	REG	2690		=	10.1	2690	7.897296473
Z1-EU32BW-431	B	REG	39700	*	=	2.1	39700	10.58910647
Z1-EU32BW-432	B	REG	7400	*	=	2	7400	8.909235279
Z1-EU32BW-433 + Dup	B	REG	2750	*	=	2.2	2750	7.919356191
Z1-EU32BW-434	B	REG	12800		=	8.8	12800	9.45720045
Z1-EU32C-455	C	REG	45300	N *	=	22.6	45300	10.72106231
Z1-EU32C-456	C	REG	28000	N *	=	23.8	28000	10.23995979
Z1-EU32MW-420	S	REG	17300	N *	=	3.2	17300	9.75846178
Z1-EU32MW-426	S	REG	5480	N *	=	10	5480	8.60886038
Z1-EU32W-418	S	REG	14000	N *	J	3.9	14000	9.546812609
Z1-EU32W-419 + Dup	S	REG	17600	N *	=	9.4	17600	9.775654181
Z1-EU32W-421	S	REG	9800	N *	=	10	9800	9.190137665
Z1-EU32W-422	S	REG	14900	N *	=	3	14900	9.609116492
Z1-EU32W-423	S	REG	48800	N *	=	18.4	48800	10.79548559
Z1-EU32W-424	S	REG	2150	N *	=	3.3	2150	7.673223121
Z1-EU32W-425	S	REG	10400	N *	=	3.4	10400	9.249561085
Z1-EU32W-427	S	REG	1300	N *	=	3.2	1300	7.170119543
Z1-EU32W-428	S	REG	2780	N *	=	3.5	2780	7.930206207
Z1-EU32W-429	S	REG	1980	N *	=	3.1	1980	7.590852124
Z1-EU32W-430	S	REG	2820	*	=	1.9	2820	7.944492164
Z1-EU33BW-443	B	REG	6020		=	9.3	6020	8.702842538
Z1-EU33BW-444	B	REG	1450	*	=	2.2	1450	7.279318835
Z1-EU33C-457	C	REG	73800	N *	=	21.7	73800	11.20911401
Z1-EU33W-435	S	REG	1520	*	=	2.2	1520	7.326465614
Z1-EU33W-436	S	REG	1960	*	=	2.2	1960	7.580699752
Z1-EU33W-437	S	REG	9740	*	=	2.5	9740	9.183996397
Z1-EU33W-438	S	REG	14300	*	=	2.2	14300	9.568014816
Z1-EU33W-439	S	REG	3430	*	=	2.1	3430	8.14031554
Z1-EU33W-440	S	REG	6530	*	=	2.1	6530	8.784162222
Z1-EU33W-441	S	REG	5900	*	=	2	5900	8.68270763

Number of Samples	57
Number of Detects	57
Minimum	1060
Median	6350
Maximum	73800
Average	14335.614
Standard Deviation	17414.049
PERT-Beta Mean	16710
Lognormal Mean	8.9178376
Lognormal Standard Deviation	1.1603307

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Mg mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	57

Raw Statistics		**Log-transformed Statistics**	
Minimum	1060	Minimum of Log Data	6.966
Maximum	73800	Maximum of Log Data	11.21
Mean	14336	Mean of log Data	8.918
Median	6350	SD of log Data	1.16
SD	17414		
Coefficient of Variation	1.215		
Skewness	1.749		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.251	Lilliefors Test Statistic	0.0994
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	18193	95% H-UCL	38631
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	26202
95% Adjusted-CLT UCL	18700	97.5% Chebyshev (MVUE) UCL	31329
95% Modified-t UCL	18282	99% Chebyshev (MVUE) UCL	41398

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.861	Data appear Lognormal at 5% Significance Level	
Theta Star	16655		
nu star	98.12		
Approximate Chi Square Value (.05)	76.27	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	18130
Adjusted Chi Square Value	75.77	95% Jackknife UCL	18193
		95% Standard Bootstrap UCL	18052
Anderson-Darling Test Statistic	1.749	95% Bootstrap-t UCL	19186
Anderson-Darling 5% Critical Value	0.785	95% Hall's Bootstrap UCL	18759
Kolmogorov-Smirnov Test Statistic	0.173	95% Percentile Bootstrap UCL	18201
Kolmogorov-Smirnov 5% Critical Value	0.122	95% BCA Bootstrap UCL	18831
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	24390
		97.5% Chebyshev(Mean, Sd) UCL	28740
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	37285
95% Approximate Gamma UCL	18443		
95% Adjusted Gamma UCL	18564		

		Potential UCL to Use							Use 95% H-UCL		38631

Statistical Summary for Manganese mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	934	N *	=	0.04	934	6.839476438
Z1-EU29W-401	S	REG	303	N *	=	0.03	303	5.713732806
Z1-EU29W-402	S	REG	623	N *	=	0.04	623	6.434546519
Z1-EU29W-403	S	REG	455	N *	=	0.03	455	6.120297419
Z1-EU29W-404	S	REG	559	N *	=	0.04	559	6.326149473
Z1-EU29W-405 + Dup	S	REG	630	N *	=	0.03	630	6.445719819
Z1-EU29W-406	S	REG	350	N *	=	0.03	350	5.857933154
Z1-EU29W-407	S	REG	715	N *	=	0.04	715	6.572282543
Z1-EU29W-408	S	REG	403	N *	=	0.04	403	5.998936562
Z1-EU29W-409	S	REG	857	N *	=	0.03	857	6.753437919
Z1-EU30BW-411	B	REG	377	N *	=	0.03	377	5.932245187
Z1-EU30C-444	C	REG	282		=	0.04	282	5.641907071
Z1-EU30C-445	C	REG	118		=	0.03	118	4.770684624
Z1-EU30C-446	C	REG	493		=	0.04	493	6.200509174
Z1-EU30C-447	C	REG	244		=	0.04	244	5.497168225
Z1-EU30C-448 + Dup	C	FR	336		=	0.04	336	5.81711116
Z1-EU30C-449	C	REG	356		=	0.04	356	5.874930731
Z1-EU30C-450	C	REG	160		=	0.04	160	5.075173815
Z1-EU30C-451	C	REG	397		=	0.04	397	5.983936281
Z1-EU30C-452	C	REG	59.2		=	0.04	59.2	4.080921542
Z1-EU30C-453	C	REG	72.5		=	0.04	72.5	4.283586562
Z1-EU30C-454	C	REG	221		=	0.04	221	5.398162702
Z1-EU31BW-415	B	REG	628	N *	=	0.04	628	6.442540166
Z1-EU31BW-416	B	REG	653	N *	=	0.04	653	6.481577129
Z1-EU31BW-417	B	REG	1080	N *	=	0.03	1080	6.98471632
Z1-EU31W-412	S	REG	274	N *	=	0.04	274	5.613128106
Z1-EU31W-413	S	REG	393	N *	=	0.03	393	5.973809612
Z1-EU31W-414	S	REG	566	N *	=	0.04	566	6.338594078
Z1-EU32BW-431	B	REG	590	N	=	0.03	590	6.380122537
Z1-EU32BW-432	B	REG	329	N	=	0.03	329	5.796057751
Z1-EU32BW-433 + Dup	B	REG	1350	N	=	0.03	1350	7.207859871
Z1-EU32BW-434	B	REG	487	N *	=	0.03	487	6.188264123
Z1-EU32C-455	C	REG	246		=	0.04	246	5.505331536
Z1-EU32C-456	C	REG	212		=	0.04	212	5.356586275
Z1-EU32MW-420	S	REG	627	N	=	0.03	627	6.440946541
Z1-EU32MW-426	S	REG	496	N	=	0.04	496	6.206575927
Z1-EU32W-418	S	REG	156	N	J	0.04	156	5.049856007
Z1-EU32W-419 + Dup	S	REG	571		=	0.03	571	6.34738921
Z1-EU32W-421	S	REG	451	N	=	0.04	451	6.11146734
Z1-EU32W-422	S	REG	479	N	=	0.03	479	6.171700597
Z1-EU32W-423	S	REG	506	N	=	0.03	506	6.226536669
Z1-EU32W-424	S	REG	1240	N	=	0.04	1240	7.122866659
Z1-EU32W-425	S	REG	317	N	=	0.04	317	5.758901774
Z1-EU32W-427	S	REG	1870	N	=	0.03	1870	7.53369371
Z1-EU32W-428	S	REG	396	N	=	0.04	396	5.981414211
Z1-EU32W-429	S	REG	769	N	=	0.03	769	6.64509097
Z1-EU32W-430	S	REG	1040	N	=	0.03	1040	6.946975992
Z1-EU33BW-443	B	REG	1290	N *	=	0.03	1290	7.162397497
Z1-EU33BW-444	B	REG	793	N	=	0.03	793	6.675823222
Z1-EU33C-457	C	REG	275		=	0.04	275	5.616771098
Z1-EU33W-435	S	REG	2210	N	=	0.04	2210	7.700747795
Z1-EU33W-436	S	REG	840	N	=	0.04	840	6.733401892
Z1-EU33W-437	S	REG	987	N	=	0.04	987	6.894670039
Z1-EU33W-438	S	REG	819	N	=	0.04	819	6.708084084
Z1-EU33W-439	S	REG	1030	N	=	0.03	1030	6.937314081
Z1-EU33W-440	S	REG	1500	N	=	0.03	1500	7.313220387
Z1-EU33W-441	S	REG	854	N	=	0.03	854	6.749931194

Number of Samples	57
Number of Detects	57
Minimum	59.2
Median	496
Maximum	2210
Average	618.74912
Standard Deviation	431.78493
PERT-Beta Mean	708.86667
Lognormal Mean	6.1916353
Lognormal Standard Deviation	0.7336584

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Mn mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	57

Raw Statistics		**Log-transformed Statistics**	
Minimum	59.2	Minimum of Log Data	4.081
Maximum	2210	Maximum of Log Data	7.701
Mean	618.7	Mean of log Data	6.192
Median	496	SD of log Data	0.734
SD	431.8		
Coefficient of Variation	0.698		
Skewness	1.552		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.156	Lilliefors Test Statistic	0.0573
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	714.4	95% H-UCL	781.2
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	933.5
95% Adjusted-CLT UCL	725.4	97.5% Chebyshev (MVUE) UCL	1062
95% Modified-t UCL	716.4	99% Chebyshev (MVUE) UCL	1315

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	2.163	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	286.1		
nu star	246.6		
Approximate Chi Square Value (.05)	211.2	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	712.8
Adjusted Chi Square Value	210.4	95% Jackknife UCL	714.4
		95% Standard Bootstrap UCL	712.1
Anderson-Darling Test Statistic	0.171	95% Bootstrap-t UCL	731.3
Anderson-Darling 5% Critical Value	0.761	95% Hall's Bootstrap UCL	738.3
Kolmogorov-Smirnov Test Statistic	0.068	95% Percentile Bootstrap UCL	713.2
Kolmogorov-Smirnov 5% Critical Value	0.119	95% BCA Bootstrap UCL	736.4
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	868
		97.5% Chebyshev(Mean, Sd) UCL	975.9
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1188
95% Approximate Gamma UCL	722.3		
95% Adjusted Gamma UCL	725.2		

		Potential UCL to Use						Use 95% Approximate Gamma UCL			722.3

Statistical Summary for Mercury mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	0.6	N *	=	0.009	0.6	-0.510825624
Z1-EU29W-401	S	REG	0.62	N *	J	0.01	0.62	-0.478035801
Z1-EU29W-402	S	REG	0.26	N *	=	0.01	0.26	-1.347073648
Z1-EU29W-403	S	REG	0.85	N *	=	0.009	0.85	-0.162518929
Z1-EU29W-404	S	REG	2.5	N *	=	0.03	2.5	0.916290732
Z1-EU29W-405 + Dup	S	FR	0.51	N *	=	0.01	0.51	-0.673344553
Z1-EU29W-406	S	REG	0.16	N *	=	0.01	0.16	-1.832581464
Z1-EU29W-407	S	REG	1.6	N *	=	0.01	1.6	0.470003629
Z1-EU29W-408	S	REG	0.11	N *	=	0.01	0.11	-2.207274913
Z1-EU29W-409	S	REG	1.1	N *	=	0.01	1.1	0.09531018
Z1-EU30BW-411	B	REG	4.4	N *	=	0.05	4.4	1.481604541
Z1-EU30C-444	C	REG	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU30C-445	C	REG	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU30C-446	C	REG	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU30C-447	C	REG	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU30C-448 + Dup	C	FR	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU30C-449	C	REG	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU30C-450	C	REG	0.02	B	=	0.01	0.02	-3.912023005
Z1-EU30C-451	C	REG	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU30C-452	C	REG	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU30C-453	C	REG	0.09		=	0.01	0.09	-2.407945609
Z1-EU30C-454	C	REG	0.02	B	=	0.01	0.02	-3.912023005
Z1-EU31BW-415	B	REG	0.33	N *	=	0.01	0.33	-1.108662625
Z1-EU31BW-416	B	REG	0.45	N *	=	0.01	0.45	-0.798507696
Z1-EU31BW-417	B	REG	0.99	N *	=	0.01	0.99	-0.010050336
Z1-EU31W-412	S	REG	0.09	N *	=	0.009	0.09	-2.407945609
Z1-EU31W-413	S	REG	0.32	N *	=	0.01	0.32	-1.139434283
Z1-EU31W-414	S	REG	0.37	N *	=	0.01	0.37	-0.994252273
Z1-EU32BW-431	B	REG	2.5	N *	=	0.04	2.5	0.916290732
Z1-EU32BW-432	B	REG	2.3	N *	=	0.03	2.3	0.832909123
Z1-EU32BW-433 + Dup	B	FR	0.29	N *	=	0.01	0.29	-1.237874356
Z1-EU32BW-434	B	REG	0.06	N *	=	0.01	0.06	-2.813410717
Z1-EU32C-455	C	REG	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU32C-456	C	REG	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU32MW-420	S	REG	0.94	N	=	0.01	0.94	-0.061875404
Z1-EU32MW-426	S	REG	1.6	N	=	0.01	1.6	0.470003629
Z1-EU32W-418	S	REG	0.61	N	J	0.01	0.61	-0.494296322
Z1-EU32W-419 + Dup	S	FR	2.5	N	=	0.03	2.5	0.916290732
Z1-EU32W-421	S	REG	2.1	N	=	0.03	2.1	0.741937345
Z1-EU32W-422	S	REG	2	N	=	0.02	2	0.693147181
Z1-EU32W-423	S	REG	1.8	N	=	0.03	1.8	0.587786665
Z1-EU32W-424	S	REG	0.17	N	=	0.01	0.17	-1.771956842
Z1-EU32W-425	S	REG	0.97	N	=	0.01	0.97	-0.030459207
Z1-EU32W-427	S	REG	0.2	N	=	0.01	0.2	-1.609437912
Z1-EU32W-428	S	REG	0.36	N	=	0.01	0.36	-1.021651248
Z1-EU32W-429	S	REG	0.11	N	=	0.01	0.11	-2.207274913
Z1-EU32W-430	S	REG	0.35	N *	J	0.01	0.35	-1.049822124
Z1-EU33BW-443	B	REG	1.2	N *	=	0.01	1.2	0.182321557
Z1-EU33BW-444	B	REG	0.47	N *	=	0.01	0.47	-0.755022584
Z1-EU33C-457	C	REG	0.01	U	U	0.01	0.005	-5.298317367
Z1-EU33W-435	S	REG	0.17	N *	=	0.01	0.17	-1.771956842
Z1-EU33W-436	S	REG	0.29	N *	=	0.01	0.29	-1.237874356
Z1-EU33W-437	S	REG	2.7	N *	=	0.03	2.7	0.993251773
Z1-EU33W-438	S	REG	4.1	N *	=	0.05	4.1	1.410986974
Z1-EU33W-439	S	REG	2	N *	=	0.03	2	0.693147181
Z1-EU33W-440	S	REG	3.1	N *	=	0.05	3.1	1.131402111
Z1-EU33W-441	S	REG	1.7	N *	=	0.03	1.7	0.530628251

Number of Samples	57
Number of Detects	46
Minimum	0.005
Median	0.36
Maximum	4.4
Average	0.877807
Standard Deviation	1.0842262
PERT-Beta Mean	0.9741667
Lognormal Mean	-1.494449
Lognormal Standard Deviation	2.2314244

Goodness-of-Fit Test Statistics for Data Sets with Non-Detects

User Selected Options

From File	P:\Waste Generator Services\EMWMF Profiles\WL 4.12\March 2009 revision\revised total metals to test c
Full Precision	OFF
Confidence Coefficient	0.9

Hg mg/kg

	Num Obs	Num Miss	Num Valid	Detects	NDs	% NDs
Raw Statistics	57	0	57	46	11	19.30%

	Number	Minimum	Maximum	Mean	Median	SD
Statistics (Non-Detects Only)	11	0.005	0.005	0.005	0.005	9.097E-19
Statistics (Detects Only)	46	0.02	4.4	1.087	0.605	1.11
Statistics (All: NDs treated as DL value)	57	0.005	4.4	0.878	0.36	1.084
Statistics (All: NDs treated as DL/2 value)	57	0.0025	4.4	0.877	0.36	1.085
Statistics (Normal ROS Estimated Data)	57	-2.52	4.4	0.605	0.36	1.426
Statistics (Gamma ROS Estimated Data)	57	1.0000E-9	4.4	0.878	0.36	1.084
Statistics (Lognormal ROS Estimated Data)	57	0.0075	4.4	0.883	0.36	1.08

	K Hat	K Star	Theta Hat	Log Mean	Log Stdv	Log CV
Statistics (Detects Only)	0.878	0.844	1.237	-0.585	1.347	-2.303
Statistics (NDs = DL)	0.47	0.457	1.867	-1.494	2.231	-1.493
Statistics (NDs = DL/2)	0.434	0.423	2.022	-1.628	2.468	-1.516
Statistics (Gamma ROS Estimates)	0.197	0.198	4.465	--	--	--
Statistics (Lognormal ROS Estimates)	--	--	--	-1.16	1.716	-1.479

Normal Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Normal ROS
Correlation Coefficient R	0.918	0.89	0.89	0.983

	Test value	Crit. (0.1)	Conclusion with Alpha(0.1)
Shapiro-Wilks (Detects Only)	0.835	0.953	Data Not Normal
Lilliefors (Detects Only)	0.206	0.119	Data Not Normal
Lilliefors (NDs = DL)	0.226	0.107	Data Not Normal
Lilliefors (NDs = DL/2)	0.225	0.107	Data Not Normal
Lilliefors (Normal ROS Estimates)	0.148	0.107	Data Not Normal

Gamma Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Gamma ROS
Correlation Coefficient R	0.982	0.97	0.966	0.903

	Test value	Crit. (0.1)	Conclusion with Alpha(0.1)
Anderson-Darling (Detects Only)	0.44	0.656	
Kolmogorov-Smirnov (Detects Only)	0.0962	0.124	Data Appear Gamma Distributed
Anderson-Darling (NDs = DL)	0.897	0.683	
Kolmogorov-Smirnov (NDs = DL)	0.123	0.114	Data Not Gamma Distributed
Anderson-Darling (NDs = DL/2)	1.004	0.69	
Kolmogorov-Smirnov (NDs = DL/2)	0.131	0.115	Data Not Gamma Distributed

Anderson-Darling (Gamma ROS Estimates)	6.466	0.748	
Kolmogorov-Smirnov (Gamma ROS Est.)	0.258	0.119	Data Not Gamma Distributed

Lognormal Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Log ROS
Correlation Coefficient R	0.98	0.94	0.928	0.98

	Test value	Crit. (0.1)	Conclusion with Alpha(0.1)
Shapiro-Wilks (Detects Only)	0.946	0.953	Data Not Lognormal
Lilliefors (Detects Only)	0.109	0.119	Data Appear Lognormal
Lilliefors (NDs = DL)	0.149	0.107	Data Not Lognormal
Lilliefors (NDs = DL/2)	0.159	0.107	Data Not Lognormal
Lilliefors (Lognormal ROS Estimates)	0.0921	0.107	Data Appear Lognormal

Note: Substitution methods such as DL or DL/2 are not recommended.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	P:\Waste Generator Services\EMWMF Profiles\WL 4.12\March 2009 revision\revised total metals to test c
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Hg mg/kg

General Statistics

Number of Valid Data	57	Number of Detected Data	46
Number of Distinct Detected Data	37	Number of Non-Detect Data	11
		Percent Non-Detects	19.30%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.02	Minimum Detected	-3.912
Maximum Detected	4.4	Maximum Detected	1.482
Mean of Detected	1.087	Mean of Detected	-0.585
SD of Detected	1.11	SD of Detected	1.347
Minimum Non-Detect	0.005	Minimum Non-Detect	-5.298
Maximum Non-Detect	0.005	Maximum Non-Detect	-5.298

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Lilliefors Test Statistic	0.835	Lilliefors Test Statistic	0.946
5% Lilliefors Critical Value	0.945	5% Lilliefors Critical Value	0.945
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.877	Mean	-1.628
SD	1.085	SD	2.468
95% DL/2 (t) UCL	1.118	95% H-Stat (DL/2) UCL	7.796
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	0.726	Mean in Log Scale	-1.16
SD	1.263	SD in Log Scale	1.716
95% MLE (t) UCL	1.006	Mean in Original Scale	0.883
95% MLE (Tiku) UCL	1.005	SD in Original Scale	1.08
		95% Percentile Bootstrap UCL	1.138
		95% BCA Bootstrap UCL	1.144

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	0.835	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	1.301		
nu star	76.85		
A-D Test Statistic	0.44	Nonparametric Statistics	
5% A-D Critical Value	0.784	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.784	Mean	0.881

5% K-S Critical Value	0.135	SD	1.072
Data appear Gamma Distributed at 5% Significance Level		SE of Mean	0.144
		95% KM (t) UCL	1.121
Assuming Gamma Distribution		95% KM (z) UCL	1.117
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	1.12
Minimum	1.0000E-9	95% KM (bootstrap t) UCL	1.165
Maximum	4.4	95% KM (BCA) UCL	1.14
Mean	0.878	95% KM (Percentile Bootstrap) UCL	1.121
Median	0.36	95% KM (Chebyshev) UCL	1.507
SD	1.084	97.5% KM (Chebyshev) UCL	1.778
k star	0.198	99% KM (Chebyshev) UCL	2.31
Theta star	4.435		
Nu star	22.57	Potential UCLs to Use	
AppChi2	12.77	95% KM (Chebyshev) UCL	1.507
95% Gamma Approximate UCL	1.552		
95% Adjusted Gamma UCL	1.576		

Note: DL/2 is not a recommended method.

Statistical Summary for Mercury mg/L

Location ID	Sample Lot	Sample Type	Result (ug/L)	Result Qualifier	Validation	Detection Limit (ug/L)	Proxy Value (mg/L)	LN Proxy Value
Z1-EU29BW-410		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU29W-401		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU29W-402		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU29W-403		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU29W-404		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU29W-405 + Dup		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU29W-406		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU29W-407		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU29W-408		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU29W-409		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU30BW-411		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU31BW-415		REG	0.17	B	U	0.06	0.00003	-10.41431318
Z1-EU31BW-416		REG	0.07	B	U	0.06	0.00003	-10.41431318
Z1-EU31BW-417		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU31W-412		REG	0.32		U	0.06	0.00003	-10.41431318
Z1-EU31W-413		REG	0.28		U	0.06	0.00003	-10.41431318
Z1-EU31W-414		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32BW-431		REG	0.12	B	=	0.06	0.00012	-9.028018815
Z1-EU32BW-432		REG	0.13	B	=	0.06	0.00013	-8.947976108
Z1-EU32BW-433 + Dup		REG	0.08	B	=	0.06	0.00008	-9.433483923
Z1-EU32BW-434		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32MW-420		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32MW-426		REG	0.07	B	=	0.06	0.00007	-9.567015316
Z1-EU32W-418		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32W-419 + Dup		REG	0.15	B	=	0.06	0.00015	-8.804875264
Z1-EU32W-421		REG	0.06	B	=	0.06	0.00006	-9.721165996
Z1-EU32W-422		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32W-423		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32W-424		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32W-425		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32W-427		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32W-428		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32W-429		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU32W-430		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU33BW-443		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU33BW-444		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU33W-435		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU33W-436		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU33W-437		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU33W-438		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU33W-439		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU33W-440		REG	0.06	U	U	0.06	0.00003	-10.41431318
Z1-EU33W-441		REG	0.06	U	U	0.06	0.00003	-10.41431318

Number of Samples	43
Number of Detects	6
Minimum	0.00003
Median	0.00003
Maximum	0.00015
Average	0.00004
Standard Deviation	2.812E-05
PERT-Beta Mean	0.00005
Lognormal Mean	-10.25191
Lognormal Standard Deviation	0.4278551

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Hg mg/L

General Statistics

Number of Valid Observations	43	Number of Distinct Observations	7

Raw Statistics		**Log-transformed Statistics**	
Minimum	3.0000E-5	Minimum of Log Data	-10.41
Maximum	1.5000E-4	Maximum of Log Data	-8.805
Mean	4.0000E-5	Mean of log Data	-10.25
Median	3.0000E-5	SD of log Data	0.428
SD	2.8115E-5		
Coefficient of Variation	N/A		
Skewness	2.959		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.416	Shapiro Wilk Test Statistic	0.433
Shapiro Wilk Critical Value	0.943	Shapiro Wilk Critical Value	0.943
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	4.7211E-5	95% H-UCL	4.3678E-5
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	4.9954E-5
95% Adjusted-CLT UCL	4.9120E-5	97.5% Chebyshev (MVUE) UCL	5.4874E-5
95% Modified-t UCL	4.7534E-5	99% Chebyshev (MVUE) UCL	6.4538E-5

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	3.876	Data do not follow a Discernable Distribution (0.05)	
Theta Star	1.0319E-5		
nu star	333.4		
Approximate Chi Square Value (.05)	292.1	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0444	95% CLT UCL	4.7052E-5
Adjusted Chi Square Value	290.7	95% Jackknife UCL	4.7211E-5
		95% Standard Bootstrap UCL	4.6761E-5
Anderson-Darling Test Statistic	12.11	95% Bootstrap-t UCL	5.1076E-5
Anderson-Darling 5% Critical Value	0.753	95% Hall's Bootstrap UCL	4.7106E-5
Kolmogorov-Smirnov Test Statistic	0.513	95% Percentile Bootstrap UCL	4.7209E-5
Kolmogorov-Smirnov 5% Critical Value	0.135	95% BCA Bootstrap UCL	5.0000E-5
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	5.8689E-5
		97.5% Chebyshev(Mean, Sd) UCL	6.6776E-5
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	8.2661E-5
95% Approximate Gamma UCL	4.5657E-5		
95% Adjusted Gamma UCL	4.5867E-5		

		Potential UCL to Use								Use 95% Student's-t UCL	4.7211E-5
										or 95% Modified-t UCL	4.7534E-5

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

		WACFACS WL L SRC INPUT						Calculations				
		STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
	SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Mercury (mg/L)		3.00E-05	3.00E-05	1.50E-04	5.00E-05	**8.41E-05**	1.68	0.00	1.00	5.00	0.0000	0.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_z(\alpha_1, \alpha_2)$ is the Incomplete Beta Function

α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

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APPENDIX E
WASTE HANDLING PLAN CROSSWALK, SAMPLING APPROACH, CALCULATION/MEASUREMENT METHODS

APPENDIX E: SELECTION AND TRANSFORMATION OF WASTE LOT 4.12 DATA

Prepared by Marshall Davenport, ETTP D&D/RA Project

This summary documents the sampling and analysis plan crosswalk, and selection/ transformation of radiological and chemical data results for development of the Waste Lot 4.12 Controlled Data Set, waste profile, and statistical summaries. A map depicting sample locations follows this documentation.

General Approach for Development of Controlled Data Set

ETTP D&D/RA Project received an electronic copy of the analytical database from the BJC (Bechtel Jacobs Company LLC) SMO (Sample Management Organization) for 59 intrusive samples (including 4 duplicate samples) collected from soils and concrete from the K-770 Scrap Yard in accordance with BJC/OR-3088, *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainmen, East Tennessee Technology Park, Oak Ridge, Tennessee* (the sample and analysis plan, or SAP). The sampling strategy involved the collection of 32 systematic random composite soil samples and 13 biased composite soil samples; and 14 systematic random concrete samples from concrete pads within the K-770 Scrap Yard representative of the final waste form. This ensured that the overall contaminant concentrations could be evaluated on the waste as a whole. A total of 45 systematic random and biased composite soil samples, (including 4 field replicate composite soil samples) were collected from the K-770 soils for individual/Total PCB analysis, Total/TCLP Semi-Volatile Organic Analysis (SVOA), Total/TCLP Metals analysis, and Radiological Parameters analysis. 44 of the 45 systematic random and biased composite soil samples (including 3 field replicate composite soil samples) were collected (with the exception of Sample Z1EU29W-401) for Total Volatile Organic Analysis (VOA). Lastly, a total of 14 systematic random samples and 1 field replicate sample were collected from K-770 Scrap Yard concrete pads for Total Metals analysis, individual/Total PCB (polychlorinated biphenyls) analysis, and Radiological Parameters analysis. Two biased composite soil samples (Z1-EU33BW-442 and Z1-EU33BW-445) were found to exhibit elevated Tc-99 concentrations of 2,710 pCi/g and 40,600 pCi/g, respectively and were excluded from consideration for disposal under Waste Lot 4.12 as anomalous wastes for Tc-99 contamination (see Appendix A). Therefore, these two samples were excluded from the Waste Lot 4.12 Controlled Data Set in Appendix C of this profile.

The resulting Waste Lot 4.12 controlled data set contains a total of 57 samples for radiological constituents, 57 samples for Total Metal constituents, 57 samples for individual/Total PCB constituents, 43 samples for TCLP Metal constituents, 43 samples for Total/TCLP SVOA constituents, and 42 samples for Total VOA constituents.Table E1 lists the total number of samples selected for characterization.

Table E1. Waste Lot 4.12 Characterization Samples (including duplicates)

Items Sampled	Total VOA	Total/ TCLP SVOA	Total Metals	TCLP Metals	Radiological Samples	PCB Samples
K-770 systematic random composite soil samples	29	30	30	30	30	30
K-770 biased composite soil samples	13	13	13	13	13	13
K-770 systematic random composite concrete samples			14		14	14

For determining chemical properties, intrusive sampling was utilized. The total number of chemical samples used for Waste Lot 4.12 statistical summaries was: 42 for Total VOA, 43 for Total/TCLP SVOA, and 57 for individual/Total PCBs.

For radiological properties, a combination of intrusive sampling and radiological field screening was utilized. The total number of radiological samples used for Waste Lot 4.12 statistical summaries was 57 for radiological SRCs (site related contaminants).

Samples were collected from a representative population of anticipated K-770 Scrap Yard waste items. Samples were analyzed for radionuclides, PCBs (individual and total), metals (total and TCLP), VOCs (total), and SVOCs (total and TCLP). As evidenced by Table E2, sampling requirements as prescribed in the SAP were met (with the exception of Total VOA), since the number of samples collected for each waste category equaled the minimum number of recommended samples provided in Table A.1 of the SAP.

Table E2. SAP Sampling Requirements Evaluation

Waste Category	Sample Parameter	Recommended Number of Samples	Actual Number of Samples Collected*
K-770 systematic random composite soil samples	Radiological	32	32
	PCBs	32	32
	Total Metals	32	32
	TCLP Metals	32	32
	Total/TCLP SVOA	32	32
	Total VOA	32	31
K-770 biased composite soil samples	Radiological	13	13
	PCBs	13	13
	Total Metals	13	13
	TCLP Metals	13	13
	Total/TCLP SVOA	13	13
	Total VOA	13	13
K-770 systematic random concrete samples	Radiological	14	14
	Total Metals	14	14
	PCBs	14	14

Notes:* - total number of samples includes duplicates

In general, the reported data were usable with the exception of the two biased composite soil samples (Z1-EU33BW-442 and Z1-EU33BW-445) that exhibitied elevated Tc-99 pCi/g concentrations. One Np-237 sample result and its field replicate result (for sample Z1-EU32BW-433) was rejected due based on professional judgment since the the field duplicate's Relative Percent Difference (RPD) was out of range, possibly due to uranium interference. In some situations, Total VOA, Total SVOA, and PCB constituents were reported at differeing concentrations and detection limits due to variable dilution factors. In all cases, only validated data supplied by the SMO with a "Data Use" flag of "Y" was used in development of the Waste Lot 4.12 Controlled Data Set and Data Quality Assessment. Table E.3 provides the details concerning the type of sample collected, date of sample collection, sample location, sample interval description, required analyses to be performed, and comments/notes associated with the sample collection and/or analysis.

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC

V&V	Log Exposure Unit 29	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/ Dups	Comments and Notes
	Exposure Unit 29												
D	WAC S Lot 1	Z1-EU29	Z1-EU29W-401	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		VOA sample not collected and analyzed ; Hexachlorocyclopentadiene data rejected
D	WAC S Lot 1	Z1-EU29	Z1-EU29W-402	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU29	Z1-EU29W-403	Five point composite 1.0-2.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 2.25-2.42 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU29	Z1-EU29W-404	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU29	Z1-EU29W-405	Five point composite 0.5-1.5 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 1.17-1.33 ft	1	1	1	1	1	1	1	1 Duplicate	Extraneous Total SVOA results rejected based on varying dilution factors
D	WAC S Lot 1	Z1-EU29	Z1-EU29W-406	Five point composite 1.5-2.5 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 1.92-2.08 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU29	Z1-EU29W-407	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous PCB results rejected based on varying dilution factors
D	WAC S Lot 1	Z1-EU29	Z1-EU29W-408	Five point composite 1.0-2.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 1.42-1.58 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU29	Z1-EU29W-409	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 2	Z1-EU29	Z1-EU29BW-410	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC													
V&V	Log	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/ Dups	Comments and Notes
	Exposure Unit 30												
D	WAC S Lot 2	Z1-EU30	Z1-EU30BW-411	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total SVOA results rejected based on varying dilution factors
	Exposure Unit 31												
D	WAC S Lot 1	Z1-EU31	Z1-EU31W-412	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU31	Z1-EU31W-413	Five point composite 1.0-2.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 1.42-1.75 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU31	Z1-EU31W-414	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 2	Z1-EU31	Z1-EU31BW-415	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 2	Z1-EU31	Z1-EU31BW-416	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 2	Z1-EU31	Z1-EU31BW-417	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC													
V&V	Log	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/ Dups	Comments and Notes
	Exposure Unit 32												
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-418	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Hexachlorocyclopentadiene result rejected
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-419	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1 Duplicate	Extraneous PCB, Total VOA, and Total SVOA results for original sample rejected due to varying dilution factors
D	WAC S Lot 1	Z1-EU32	Z1-EU32MW-420	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-421	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total SVOA results rejected due to varying dilution factors
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-422	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-423	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-424	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-425	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32MW-426	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-427	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-428	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU32	Z1-EU32W-429	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC

V&V	Log	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/ Dups	Comments and Notes
D	WAC S Lot 2	Z1-EU32	Z1-EU32W-430	Five point composite 0.0-0.833 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 2	Z1-EU32	Z1-EU32BW-431	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA + Total SVOAresults rejected due to varying dilution factors
D	WAC S Lot 2	Z1-EU32	Z1-EU32BW-432	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 2	Z1-EU32	Z1-EU32BW-433	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1	1 Duplicate	Np-237 pCi/g results rejected
D	WAC S Lot 2	Z1-EU32	Z1-EU32BW-434	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
	Exposure Unit 33												
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-435	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-436	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-437	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-438	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-439	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-440	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC

V&V	Log	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/ Dups	Comments and Notes
D	WAC S Lot 1	Z1-EU33	Z1-EU33W-441	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 2	Z1-EU33	Z1-EU33BW-442	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA + Total SVOAresults rejected due to varying dilution factors. Sample removed from WL 4.12 Controlled Data Set due to anomalous Tc-99 result of 2,710 pCi/g
D	WAC S Lot 2	Z1-EU33	Z1-EU33BW-443	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 2	Z1-EU33	Z1-EU33BW-444	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA results rejected due to varying dilution factors
D	WAC S Lot 2	Z1-EU33	Z1-EU33BW-445	Five point composite 0.0-1.0 ft 10ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		Extraneous Total VOA + Total SVOAresults rejected due to varying dilution factors. Sample removed from WL 4.12 Controlled Data Set due to anomalous Tc-99 result of 40,600 pCi/g
	Concrete Samples												
		K-725 building slab											
D	WAC conc	Z1-EU30	Z1-EU30C-444	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-445	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-446	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-447	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-448	0-0.25' concrete sample				1		1	1	1 Duplicate	
D	WAC conc	Z1-EU30	Z1-EU30C-449	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-450	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-451	0-0.25' concrete sample				1		1	1		

Table E-3 – WL 4.12 Sample summary Table for Zone 1 K770 Soils WAC

V&V	Log	Exposure Unit	Location ID	Sample Interval	VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD	Splits/ Dups	Comments and Notes
		Other concrete slabs EU 30											
D	WAC conc	Z1-EU30	Z1-EU30C-452	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-453	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU30	Z1-EU30C-454	0-0.25' concrete sample				1		1	1		
		K726 building slab EU 32											
D	WAC conc	Z1-EU32	Z1-EU32C-455	0-0.25' concrete sample				1		1	1		
D	WAC conc	Z1-EU32	Z1-EU32C-456	0-0.25' concrete sample				1		1	1		
		Other concrete slabs EU 33											
D	WAC conc	Z1-EU33	Z1-EU33C-457	0-0.25' concrete sample				1		1	1		
				Total Samples Collected & Analyzed	44	45	45	59	45	59	59		
				Total Samples Used in WL 4.12 Controlled Data Set & Statistical Summary	42	43	43	57	43	57	57		

In general, Total Metal concentrations were reported in millgrams/kilogram, (mg/kg), TCLP Metal concentrations were reported in micrograms/Liter (ug/L), Total VOA, Total SVOA, and Total PCB concentrations were reported in micrograms/kilogram (ug/kg), TCLP SVOA concentrations were reported in milligrams/Liter (mg/L), and radiological concentrations were reported in pico-Curies per gram, (pCi/g). All data used in the Waste Lot 4.12 Controlled Data Set (Appendix C) and Data Quality Assessment (Appendix G) were derived from analytical data collected in accordance with the SAP.

Treatment of Sample and Duplicate Results

In situations where an intrusive sample was collected in conjunction with a duplicate (field replicate) sample, the following approach was used to create a single data point for inclusion in statistical analysis:

- If the sample and its duplicate were assigned "U" or "UJ" laboratory qualifiers or data validation code, then the maximum detection limit (DL) for either the sample or its duplicate was used to represent the sample result and its duplicate result. Note: Data validation codes supersede laboratory qualifiers.

- If either the sample or its duplicate were assigned a "U" or "UJ" laboratory qualifier or data validation code, and the other result was not assigned a "U" or "UJ" laboratory qualifier or data validation code (e.g., J-flagged or "=" code assigned), then the J-flagged or "="coded reported result was used to represent the sample result and it's duplicate result. Note: Data validation codes supersede laboratory qualifiers.

- If the sample result and its duplicate sample result were not assigned "U" or "UJ" laboratory qualifiers or data validation codes, the maximum reported result for either the sample or its duplicate was used to represent the sample result and its duplicate result. Note: Data validation codes supersede laboratory qualifiers.

Data Conditioning

In order to quantify Total Metal, Total VOA, Total SVOA, Total Pesticide/Herbicide, and Total PCB SRC values for the Waste Lot 4.12 profile and statistical summary, analytical data in micrograms per kilogram (ug/kg) or micrograms per gram (ug/g) were converted to milligrams per kilogram (mg/kg) using the following equations:

mg/kg = ug/kg * 1 mg/1000 ug

mg/kg = ug/g * 1mg/1000 ug * 1000 g/kg

In order to quantify TCLP Metal, and TCLP SVOA SRC values for the Waste Lot 4.12 statistical summary, analytical data in micrograms per liter (ug/L) were converted to milligrams per liter (mg/L) using the following equation:

mg/L = ug/L * 1 mg/1000 ug

In accordance with Appendix C of DOE/OR/01-1909&D3, *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee*, the following data use strategies were employed during development of Total/TCLP Metal, Total VOA, Total/TCLP SVOA, and individual/Total PCB statistical summaries:

- for analytical data assigned laboratory qualifier or data validation codes other than "U" or "UJ", the reported data value converted to mg/kg or mg/L was used

- for analytical data assigned laboratory qualifier or data validation codes "U" or "UJ", the reported minimum detection value converted to mg/kg or mg/L divided by 2 was used

In accordance with Appendix C of DOE/OR/01-1909&D3, *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee*, the following data use strategies were employed during development of radiological isotope-specific statistical summaries:

- for analytical data assigned laboratory qualifier or data validation codes other than "U" or "UJ", the reported data value expressed in pCi/g was used

- for analytical data assigned laboratory qualifier or data validation codes "U" or "UJ", the reported minimum detection value expressed in pCi/g was used

Specific Applications to Waste Lot 4.12 Profile

<u>Administrative WAC</u>

For Table 1 of the WL 4.12 profile, maximum transuranic isotope-specific concentrations in pico-Curies per gram (pCi/g) were converted to nano-Curies per gram (nCi/g) as follows:

Am-241 nCi/g = 2.13E-02 pCi/g * 1 nCi/g / 1000 pCi/g = 2.13E-05 nCi/g
Np-237 nCi/g = 3.20E-01 pCi/g * 1 nCi/g / 1000 pCi/g = 3.20E-04 nCi/g
Pu-238 nCi/g = 1.70E-03 pCi/g * 1 nCi/g / 1000 pCi/g = 1.70E-06 nCi/g
Pu-239/240 nCi/g = 1.11E-02 pCi/g * 1 nCi/g / 1000 pCi/g = 1.11E-05 nCi/g

Total TRU nCi/g = 2.13E-05 nCi/g Am-241
\+ 3.20E-04 nCi/g Np-237
\+ 1.70E-06 nCi/g Pu-238
\+ 1.11E-05 nCi/g Pu-239/240

= 3.54E-04 nCi/g TRU

For Section 2.4 (RCRA Compliance) and Table 2 of the Waste Lot 4.12 profile, the following approach was developed to support the RCRA non-hazardous waste determination of the K-770 soil and concrete wastes.

The original K-770 soils/concrete database containing the initial TCLP Metals and TCLP SVOAs data were converted from ug/L to mg/L and the mg/L values were compared to the 40 CFR 261.24 regulatory limit for each of these TCLP constituents. In cases, where constituents were not detected (e.g. TCLP SVOAs), the maximum detection limit (DL) value was used against the 40 CFR 261.24 regulatory limit for the determination.

The comparision for constituents for which only Total concentration analytical results were available was made in a similar manner. The K-770 soils/concrete Total concentration data were converted from ug/kg to mg/kg. The maximum value (or DL if the chemical was not detected), in mg/kg, was then divided by 20 (to implement the "20 times rule"). The resulting value was then compared to the 40 CFR 261.24 regulatory limits for those constituents to support the determination.

An initial assessment of these constituents was performed by the Project upon receipt of data from the laboratories. During this assessment the Project determined that none of the maximum Total VOA or SVOA concentrations exceeded its regulatory limit using the 20 times rule.

Table 2 provides the basis for the RCRA non-hazardous waste determination for the Waste Lot 4.12 in Section 2.4 of the Waste Lot 4.12 profile. The waste determination is supported by process knowledge and the use of visual inspection and sorting/segregation techniques for waste items to be disposed at the EMWMF. Due diligence has been provided based on process knowledge, analytical data review, and continuation/enhancement of best management practice (visual inspection and sorting/segregation of waste items) to ensure successful removal of anomalous wastes for future wastes offered for disposal at EMWMF. The method of comparision described above, the results in Table 2 (profile Section 2.4), and the determination that the waste in this waste lot is not hazardous as defined by RCRA have been reviewed and approved by ETTP D&D/RA Project Environmental Compliance.

For Table 3 of the Waste Lot 4.12 profile, average uranium isotope-specific concentrations in

pico-Curies U-isotope per gram waste ($pCi^{U\text{-}isotope}/g_{waste}$) were converted to microgram U-isotope per gram waste ($ug^{U\text{-}isotope}/g_{waste}$) as follows:

U-234 ug/g_{waste} $= 3.95E{+}01\ pCi^{U\text{-}234}/g_{waste} * (1\ g^{U234} / 6.2E{+}09\ pCi^{U234}) * 1.0E{+}06\ ug^{U234} / g^{U234}$
$= 6.36E{-}03\ ug^{U234}/g_{waste}$
U-235 ug/g_{waste} $= 5.07E{+}00\ pCi^{U\text{-}235}/g_{waste} * (1\ g^{U235} / 2.2E{+}06\ pCi^{U235}) * 1.0E{+}06\ ug^{U235} / g^{U235}$
$= 2.30E{+}00\ ug^{U235}/g_{waste}$
U-238 ug/g_{waste} $= 3.35E{+}01\ pCi^{U\text{-}238}/g_{waste} * (1\ g^{U238} / 3.4E{+}05\ pCi^{U238}) * 1.0E{+}06\ ug^{U238} / g^{U238}$
$= 9.84E{+}01\ ug^{U238}/g_{waste}$

Total U ugU/g_{waste} $= 6.36E{-}03\ ug^{U234}/g_{waste}$
$+\ 2.30E{+}00\ ug^{U235}/g_{waste}$
$+\ 9.84E{+}01\ ug^{U238}/g_{waste}$

$= 1.01E{+}02\ ugU/g_{waste}$

Preparer Marshall Davenport Date 4/14/2009

Reviewer [signature] Date 4/15/2009

BECHTEL JACOBS
Bechtel Jacobs Company LLC

BJC/OR-3088

Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment East Tennessee Technology Park, Oak Ridge, Tennessee

This document is approved for public release per review by:

[signature] 11/20/08

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Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment East Tennessee Technology Park, Oak Ridge, Tennessee

Date Issued—August 2008

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U.S. Department of Energy
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BECHTEL JACOBS COMPANY LLC
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APPROVALS

Sampling and Analysis Plan for K-770 Soils
for Waste Acceptance Criteria Attainment
East Tennessee Technology Park,
Oak Ridge, Tennessee
BJC/OR-3088

August 2008

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CONTENTS

TABLES

FIGURES

ACRONYMS

ACM	asbestos-containing material
BJC	Bechtel Jacobs Company LLC
CDM	CDM Federal Programs
COC	contaminant of concern
DQO	data quality objective
DVS	Dynamic Verification Strategy
EMWMF	Environmental Management Waste Management Facility
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
EU	exposure unit
FIDLER	field instrument for detection of low energy radiation
FY	fiscal year
ORNL	Oak Ridge National Laboratory
PCB	polychlorinated biphenyl
PRG	preliminary remediation goal
QAPP	Quality Assurance Project Plan
Quadrex	Quadrex Corporation
RA	remedial action
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act of 1976
RL	remediation level
SAP	Sampling and Analysis Plan
SOF	sum of fractions
SRS	Savannah River Site
SVOC	semivolatile organic compound
TAL	target analyte list
TCLP	Toxicity Characteristic Leaching Procedure
VOC	volatile organic compound
WAC	waste acceptance criteria

1. INTRODUCTION

This Sampling and Analysis Plan (SAP) describes the sampling and analysis that will be performed to support development of a waste profile for K-770 soils, which will satisfy the data quality objective (DQO) requirements for disposal at the Environmental Management Waste Management Facility (EMWMF). The soil volume addressed by this SAP includes soils contaminated by storage and staging of contaminated metal scrap within the K-770 Exposure Unit (EU) Group on the Powerhouse Peninsula at the East Tennessee Technology Park (ETTP), Oak Ridge Tennessee. The objective of this SAP is to provide data of known quality that is representative of the waste lot for comparison under the waste acceptance criteria (WAC) attainment guidance for disposal at EMWMF. The sampling strategy, methodology, sample locations, and analytical protocols are outlined in this SAP.

2. PROJECT DESCRIPTION

The K-770 remedial action (RA) will be executed in accordance with the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, TN* (DOE 2005) and the *Remedial Action Work Plan for Dynamic Verification Strategy for Zone 1 East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2007) (Zone 1 RAWP). The K-770 soils waste lot is expected to meet EMWMF WAC as a single waste lot, but the volume may be subdivided into two waste lots if the sample data indicates a high sum of fractions (SOF) volume is present that can be segregated during execution of the RA.

3. SITE DESCRIPTION

The K-770 Scrap Metal Yard and Contaminated Debris Site is a storage area located southwest of the main portion of ETTP, outside the security perimeter fence in the Powerhouse Area adjacent to the Clinch River. The site is located upstream from the confluence of the Clinch River with Poplar Creek. The scrap yard is surrounded by a locked fence and scrap metal is stored on the ground in piles and as loose objects in the area. The K-770 Scrap Metal Yard and Contaminated Debris Site occupy an approximately 21-acre tract of land. Building K-726, which was used to store polychlorinated biphenyl (PCB)-contaminated fluids scheduled for incineration, is also located within this area.

The K-770 area was used to store radioactively contaminated or suspected contaminated materials during and previous to the cascade upgrading program. Other known or suspected contaminants include PCBs, mercury, and asbestos incidental to scrap metal operations that were stored at the site prior to initiation of a waste management tracking program in 1977. The waste storage facility began operation in the 1960s and is estimated to at one time contain in excess of 40,000 tons of low-level, radioactively contaminated scrap metal. Also, the scrap metal piles contained approximately 20,000 ft^2 of asbestos-containing material (ACM), which consisted primarily of metal pipe. Scrap metal was taken to the site when it was found to contain alpha or beta/gamma activity on the surface or if the scrap metal originated from a process building.

Prior to 1984, there was no segregation of the low-level, radioactively contaminated scrap metal brought to the K-770 Scrap Yard. Cleanup of the scrap yard was initiated when Martin Marietta Energy Systems, Inc. contracted Quadrex Corporation (Quadrex) to relocate the material out of the 100-year floodplain, reduce the size of the material in an on-site processing unit, and segregate the material into piles separated by metal type. Quadrex performed the Health Physics activities of the contract and subcontracted the task of material handling to Southern Alloy. All material Quadrex was permitted to handle was removed from the floodplain and segregated into piles. The segregated metal debris was removed from the site as part of the K-770 Scrap Removal RA Project that was completed in fiscal year (FY) 2007 by Bechtel Jacobs Company LLC (BJC). An area of approximately 10 acres is located in EUs 29 and 31 where the scrap was originally located in the 100-year floodplain. In the process of moving the materials around and establishing segregated waste piles above the 100-year floodplain, the footprint of the site was expanded by 10-15 acres in EUs 30 and 32. The area in EUs 29 and 31 that was cleared of metallic debris in the floodplain was sown with grass. The areas in EUs 30 and 32 have some scattered vegetation but are generally open and accessible.

Several material categories established for waste at the K-770 Site during the segregation phase include the following:

- Asbestos-containing material
- Rubbish
- Items with hot spots above acceptable limits
- Segregated metal
- Class 004
- Cooling tower wood

With limited exception, all materials contained in these segregated piles have been removed and disposed of at EMWMF. Soils that underlay the original waste storage area in EUs 29 and 31 as well as soils that underlay the scrap piles in EUs 30 and 32 show substantially elevated radioactivity. In addition to soils present at the site, the slabs for Bldgs. K-725 and K-726 as well as several small concrete pads will be included in this waste lot. These slabs will be characterized as a separate data set. Characterization of these soils and the concrete slabs for disposal at EMWMF comprise the scope of this SAP. Contaminants present in these soils are directly derived from metallic debris and rubbish handled by the waste storage operations and will include the predominant constituents of concern associated with the metallic waste already disposed of at EMWMF. Contaminants on the surface of Bldgs. K-725 and K-726 slabs are associated with beryllium operations and PCB storage activities, respectively. Further sampling and characterization of residual metallic debris embedded in the soils that underlay the debris piles will not be conducted. The residual metallic debris will meet the same WAC criteria as the primary metallic waste lot profile as defined in Waste Lot Profile 65.1 (BJC 2004a), Waste Lot Profile 65.2 (BJC 2004b), and Waste Lot Profile 65.3 (BJC 2005). This residual metal debris will comprise approximately 5% of the total mass of material that will be generated under this RA.

3.1 PREVIOUS CHARACTERIZATION ACTIVITIES

Two investigative programs have been performed in EUs 29 and 31. An investigation conducted by CDM Federal Programs (CDM) under the Radiological Characterization of Inactive Waste Sites Program was performed in the mid-1990s, and Dynamic Verification Strategy (DVS) characterization of the area was performed in late 2004 and early 2005. Both programs used a combination of radiological walkover surveys and subsequent physical sampling to provide an assessment of this portion of the K-770 Waste Storage Site.

3.1.1 Radiation Walkover Surveys

A full-coverage survey of all open and accessible areas in EUs 29 and 31 and the southwestern portion of EU 33 were performed by CDM in the mid-1990s. This survey used a 2X2 NaI probe with geographic positioning equipment to obtain activity data coverage of the accessible areas. One large area of elevated activity and several smaller anomalies within the site were defined.

In 2004, BJC and Restoration Services Inc. conducted a walkover survey in EU 29 of the large area of elevated activity defined by the CDM survey. The more recent survey used a field instrument for detection of low-energy radiation (FIDLER) and was conducted to confirm the extent of elevated activity could be defined using a different field instrument. The FIDLER survey was successful in defining the same approximate boundary as defined by the CDM survey. The use of these survey instruments was to define areas of anomalous conditions and not to estimate quantitative radioisotopic concentrations.

3.1.2 Soil Sampling

Thirty-four surface soil samples were collected under the 1994 CDM assessment program. These were all biased samples selected to provide laboratory analyses in areas of significantly elevated radioactivity. Also, all of these samples were analyzed by gamma spectroscopy [U.S. Environmental Protection Agency (EPA) Method 901.1]. Concentrations of many of the primary Zone 1 radioisotopic contaminants of concern (COCs) cannot be accurately determined by this method; therefore, the radioisotopic concentrations results are considered unreliable and are not used in the assessment of the proposed waste lot.

Under the DVS Soils Characterization Program, the entire areas of EUs 29 and 31 were classified as Class 1 soil units. Based on the historic radiation walkover survey and historic sampling, there was a high degree of confidence that soil contamination in portions of the EUs was above Zone 1 maximum remediation levels (RLs) and an RA was required. The sampling plan, as defined in the K-770 DQO Summary Report, defined a base program of 40 sample locations placed on a systematic grid over the two EUs. In addition, 21 biased sampling locations were added to the base program sample set. These additional locations where selected within areas of elevated activity as defined by the radiation walkover surveys and, in some cases, in proximity to the historic sample locations to determine the concentration of radioactive contaminants present and compare to the reported historic sample results.

As prescribed under the DVS characterization DQOs, the sampling methodology is biased to high radioactive contaminant areas and intervals. The sampling approach is designed to provide data to support an action/no-action determination as a program objective and produce a high biased data set. The approach does not provide data appropriate for WAC determinations because the data are not representative of the average contaminant concentrations associated with the waste. The analytical methods are designated in the Zone 1 RAWP (DOE 2007) and are appropriate for all the respective radioisotopes. The data are 100% validated and are considered accurate to meet program DQO requirements.

The predominate radiological contaminants identified by the DVS data set include cesium-137 (maximum result = 27 pCi/g), technetium-99 (maximum result = 695 pCi/g), thorium-232 (maximum result = 60.7 pCi/g), uranium-234 (maximum result = 2090 pCi/g), uranium-235 (maximum result = 110 pCi/g), and uranium-238 (maximum result = 1660 pCi/g). With the exception of technicium-99, all of these isotopes are Zone 1 contaminants of concern. It is noted that neptunium was not detected in any DVS samples and radium-226 was detected at very low concentrations, with a maximum reported result of 3.1 pCi/g. These results are in contrast to very high reported concentrations in the historic data set analyzed by gamma spectroscopy. This substantial discrepancy supports the conclusion that the CDM data set is unreliable.

Other possible contaminants that may be present based on historic information include beryllium associated with the K-725 building slab, PCBs and wrapped pipe that contained asbestos. PCBs were stored in Bldg. K-726 prior to incineration.

A summary of sample results for U-238 from the DVS data set are presented in Table 1. These data represent a high bias set and are not considered representative of average concentrations that will be present in the K-770 soil waste lot.

No samples have been collected from the concrete slabs.

Table 1. Uranium-238 results for physical soil samples within the area of excavation at the K-770 soils site

EU	Location ID	Date	Depth		Sample ID	Result	Val Q	Lab Q	Detect	Error	X	Y
			Top	Bottom								
Z1-EU29	EU29B-132	1/20/2005	0.0	0.5	K7700708	1.41	=		0.112	0.256	2437910	580827
Z1-EU31	EU31B-125	1/5/2005	0.5	2.0	K7701172	1.42	=		0.1	0.294	2437677	581260
Z1-EU29	EU29B-121	1/3/2005	1.5	2.0	K7700295	1.43	=		0.0762	0.296	2437848	580509
Z1-EU29	EU29B-122	12/14/2004	0.9	2.0	K7700653	2.74	=		0.0807	0.354	2437731	580567
Z1-EU29	EU29B-125	1/14/2005	0.5	2.0	K7700345	3.5	=		0.0697	0.394	2437809	580686
Z1-EU29	EU29B-130	1/11/2005	0.5	2.0	K7700395	3.54	=		0.0587	0.398	2437724	580896
Z1-EU31	EU31B-123	1/25/2005	0.5	2.0	K7701142	3.78	=		0.0716	0.466	2437750	581055
Z1-EU29	EU29B-131	1/10/2005	0.5	2.0	K7700405	4.51	=		0.0998	0.482	2437845	580909
Z1-EU29	EU29B-126	12/14/2004	0.5	2.0	K7700355	4.79	=		0.116	0.466	2437760	580698
Z1-EU29	EU29B-119	12/20/2004	0.5	2.0	K7700275	5.43	=		0.103	0.581	2437802	580446
Z1-EU31	EU31-101	1/12/2005	0.0	2.0	K7701039	5.95	=		0.0698	0.513	2437837	580953
Z1-EU29	EU29B-129	1/12/2005	0.5	2.0	K7700385	10.9	=		0.0813	0.707	2437731	580825
Z1-EU29	EU29B-129	1/12/2005	0.0	0.5	K7700693	11.3	=		0.0313	0.722	2437731	580825
Z1-EU29	EU29B-128	1/12/2005	0.5	2.0	K7700375	11.8	=		0.0702	0.726	2437852	580815
Z1-EU29	K-770 MSY-SS8	11/5/2004	0.0	1.0	SS8K7701101-RAD	12.5	=		0.03	1.1	2437729	580632
Z1-EU31	EU31-104	1/13/2005	0.0	0.5	K7701052	13.8	=		0.085	0.812	2437886	581036
Z1-EU31	EU31B-126	1/5/2005	0.5	2.0	K7701187	14.4	=		0.0753	0.933	2437815	581314
Z1-EU29	EU29B-125	1/14/2005	0.0	0.5	K7700673	14.6	=		0.0709	0.811	2437809	580686
Z1-EU29	EU29B-130	1/11/2005	0.0	0.5	K7700698	16.4	=		0.116	0.879	2437724	580896
Z1-EU29	EU29B-127	1/20/2005	0.0	0.5	K7700683	18.2	=		0.03	0.896	2437839	580704
Z1-EU29	EU29-111	1/14/2005	0.0	0.5	K7700572	23.4	=		0.0773	1.07	2437837	580785
Z1-EU31	EU31-105	1/21/2005	0.1	0.5	K7701057	24.5	=		0.0766	1.13	2437789	581036
Z1-EU31	EU31B-125	1/5/2005	0.0	0.5	K7701167	26.7	=		0.0802	1.31	2437677	581260
Z1-EU31	EU31B-124	1/7/2005	0.5	2.0	K7701157	27.3	=		0.143	1.28	2437608	581173
Z1-EU29	EU29-118	1/24/2005	1.4	1.9	K7700628	31.4	=		0.0922	1.32	2437886	580869
EU33	EU33-145	12/28/2004	0.0	0.7	K7701586	33.6	=		0.072	1.39	2437789	581538
Z1-EU31	EU31-102	1/21/2005	0.7	1.2	K7701044	40.6	=		0.0843	1.52	2437741	580953
Z1-EU29	EU29B-124	12/14/2004	0.5	0.9	K7700327	42.8	=		0.0319	1.42	2437764	580600
Z1-EU29	EU29-109	12/10/2004	0.2	0.5	K7700554	43.2	=		0.0472	1.73	2437644	580785
Z1-EU29	EU29B-127	1/20/2005	0.5	0.9	K7700365	43.2	=		0.0316	1.42	2437839	580704
Z1-EU31	EU31-106	12/16/2004	0.1	0.5	K7701061	45.3	=		0.0749	1.65	2437692	581036
Z1-EU31	EU31B-126	1/5/2005	0.0	0.5	K7701182	53.4	=		0.0795	1.85	2437815	581314
Z1-EU29	EU29M-110	12/15/2004	0.7	1.0	K7700564	55.3	=		0.113	2.06	2437741	580785
Z1-EU29	EU29-103	12/15/2004	0.1	0.5	K7700504	56.6	=		0.125	1.9	2437837	580451
Z1-EU29	EU29B-123	12/14/2004	1.7	2.0	K7700315	61.3	=		0.119	1.72	2437693	580619
Z1-EU29	EU29B-131	1/10/2005	0.0	0.5	K7700703	71	=		0.102	1.93	2437845	580909

Table 1. Uranium-238 results for physical soil samples within the area of excavation at the K-770 soils site (cont.)

EU	Location ID	Date	Depth Top	Depth Bottom	Sample ID	Result	Val Q	Lab Q	Detect	Error	X	Y
Z1-EU29	EU29B-126	12/14/2004	0.0	0.4	K7700678	84.7	=		0.0924	2.23	2437760	580698
Z1-EU31	EU31B-128	1/10/2005	0.5	2.0	K7701217	90.5	=		0.135	2.34	2437893	581058
Z1-EU29	EU29-114	12/10/2004	0.0	0.3	K7700598	92.1	=		0.128	2.82	2437692	580702
Z1-EU31	EU31-103	12/16/2004	0.2	0.6	K7701048	117	=		0.0753	3.6	2437644	580953
Z1-EU29	EU29B-119	12/20/2004	0.0	0.5	K7700638	124	=		0.11	3.32	2437802	580446
Z1-EU29	EU29B-128	1/12/2005	0.0	0.5	K7700688	131	=		0.0609	3.43	2437852	580815
Z1-EU29	EU29-107	12/13/2004	0.0	0.3	K7700542	134	=		0.164	3.85	2437741	580618
Z1-EU29	EU29-113	12/13/2004	0.0	0.3	K7700590	147	=		0.0775	4.1	2437789	580702
Z1-EU31	EU31B-123	1/25/2005	0.1	0.5	K7701137	179	=		0.224	4.7	2437750	581055
Z1-EU29	EU29B-122	12/14/2004	0.0	0.3	K7700305	180	=		0.137	4.33	2437731	580567
Z1-EU31	EU31B-124	1/7/2005	0.0	0.5	K7701152	209	=		0.24	5.49	2437608	581173
Z1-EU29	EU29B-124	12/14/2004	0.0	0.3	K7700665	342	J		0.104	7.23	2437764	580600
Z1-EU29	EU29B-121	1/3/2005	0.0	0.5	K7700648	935	=		1.07	23.7	2437848	580509
Z1-EU29	EU29B-123	12/14/2004	0.4	0.6	K7700658	1660	J		1.06	36.1	2437693	580619
Z1-EU31	EU31B-128	1/10/2005	0.0	0.5	K7701212	15900	J		5.79	368	2437893	581058
	All result	Min	1.41	Data set less 15900 result	Min	1.41						
		Max	15900.00		Max	1660.00						
		Mean	415.05		Mean	105.35						
		Standard deviation	2227.21		Standard deviation	265.09						

EU = exposure unit
ID = identification
Max = maximum
Min = minimum

4. PROJECT DQOS

The DQO process is a systematic approach to defining sample program requirements. The following sections provide the K-770 WAC program DQO logic.

The RA to be taken at the K-770 Site will involve a surface excavation within the areas (approximately 10.1 acres) defined by the radiological walkover survey. Soils will be removed over the area to a depth of approximately 1 ft below the existing surface grade. The resultant waste lot will be comprised of 95% soils and approximately 5% metallic debris imbedded in the soil that underlay the scrap waste piles in the area.

4.1 STATE THE PROBLEM

The types and concentrations of PCBs and semivolatile organic, radioactive, and inorganic (metallic) contaminants in the soils and concrete slabs waste lot must be determined to transport and dispose of the contaminated materials from the K-770 Site.

4.2 PRINCIPLE STUDY QUESTION

The principle study question is to determine the average contaminant concentrations for PCBs, semivolatile organic, and radioactive and inorganic (metallic) constituents to a 95% confidence level for the K-770 soil and concrete waste lot, and ascertain if the waste can be disposed of in the EMWMF.

4.3 INFORMATION INPUTS

The following is needed to identify information inputs:

- EMWMF WAC requirements
- Historical information, including facility and site operations
- Analytical data associated with the metallic debris formally stored at the site and the presumed source of the soil contamination.
- Radiological walkover survey data
- DVS program laboratory sample data
- Newly acquired laboratory sample data

Waste acceptance will be determined using EMWMF evaluation criteria as defined in the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2001).

4.4 PROCESS KNOWLEDGE

Beginning in 1944-45, this area was the site of a tank farm designated F-22 and used for storing Bunker C oil (No. 3 grade fuel oil). This oil was stored in 13 tanks, each with a 470,000-gal capacity adjacent to the Clinch River. Each tank was individually isolated by an earthen dike and a secondary dike around each group of three tanks. Fuel oil usage at the Powerhouse extended from 1944 through the end of 1953 and the tanks remained in place until 1954.

Scrap metal storage in this area began in the 1960s and waste management tracking operations began in 1977. From 1984 to 1986, the metals were segregated under a contract to Quadrex. The waste materials were separated by metal type and reduced in volume by shearing. Categories of metals were ACM, rubbish, items with radiological hot spots, and Class 004 (too large to shear). A Resource Conservation and Recovery Act of 1976 (RCRA) assessment was performed on this site in FY 1994 and all readily identified and accessible RCRA-regulated materials were removed.

The majority of metal at the K-770 Scrap Yard was generated during the Cascade Improvement Program/Cascade Upgrade Program. Most of the scrap metal passed through the K-1420 decontamination facility, where it was vacuumed and washed using water with dilute nitric acid or an alkaline detergent. This decontamination process removed transferable uranium prior to outside storage. In the 1980s, much of the scrap metal was segregated and size reduced. The metal was segregated into groupings of ferrous metals, non-ferrous metals, and other metals with potential recycle value. In addition to material from the ETTP Site (formerly known as the K-25 Site), materials from the Y-12 Site, Savannah River Site (SRS), and Oak Ridge National Laboratory (ORNL) were received at this scrap yard. Material from the Y-12 and K-25 Sites was contaminated with uranium, the SRS material contained scrap metal released as part of a recycling program, and the ORNL waste included four heat exchangers. The total non-uranium based waste (i.e., non-K-25 Site or Y-12 Site waste) was < 0.5% of the total waste. The scrap yard material consisted of five primary waste piles of scrap metal that comprised approximately 40% of the waste by weight and were disposed of at EMWMF. All building structures within the area of the site have been demolished to the building slabs, which remain in place. All scrap metal that was not embedded in the surface soils has been removed and disposed of at EMWMF. All physical samples collected by the Zone 1 DVS Soils Characterization Program were analyzed for the presence of PCBs and metals. Results of these analyses indicated the metal concentrations in some samples could exceed the land disposal regulations. No volatile organic compounds (VOCs) were reported in any DVS samples above the industrial use preliminary remediation goals (PRGs), and only two DVS samples reported semivolatile organic compounds (SVOCs) present above the industrial use PRGs. Two samples were reported with PCBs above the Zone 1 average RLs.

4.4.1 K-725 Building

In 1944-1945, the K-725 building was originally used as a machine shop to support activities at the Fercleve S-50 Thermal Diffusion Plant. In the late 1940s and early 1950s, the building was used for beryllium machining and experimentation. Building surveys during the late 1950s identified considerable beryllium contamination and some minor radiological contamination on equipment and building structures (air vents and floor tiles). At least two unsuccessful attempts were made to decontaminate the building. The building was closed to work activities in the 1970s. The structure has been demolished and only the floor slab [approximately 160 × 85 ft (estimated 250 yd of concrete)] remains.

4.4.2 K-726 Building

The K-726 building was originally built as a boiler house to burn bunker C oil to support the Fercleve Thermal Diffusion experiments. Operations at this building were discontinued in 1945. Beginning in 1978, the building was used to store PCB-containing liquids and solids. The structure has been demolished and only the floor slab remains.

4.5 BOUNDARIES OF THE STUDY

The proposed excavation boundaries shown as a green line on Fig. 1 have been defined based on radiological walkover surveys. The area is approximately 10.1 acres in extent and is comprised of three large contiguous areas over 1 acre that is presumed to have contamination generally above Zone 1 average RLs. Several smaller areas of substantially elevated radioactivity are defined within the large contiguous boundaries and at isolated locations of limited areal extent in the surrounding areas of the site. Concrete slabs represent approximately 400 yd of material.

4.6 ANALYTIC APPROACH AND FINAL DECISION STATEMENTS

Contamination at the K-770 Site is present on the ground surface over most of the area to be remediated. Within the larger contiguous areas, there is some acreage that does not appear to have surface contamination. The surface contamination area is identifiable using radiation field-detecting instruments that clearly define anomalous conditions and can be used to establish the initial excavation area boundary. The radiation walkover survey data set, in conjunction with the surface release conceptual model, is supported by institutional knowledge. The high bias data set that was collected by the DVS Characterization Program provided a general depiction of the nature and extent of contamination at the site. The data confirm results of the radiological walkover survey, which indicates there are three large contiguous areas that exhibit slightly to moderately elevated radioactivity (U-238 results, which are the predominant contaminant at the site, are presented in Table 1). Samples located within the areas of elevated radioactivity where contaminated metallic debris was stored generally reported concentrations for at least one radioisotope above Zone 1 average RLs. DVS data indicates the contamination is contained in very thin layers of surface-contaminated soils that are generally no more than a few inches thick. The contaminants remain in the upper foot of soil where contamination has been covered by site activities. Laboratory data indicates the contaminants in excess of Zone 1 average RLs are distributed in surface soils over the broader contiguous areas. Isolated smaller spots of substantially elevated contamination (at or above Zone 1 maximum RLs) are contained within the limits of the broader lower activity surface areas and as isolated smaller areas distributed around the primary area of contamination to the north and east. The proposed RA will define the excavation area boundary using the radiation walkover survey data to define the extent of anomalous activity above approximately 2X background (approximately 8000 cpm using a 2X2 NaI detector, and 3000 cpm for the FIDLER instrument), which generally corresponds to the average RL for Uranium-238. Since more than one radioisotope may be present, the field instrumentation is not considered quantitative. Remedial action will entail scraping approximately 1 ft of surface soil from the area inside the defined boundaries. Certain isolated areas that have high activity (50,000+ cpm) may be segregated from the large soil waste lot as a high SOF waste lot (see decision rule 2 below).

Decision rule no.	If	Then	Otherwise
1	The average concentration of soil COCs in the K-770 waste lot meets WAC for disposal at EMWMF	Dispose of the K-770 soils at EMWMF	Identify and segregate high SOF soils, handle as a separate waste lot, and re-evaluate the remainder against the EMWMF WAC; repeat until a waste lot is acceptable for disposal at the EMWMF
2	The concentration of soil COCs in the high SOF waste lot meets WAC for disposal at EMWMF	Dispose of the high SOF K-770 soils waste lot at EMWMF	Dispose of at an off-site facility

Fig. 1. K-770 planned sample locations overlain on the radiological walkover survey map.

4.7 PERFORMANCE OR ACCEPTANCE CRITERIA

The acceptability of the soils for disposal at EMWMF will be based on samples collected under this SAP and will not include results from previously acquired soil samples. Laboratory detection levels, analytical methods, and reporting requirements shall follow the Zone 1 RAWP Quality Assurance Project Plan (QAPP) (DOE 2007). Waste acceptance will be determined using EMWMF evaluation criteria that are defined in the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2001)

4.8 PLAN FOR OBTAINING DATA

Based on the description above, data collected within the proposed excavation area in EUs 29 and 31 were used to support a determination of the number of samples required to characterize the large contiguous areas of contamination. The DVS data set includes all laboratory sample results from all sample boring locations located within the proposed excavation area boundary. Results from all depths from 0-10-ft BGS are included in the complete data set. Thirty-four sample locations in the DVS program are located within the area of excavation. Of these 34 locations, 16 were placed using VSP™ software on a systematic triangular offset grid with a random start location. One sample was collected from each of the systematic grid locations in the 0-2 ft interval (16 samples). The other 18 sample locations were targeted biased locations associated with areas of substantially elevated radioactivity (greater than 2X background) as defined by the CDM radiological walkover survey of the area. There are two samples from each of these locations in the 0-2.0 ft interval (0-0.5 and 0.5-2.0ft), of these 18 locations one had only a surface sample collected (35 samples) The total number of soil samples collected in the 0-2.0 ft interval within the area to be excavated in EUs 29 and 31 identified 51 total sample results for U-238.

Using the DVS data set laboratory results for U-238, the statistical characteristics of the data were determined and are presented in Fig. 2. Note that the entire data set includes 51 results for U-238, however, the highest result associated with one sample was more than an order of magnitude higher than the next highest value. It is known that there are small isolated areas within the site that have substantial contamination but low volumes. For this reason, the highest value was dropped from the data set. The small isolated areas exhibiting activity > 50,000 cpm will be sampled as a biased set of samples, which may represent a low volume, high sum of fractions waste lot. The sample design is predicated upon collecting two separate data sets. The N value calculated for the large areas of the relatively low-level contamination (large volume low sum-of fractions) waste lot is based on the data set that does not include this single high result. The remaining data set is representative of the broad areas of low contamination and this set of data is used to determine the number of samples needed to characterize the large areas of contaminated soil. A second set of samples biased to the highly contaminated localized soils areas are proposed to provide a representative set of samples for what may be a high SOF small volume waste lot.

Using these data sets and VSP™ software (alpha = 0.05, beta = 0.20, delta = 130, action level = 50, and standard deviation of the U-238 data set = 265), alpha and beta are selected to provide a 95% confidence level on the mean and delta is selected based on the clean-up criteria and risk protocol, which results in removing contaminated soil areas to levels that will not result in an average RL exceedance over the area of an EU. The action level of 50 corresponds to the average remediation level for U-238 as defined by the Zone 1 ROD. Using these parameters the number (N) of samples required to adequately characterize the proposed excavation was determined to be 32 samples. Individual isolated areas to the north and east, and hot spots contained within the large areas of surface contamination that exhibit radioactivity above 50,000 cpm on FIDLER surveys, will be sampled as a separate biased data set. Approximately 13 samples will comprise this separate data set (see Appendix A).

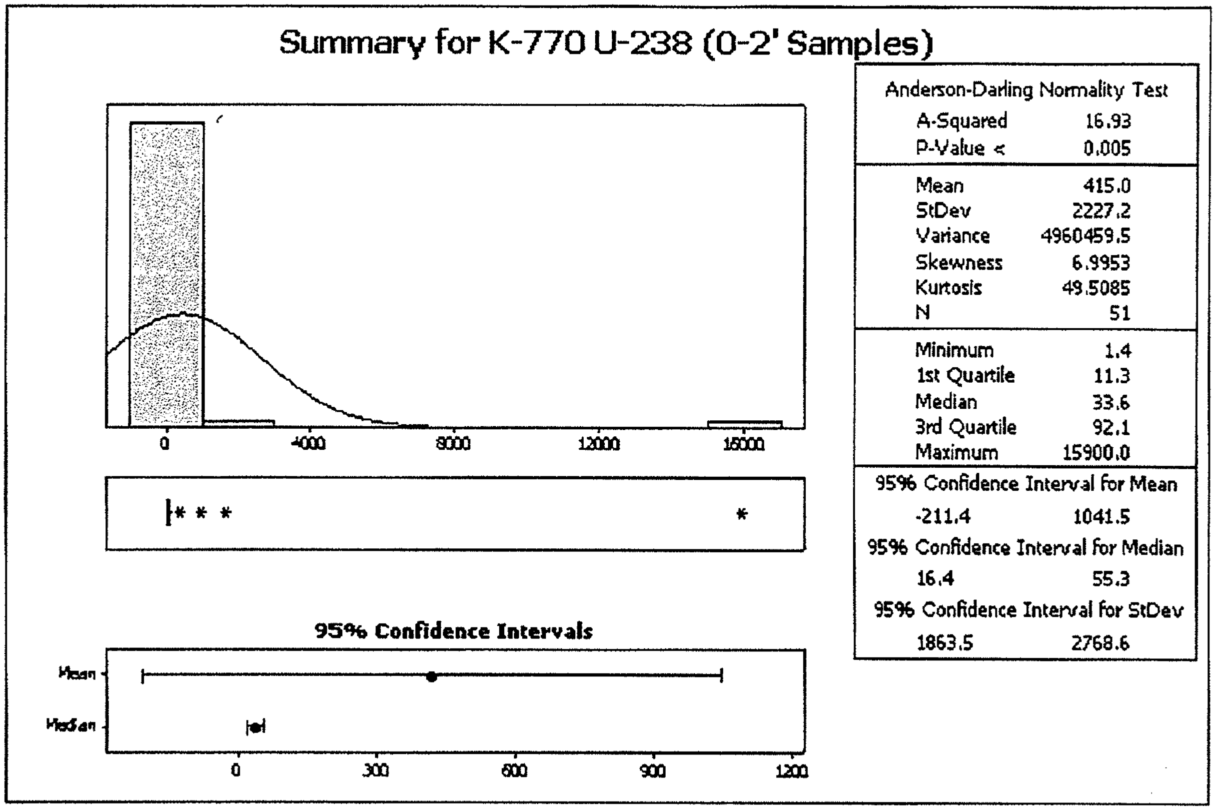

Fig. 2. Summary for K-770 excavation area (0-2.0 ft interval U-238 results).

Sample locations shown on Fig. 1 are generated in VSP on a triangular offset grip with a random start location, and are approximately 113 ft apart over the excavation areas. The proposed excavation boundary does not include portions of the EU outside the proposed excavation boundary. The three large areas of low-level contamination were treated in VSP as a single polygonal feature. The 32 locations are distributed in relationship to the total large low-contamination proposed excavation area. All samples will be five-point surface composite samples comprised of five equal aliquots of soil collected from the surface to a depth of 1 ft below existing grade. The five aliquots of soil will be spaced 10 ft from the location center point oriented in the cardinal directions. The ground location coordinates are assigned to the sample location center point and are included on the Sample Summary Table (Appendix A).

The five aliquots of soil will be thoroughly mixed according to the sampling procedure identified in the Zone 1 RAWP. All sampling activities will follow the Zone 1 RAWP DVS requirements (DOE 2007). Laboratory results will be validated and verified according to Zone 1 RAWP DVS requirements. Proposed center-point sample locations for the two proposed sample sets are shown on Fig. 1.

The analytical suite for all samples will include VOC, SVOC, target analyte list (TAL) metals, PCBs, Toxicity Characteristic Leaching Procedure (TCLP) SVOC, TCLP metals, and a full suite of radioisotopic analyses as defined in the Zone 1 QAPP, Appendix A, Table A.9 (DOE 2007). Details of the analytical requirements are included in the Zone 1 RAWP, Appendix A, Table A.9, that was developed following the EPA QAPP SAP checklist requirements.

4.9 CONCRETE SAMPLES

A total of 14 concrete samples will be collected (eight from the K-725 slab, two from the K-726 slab, and one from each of the small concrete pads within the K-770 Site). The number of samples represents a 25-ft-radius hot spot generated by VSP software on a systematic grid with a random start location for the K-725 and K-726 buildings. The hot spot radius selected for concrete samples was selected at half of the Zone 1 DVS hot spot size to provide a minimum number of samples. Concrete samples will be collected according to Zone 1 RAWP concrete sampling protocol, which allows roto-hammer drill cutting to be used for all analytes other than VOCs, or chipping to collect PCBs if required. Analyses of the concrete samples will be for radiological constituents, PCBs, and TAL metals, plus beryllium and mercury. Locations of the concrete samples relative to the slab surfaces are shown on Fig. 3. Ground location coordinates and required analyses are provided in the Sample Summary Table (Appendix A).

Fig. 3. K-770 concrete slab sample location map.

5. REFERENCES

BJC 2004a. *Waste Profile for the Disposal of the Scrap Removal Project Waste Lot 65.1*, BJC/OR-1857, Rev. 1, Bechtel Jacobs Company LLC, July.

BJC 2004b. *Waste Profile for Disposal of the Scrap Removal Project Waste Lot 65.2, East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1859, Rev. 1, Bechtel Jacobs Company LLC, August.

BJC 2005. *Waste Profile for Disposal of the Scrap Removal Project Waste Lot 65.3 - East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1859, Rev. 4, Bechtel Jacobs Company LLC, May.

DOE 2001. *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-1909&D3, Bechtel Jacobs Company LLC, Oak Ridge, TN, October.

DOE 1993. Radiation Protection of the Public and the Environment, DOE Order 5400.5, Change 2, U.S. Department of Energy, Washington, D.C.

DOE 2002. *Record of Decision for Interim Remedial Actions for Selected Contaminated Areas Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-1997&D2, Bechtel Jacobs Company LLC, Oak Ridge, TN.

DOE 2005. *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, TN*, DOE/OR/01-1997&D2, Bechtel Jacobs Company LLC, Oak Ridge, Tennessee.

DOE 2007. *Remedial Action Work Plan for Dynamic Verification Strategy for Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-2182&D4, Bechtel Jacobs Company LLC, Oak Ridge, TN.

APPENDIX A.
SAMPLE SUMMARY TABLE

Table A.1. Sample summary table for Zone 1 K-770 soils WAC

Exposure unit	Location ID	Location		Sample Interval	Off-site laboratory							Splits/ dups	Comments and notes
		North	East		VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD		
Exposure Unit 29													
Z1-EU29	Z1-EU29W-401	580602	2437882	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-402	580602	2437769	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-403	580700	2437826	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-404	580700	2437712	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-405	580798	2437882	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-406	580798	2437769	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-407	580798	2437656	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-408	580896	2437826	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29W-409	580896	2437712	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU29	Z1-EU29BW-410	580456	2437818	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Exposure Unit 30													
Z1-EU30	Z1-EU30BW-411	580614	2437954	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Exposure Unit 31													
Z1-EU31	Z1-EU31W-412	580994	2437882	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU31	Z1-EU31W-413	580994	2437769	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU31	Z1-EU31W-414	580994	2437656	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU31	Z1-EU31BW-415	581159	2437610	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU31	Z1-EU31BW-416	581238	2437690	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU31	Z1-EU31BW-417	581321	2437802	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Exposure Unit 32													
Z1-EU32	Z1-EU32W-418	581006	2438160	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-419	581006	2438273	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-420	581006	2438387	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-421	581104	2438104	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-422	581104	2438217	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-423	581104	2438330	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-424	581104	2438443	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-425	581202	2438160	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		

Table A.1. Sample summary table for Zone 1 K-770 soils WAC (cont.)

Exposure unit	Location ID	Location		Sample interval	Off-site laboratory							Splits/ dups	Comments and notes
		North	East		VOC	SVOC	TCLP SVOC	Metals & Hg	TCLP Metals	PCB	Full RAD		
Z1-EU32	Z1-EU32W-426	581202	2438273	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-427	581202	2438387	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-428	581300	2438217	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-429	581300	2438330	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0 5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32W-430	581300	2438443	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32BW-431	581040	2438206	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32BW-432	581090	2438171	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32BW-433	581221	2438337	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU32	Z1-EU32BW-434	581043	2437889	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Exposure Unit 33													
Z1-EU33	Z1-EU33W-435	581398	2438273	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU33	Z1-EU33W-436	581398	2438387	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU33	Z1-EU33W-437	5814878	2438329	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU33	Z1-EU33W-438	581605	2438397	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU33	Z1-EU33W-439	581722	2438339	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0 5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU33	Z1-EU33W-440	581722	2438465	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU33	Z1-EU33W-441	581839	2438397	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0 7 ft	1	1	1	1	1	1	1		
Z1-EU33	Z1-EU33BW-442	581633	2437689	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU33	Z1-EU33BW-443	581564	2437760	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0 5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU33	Z1-EU33BW-444	2438138	581565	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Z1-EU33	Z1-EU33BW-445	2438144	581450	Five point composite 0.0-1.0 ft, 10 ft offset from center point in cardinal directions, discrete VOA at center point 0.5-0.7 ft	1	1	1	1	1	1	1		
Concrete samples													
K-725 building slab													
Z1-EU30	Z1-EU30C-444	580609	2438222	Concrete sample				1		1	1		
Z1-EU30	Z1-EU30C-445	580609	2438250	Concrete sample				1		1	1		
Z1-EU30	Z1-EU30C-446	580633	2438208	Concrete sample				1		1	1		
Z1-EU30	Z1-EU30C-447	580633	2438236	Concrete sample				1		1	1		
Z1-EU30	Z1-EU30C-448	580633	2438264	Concrete sample				1		1	1		
Z1-EU30	Z1-EU30C-449	580658	2438194	Concrete sample				1		1	1		
Z1-EU30	Z1-EU30C-450	580658	2438222	Concrete sample				1		1	1		
Z1-EU30	Z1-EU30C-451	580682	2438208	Concrete sample				1		1	1		
K-726 building slab													
Z1-EU30	Z1-EU30C-452	580917	2438275	Concrete sample				1		1	1		
Z1-EU30	Z1-EU30C-453	580950	2438294	Concrete sample				1		1	1		
Other concrete slabs EU 30													
Z1-EU30	Z1-EU30C-454	580697	2437979	Concrete sample				1		1	1		
Other concrete slabs EU 32													
Z1-EU32	Z1-EU30C-455	581078	2438007	Concrete sample				1		1	1		
Z1-EU32	Z1-EU30C-456	581111	2437988	Concrete sample				1		1	1		

Table A.1. Sample summary table for Zone 1 K-770 soils WAC (cont.)

ID = identification
PCB = polychlorinated biphenyl
RAD = radiological
SVOC = semivolatile organic contaminants
TCLP = Toxicity Characteristic Leaching Procedure
VOC = volatile organic contaminants
WAC = waste acceptance criteria

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FCN-ETTP-Zone 1-092

Core Team Concurrence

In accordance with the Dynamic Verification Strategy, the following revisions are proposed for the Zone 1 Powerhouse 770 Area (EUs Z1-28-33)

Area: Zone 1 770 Area — approve the 770 Area Waste Acceptance Criteria (WAC) Sampling and Analysis Plan (SAP).

Change(s): The proposed change is to approve the attached 770 Area WAC SAP.

This action will be documented in the Zone 1 Powerhouse 770 Area Technical Memoranda, which will be an appendix in future Phased Construction Completion Reports.

Concurrence:

M. A. Travaglini
U.S. Department of Energy — Date: 8/21/08

Thomas A. Gebhart
Tennessee Department of Environment and Conservation — Date: 8/20/08

Constance Allison Jones
U.S. Environmental Protection Agency — Date: 8/19/08

BECHTEL JACOBS
Bechtel Jacobs Company LLC

SOW: BKET02533
Revision: 5
Date: 02/17/2009
SOW Group: STANDARD

OAK RIDGE SAMPLE MANAGEMENT OFFICE
ANALYTICAL STATEMENT OF WORK

Project Description: Characterization studies for the ETTP Site Zone 1 Areas. Multiple sampling events will determine need for analysis to determine risk for identified exposure units. This SOW is a continuation of the FY08 Zone 1 lab SOW and will include regular sampling events.

Project No: ETTP Zone 1
Work Release No:

Project Manager: Richard Lee
Telephone: (865)576-6596
Fax: (865)241-8850
Address: MS 6410, Bldg 6556U
PO Box 2008
Bethel Valley Road
Oak Ridge, TN 37831-6410

Project Control Engineer: Diana Boshears
Telephone: (865)576-6481
Fax: (865)241-5142
Alternate:

Charge Number: KKHIDVS1
ADS:
B & R No.:
Funding Source:

Sample Start Date: 09/29/2008
Sample Completion Date: 09/30/2009
Sampling Events: One event at present; additional sampling requirements to be added as needed.
Containers: Lab **WILL** supply containers.

Sample Quantity:

Sample Disposal: LAB DISPOSAL
Required Archival: 3 Month(s)
Comments:

Suspected Hazards:
TSCA Regulated: No
(PCBs > 50 ppm)

Isotopes of Concern: Alpha emitters
Estimated Level of Radioactivity:
Comments:

Shipping: The Project Manager is to fax the Chain of Custody and any supporting documentation (RFA, Total Activity Report, etc.) to the OR SMO prior to each shipment.

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(NOTE: All turnaround and holding times are in calendar days. An 'NC' in the Hold Time column indicates that the holding time will not be

calculated for these analyses. CAS Numbers with the prefix of 'N' are non-standard identifiers assigned by the Oak Ridge Environmental Information System. The provided standard and non-standard CAS numbers must be used to report the listed analytes in electronic data.)

Qty	Matrix Type	Proponent/Method	Analyte	Cas No.	Req Report Limit	Turn Time	Hold Time
10	WATER	RAD-GAMMA SPECTROSCOPY	Cesium-137	10045-97-3	PER METHOD	30	180
10	WATER	RAD-GAMMA SPECTROSCOPY	Cobalt-60	10198-40-0	PER METHOD	30	180
10	WATER	RAD-GAMMA SPECTROSCOPY	Potassium-40	13966-00-2	PER METHOD	30	180
10	WATER	RAD-GAMMA SPECTROSCOPY	Thorium-234	15065-10-8	PER METHOD	30	180
10	WATER	RAD-GAMMA SPECTROSCOPY	Uranium-235	15117-96-1	PER METHOD	30	180
10	WATER	RAD-GAMMA SPECTROSCOPY	zz All other gamma isos >MDA		PER METHOD	30	180
10	WATER	RAD-GROSS ALPHA/BETA	Gross Alpha	12587-46-1	PER METHOD	30	180
10	WATER	RAD-GROSS ALPHA/BETA	Gross Beta	12587-47-2	PER METHOD	30	180
10	WATER	RAD-NP-237 BY ALPHA	NP-237	13994-20-2	PER METHOD	30	180
10	WATER	RAD-TC-99 BY BETA LSC	TC-99	14133-76-7	PER METHOD	30	180
10	WATER	RAD-TH ISO BY ALPHA	Thorium-228	14274-82-9	PER METHOD	30	180
10	WATER	RAD-TH ISO BY ALPHA	Thorium-230	14269-63-7	PER METHOD	30	180
10	WATER	RAD-TH ISO BY ALPHA	Thorium-232	N2608	PER METHOD	30	180
10	WATER	RAD-U ISO BY ALPHA	U-233/234	NS632	PER METHOD	30	180
10	WATER	RAD-U ISO BY ALPHA	U-235/236	N1047	PER METHOD	30	180
10	WATER	RAD-U ISO BY ALPHA	U-238	24678-82-8	PER METHOD	30	180
88	WATER	SW846-6010B	Aluminum	7429-90-5	PER METHOD	30	180
88	WATER	SW846-6010B	Arsenic	7440-38-2	PER METHOD	30	180
88	WATER	SW846-6010B	Barium	7440-39-3	PER METHOD	30	180
88	WATER	SW846-6010B	Beryllium	7440-41-7	PER METHOD	30	180
88	WATER	SW846-6010B	Boron	7440-42-8	PER METHOD	30	180
88	WATER	SW846-6010B	Calcium	7440-70-2	PER METHOD	30	180
88	WATER	SW846-6010B	Chromium	7440-47-3	PER METHOD	30	180
88	WATER	SW846-6010B	Cobalt	7440-48-4	PER METHOD	30	180
88	WATER	SW846-6010B	Copper	7440-50-8	PER METHOD	30	180
88	WATER	SW846-6010B	Iron	7439-89-6	PER METHOD	30	180
88	WATER	SW846-6010B	Lead	7439-92-1	PER METHOD	30	180
88	WATER	SW846-6010B	Lithium	7439-93-2	PER METHOD	30	180
88	WATER	SW846-6010B	Magnesium	7439-95-4	PER METHOD	30	180
88	WATER	SW846-6010B	Manganese	7439-96-5	PER METHOD	30	180
88	WATER	SW846-6010B	Molybdenum	7439-98-7	PER METHOD	30	180
88	WATER	SW846-6010B	Nickel	7440-02-0	PER METHOD	30	180
88	WATER	SW846-6010B	Potassium	7440-09-7	PER METHOD	30	180
88	WATER	SW846-6010B	Selenium	7782-49-2	PER METHOD	30	180
88	WATER	SW846-6010B	Silver	7440-22-4	PER METHOD	30	180
88	WATER	SW846-6010B	Sodium	7440-23-5	PER METHOD	30	180
88	WATER	SW846-6010B	Vanadium	7440-62-2	PER METHOD	30	180
88	WATER	SW846-6010B	Zinc	7440-66-6	PER METHOD	30	180
88	WATER	SW846-6020A	Antimony	7440-36-0	PER METHOD	30	180
88	WATER	SW846-6020A	Cadmium	7440-43-9	PER METHOD	30	180
88	WATER	SW846-6020A	Thallium	7440-28-0	PER METHOD	30	180
88	WATER	SW846-6020A	Uranium	7440-61-1	PER METHOD	30	180
88	WATER	SW846-7470A	Mercury	7439-97-6	PER METHOD	30	28
10	WATER	SW846-8082	Aroclor 1016	12674-11-2	PER METHOD	30	7
10	WATER	SW846-8082	Aroclor 1221	11104-28-2	PER METHOD	30	7
10	WATER	SW846-8082	Aroclor 1232	11141-16-5	PER METHOD	30	7
10	WATER	SW846-8082	Aroclor 1242	53469-21-9	PER METHOD	30	7
10	WATER	SW846-8082	Aroclor 1248	12672-29-6	PER METHOD	30	7

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(NOTE: All turnaround and holding times are in calendar days. An 'NC' in the Hold Time column indicates that the holding time will not be calculated for these analyses. CAS Numbers with the prefix of 'N' are non-standard identifiers assigned by the Oak Ridge Environmental Information System. The provided standard and non-standard CAS numbers must be used to report the listed analytes in electronic data.)

Qty	Matrix Type	Proponent/Method	Analyte	Cas No.	Req Report Limit	Turn Time	Hold Time
10	WATER	SW846-8082	Aroclor 1254	11097-69-1	PER METHOD	30	7
10	WATER	SW846-8082	Aroclor 1260	11096-82-5	PER METHOD	30	7
10	WATER	SW846-8082TPCB	Total PCB	TOTAL PCB	PER METHOD	30	7
30	WATER	SW846-8260B	ALL ANALYTES		PER METHOD	30	14
10	WATER	SW846-8270C	ALL ANALYTES		PER METHOD	30	7
26	SOIL	RAD-GAMMA SPECTROSCOPY	Cesium-137	10045-97-3	1.0 PCI/G	30	180
26	SOIL	RAD-GAMMA SPECTROSCOPY	Cobalt-60	10198-40-0	1.0 PCI/G	30	180
26	SOIL	RAD-GAMMA SPECTROSCOPY	Potassium-40	13966-00-2	10.0 PCI/G	30	180
26	SOIL	RAD-GAMMA SPECTROSCOPY	Thorium-234	15065-10-8	1.0 PCI/G	30	180
26	SOIL	RAD-GAMMA SPECTROSCOPY	Uranium-235	15117-96-1	PER ATTACHMENT	30	180
26	SOIL	RAD-GROSS ALPHA/BETA	Gross Alpha	12587-46-1	5.0 PCI/G	30	180
26	SOIL	RAD-GROSS ALPHA/BETA	Gross Beta	12587-47-2	5.0 PCI/G	30	180
26	SOIL	RAD-NP-237 BY ALPHA	NP-237	13994-20-2	1.0 PCI/G	30	180
26	SOIL	RAD-TC-99 BY BETA LSC	TC-99	14133-76-7	10.0 PCI/G	30	180
26	SOIL	RAD-TH ISO BY ALPHA	Thorium-228	14274-82-9	1.0 PCI/G	30	180
26	SOIL	RAD-TH ISO BY ALPHA	Thorium-230	14269-63-7	1.0 PCI/G	30	180
26	SOIL	RAD-TH ISO BY ALPHA	Thorium-232	N2608	1.0 PCI/G	30	180
26	SOIL	RAD-U ISO BY ALPHA	U-233/234	NS632	1.0 PCI/G	30	180
26	SOIL	RAD-U ISO BY ALPHA	U-238	24678-82-8	1.0 PCI/G	30	180
26	SOIL	RAD-U ISO BY ALPHA	Uranium-235/236	N1047	1.0 PCI/G	30	180
112	SOIL	SW846-6010B	Aluminum	7429-90-5	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Arsenic	7440-38-2	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Barium	7440-39-3	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Beryllium	7440-41-7	0.1 MG/KG	30	180
112	SOIL	SW846-6010B	Boron	7440-42-8	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Calcium	7440-70-2	5.0 MG/KG	30	180
112	SOIL	SW846-6010B	Chromium	7440-47-3	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Cobalt	7440-48-4	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Copper	7440-50-8	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Iron	7439-89-6	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Lead	7439-92-1	0.3 MG/KG	30	180
112	SOIL	SW846-6010B	Lithium	7439-93-2	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Magnesium	7439-95-4	5.0 MG/KG	30	180
112	SOIL	SW846-6010B	Manganese	7439-96-5	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Molybdenum	7439-98-7	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Nickel	7440-02-0	1.0 MG/KG	30	180
112	SOIL	SW846-6010B	Potassium	7440-09-7	5.0 MG/KG	30	180
112	SOIL	SW846-6010B	Selenium	7782-49-2	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Silver	7440-22-4	0.5 MG/KG	30	180
112	SOIL	SW846-6010B	Zinc	7440-66-6	0.5 MG/KG	30	180
112	SOIL	SW846-6020A	Antimony	7440-36-0	0.5 MG/KG	30	180
112	SOIL	SW846-6020A	Cadmium	7440-43-9	0.1 MG/KG	30	180
112	SOIL	SW846-6020A	Thallium	7440-28-0	0.2 MG/KG	30	180
112	SOIL	SW846-6020A	Uranium	7440-61-1	0.002 MG/KG	30	180
112	SOIL	SW846-7471A	Mercury	7439-97-6	0.1 MG/KG	30	28
112	SOIL	SW846-8082	Aroclor 1016	12674-11-2	33 UG/KG	30	14
112	SOIL	SW846-8082	Aroclor 1221	11104-28-2	67 UG/KG	30	14
112	SOIL	SW846-8082	Aroclor 1232	11141-16-5	33 UG/KG	30	14

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(NOTE: All turnaround and holding times are in calendar days. An 'NC' in the Hold Time column indicates that the holding time will not be calculated for these analyses. CAS Numbers with the prefix of 'N' are non-standard identifiers assigned by the Oak Ridge Environmental Information System. The provided standard and non-standard CAS numbers must be used to report the listed analytes in electronic data.)

Qty	Matrix Type	Proponent/Method	Analyte	Cas No.	Req Report Limit	Turn Time	Hold Time
112	SOIL	SW846-8082	Aroclor 1242	53469-21-9	33 UG/KG	30	14

112	SOIL	SW846-8082	Aroclor 1248	12672-29-6	33 UG/KG	30	14
112	SOIL	SW846-8082	Aroclor 1254	11097-69-1	33 UG/KG	30	14
112	SOIL	SW846-8082	Aroclor 1260	11096-82-5	33 UG/KG	30	14
112	SOIL	SW846-8082TPCB	Total PCB	TOTAL PCB	67 UG/KG	30	14
30	SOIL	SW846-8260B	ALL ANALYTES		PER ATTACHMENT	30	14
35	SOIL	SW846-8270C	ALL ANALYTES		PER ATTACHMENT	30	14

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QUALITY CONTROL REQUIREMENTS / DATA DELIVERABLE:

METHODOLOGY	QC REQUIREMENTS	DATA DELIVERABLE
METALS	PER APPROPRIATE AMS	FORMS PLUS RAW DATA
PEST,PCB,HERB	PER APPROPRIATE AMS	FORMS PLUS RAW DATA

RADIOLOGICAL	PER APPROPRIATE AMS	FORMS PLUS RAW DATA
VOA & SVOA	PER APPROPRIATE AMS	FORMS PLUS RAW DATA

QC COMMENTS: Per ICPT AMS and Specified Methodology

Results will be reported as dry weight unless otherwise specified in the following comment field or as an attachment.

DATA DELIVERABLE COMMENTS: Orgnl/CD to Ann Masvidal; CD to SMO; AMSED EDD to PEMS

TICS: For GC/MS methods, lab must report TICs: **YES**

(For AMSED files, lab must submit .tic file when TICs are required.)

ANALYTICAL BATCH REQUIREMENTS: PROJECT SPECIFIC

REPORTING REQUIREMENTS: (Report results formally to:)

Original:
Ann Masvidal
Bechtel Jacobs Company, LLC
P.O. Box 4699
Highway 58 and Blair Road
Bldg. 1580, Mail Stop 7120
Oak Ridge, TN 37831

Copy:
Attention: Mr. Ben Dettorre
Bechtel Jacobs Company, LLC
ETTP Central Receiving
2010 Highway 58
Building CT97500, Room No. 25, MS 6400
Oak Ridge, TN 37830

ATTACHMENTS: Attachments provide the project analyte list with reporting levels for soil matrices.

OTHER COMMENTS & REVISION HISTORY: Quick TAT may be requested. Quick TAT= complete data package. Sample receipt verification within 24 hrs of receipt of samples. TAT is calculated based on calendar days only.

Richard R. Lee — 4/14/09
Richard Lee **Date**
Project Manager

4/14/09
Approving Manager **Date**

4/14/09
Jim Chambers **Date**
SMO Representative

SAMPLE RECEIPT CONFIRMATION: *The laboratory is to fax a copy of the signed Chain of Custody, Sample Receipt Report, and other supporting documentation to the OR SMO and the Project Manager with each shipment received.*

Thu, April 09, 2009 11:46:38 (SOW Main Menu)

Analytical methods and estimated quantitation levels for VOCs analyzed at the off-site laboratory

VOC	Analytical method	Quantitation level in soils*
1,1,1-Trichloroethane	SW846-8260B	5 µg/kg
1,1,2,2-Tetrachloroethane	SW846-8260B	5 µg/kg
1,1,2-Trichloroethane	SW846-8260B	5 µg/kg
1,1-Dichloroethane	SW846-8260B	5 µg/kg
1,1-Dichloroethene	SW846-8260B	5 µg/kg
1,2-Dichloroethane	SW846-8260B	5 µg/kg
1,2-Dichloropropane	SW846-8260B	5 µg/kg
2-Butanone	SW846-8260B	10 µg/kg
2-Hexanone	SW846-8260B	10 µg/kg
4-Methyl-2-pentanone	SW846-8260B	10 µg/kg
Acetone	SW846-8260B	10 µg/kg
Benzene	SW846-8260B	5 µg/kg
Bromodichloromethane	SW846-8260B	5 µg/kg
Bromomethane	SW846-8260B	10 µg/kg
Carbon disulfide	SW846-8260B	5 µg/kg
Carbon tetrachloride	SW846-8260B	5 µg/kg
Chlorobenzene	SW846-8260B	5 µg/kg
Chloroethane	SW846-8260B	10 µg/kg
Chloroform	SW846-8260B	5 µg/kg
Chloromethane	SW846-8260B	10 µg/kg
cis-1,3-Dichloropropene	SW846-8260B	5 µg/kg
cis-1,2-Dichloroethene	SW846-8260B	5 µg/kg
Dibromochloromethane	SW846-8260B	5 µg/kg
Ethylbenzene	SW846-8260B	5 µg/kg
Methylene chloride	SW846-8260B	5 µg/kg
Styrene	SW846-8260B	5 µg/kg
Tetrachloroethene	SW846-8260B	5 µg/kg
Toluene	SW846-8260B	2 µg/kg
trans-1,3-Dichloropropene	SW846-8260B	5 µg/kg
trans-1,2-Dichloroethene	SW846-8260B	5 µg/kg
Tribromomethane	SW846-8260B	5 µg/kg
Trichloroethene	SW846-8260B	5 µg/kg
Vinyl chloride	SW846-8260B	2 µg/kg
Xylenes (total)	SW846-8260B	5 µg/kg

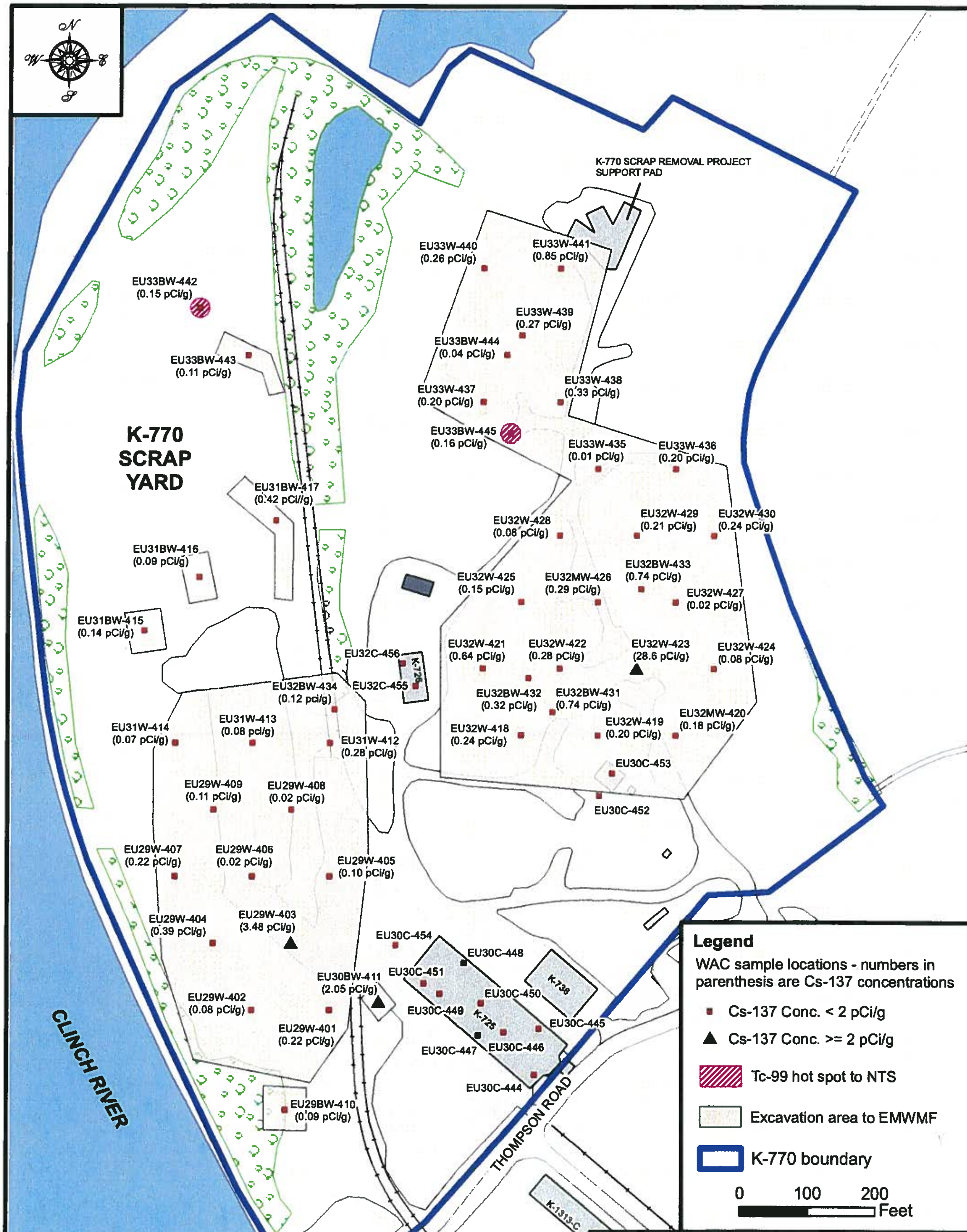
*Report results on dry weight basis.
Mg/kg = milligrams per kilogram

Analytical Method and estimated quantitation levels for SVOCs analyzed at the off-site laboratory

SVOC	Analytical method	Quantitation level in soils
Acenaphthene	SW846-8270C	330 µg/kg
Acenaphthylene	SW846-8270C	330 µg/kg
Aniline	SW846-8270C	830 µg/kg
Anthracene	SW846-8270C	330 µg/kg
Benz(a)anthracene	SW846-8270C	330 µg/kg
Benzo(b)fluoranthene	SW846-8270C	330 µg/kg
Benzo(k)fluoranthene	SW846-8270C	330 µg/kg
Benzoic acid	SW846-8270C	1700 µg/kg
Benzo(g,h,i)perylene	SW846-8270C	330 µg/kg
Benzo(a)pyrene	SW846-8270C	330 µg/kg
Benzyl alcohol	SW846-8270C	330 µg/kg
Bis(2-chloroethoxy)methane	SW846-8270C	330 µg/kg
Bis(2-chloroethyl) ether	SW846-8270C	330 µg/kg
Bis(2-chloroisopropyl) ether	SW846-8270C	330 µg/kg
4-Bromophenyl phenyl ether	SW846-8270C	330 µg/kg
Butyl benzyl phthalate	SW846-8270C	330 µg/kg
4-Chloroaniline	SW846-8270C	830 µg/kg
4-Chloro-3-methylphenol	SW846-8270C	330 µg/kg
2-Chloronaphthalene	SW846-8270C	330 µg/kg
2-Chlorophenol	SW846-8270C	330 µg/kg
4-Chlorophenyl phenyl ether	SW846-8270C	330 µg/kg
Carbazole	SW846-8270C	330 µg/kg
Chrysene	SW846-8270C	330 µg/kg
Dibenz(a,h)anthracene	SW846-8270C	330 µg/kg
Dibenzofuran	SW846-8270C	330 µg/kg
1, 2-Dichlorobenzene	SW846-8270C	330 µg/kg
1, 3-Dichlorobenzene	SW846-8270C	330 µg/kg
1, 4-Dichlorobenzene	SW846-8270C	330 µg/kg
3, 3'-Dichlorobenzidine	SW846-8270C	1700 µg/kg
2, 4-Dichlorophenol	SW846-8270C	330 µg/kg
Diethyl phthalate	SW846-8270C	330 µg/kg
2, 4-Dimethylphenol	SW846-8270C	330 µg/kg
Dimethyl phthalate	SW846-8270C	330 µg/kg
4, 6-Dinitro-2-methylphenol	SW846-8270C	1700 µg/kg
2, 4-Dinitrophenol	SW846-8270C	1700 µg/kg
2, 4-Dinitrotoluene	SW846-8270C	330 µg/kg
2, 6-Dinitrotoluene	SW846-8270C	330 µg/kg
Di-n-octyl phthalate	SW846-8270C	330 µg/kg
Bis(2-ethylhexyl) phthalate	SW846-8270C	330 µg/kg
Fluoranthene	SW846-8270C	330 µg/kg
Fluorene	SW846-8270C	330 µg/kg
Hexachlorobenzene	SW846-8270C	330 µg/kg
Hexachlorobutadiene	SW846-8270C	330 µg/kg
Hexachlorocyclopentadiene	SW846-8270C	330 µg/kg
Hexachloroethane	SW846-8270C	330 µg/kg
Indeno(1,2,3-cd)pyrene	SW846-8270C	330 µg/kg
Isophorone	SW846-8270C	330 µg/kg
2-Methylnaphthalene	SW846-8270C	330 µg/kg
2-Methylphenol	SW846-8270C	330 µg/kg
4-Methylphenol	SW846-8270C	330 µg/kg
Naphthalene	SW846-8270C	330 µg/kg
2-Nitroaniline	SW846-8270C	1700 µg/kg

SVOC	Analytical method	Quantitation level in soils
3-Nitroaniline	SW846-8270C	1700 µg/kg
4-Nitroaniline	SW846-8270C	1700 µg/kg
Nitrobenzene	SW846-8270C	330 µg/kg
2-Nitrophenol	SW846-8270C	330 µg/kg
4-Nitrophenol	SW846-8270C	1700 µg/kg
N-Nitrodiphenylamine	SW846-8270C	330 µg/kg
N-Nitroso-di-n-propylamine	SW846-8270C	330 µg/kg
N-Nitrosodiphenylamine	SW846-8270C	330 µg/kg
Pentachlorophenol	SW846-8270C	1700 µg/kg
Phenanthrene	SW846-8270C	330 µg/kg
Phenol	SW846-8270C	330 µg/kg
Pyrene	SW846-8270C	330 µg/kg
Pyridine	SW846-8270C	330 µg/kg
1,2,4-Trichlorobenzene	SW846-8270C	330 µg/kg
2,3,4,6-Tetrachlorophenol	SW846-8270C	1700 µg/kg
2,4,5-Trichlorophenol	SW846-8270C	330 µg/kg
2,4,6-Trichlorophenol	SW846-8270C	330 µg/kg

µg/kg = micrograms per kilogram
ND = not determined



K-770 WAC Sample Locations

APPENDIX F
DATA QUALITY OBJECTIVES CHECKLIST

APPENDIX F: DATA QUALITY OBJECTIVES

Waste acceptance criteria used to develop decision rules for the EMWMF are provided in the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria* DOE/OR/01-1909&D3 and the *Waste Acceptance Criteria Attainment Team Project Execution Plan* BJC/OR-1091, Revision 4. The null hypothesis or baseline condition generally applied to the EMWMF decision rules is stated in terms that the waste does not exceed waste acceptance criteria and is acceptable for disposal. The Action Level and the Type I (α = 0.05) and Type II (β = 0.20) decision errors associated with the null hypothesis are thoroughly evaluated for each applicable waste acceptance criteria and are then used to create a statistical-based sample design. The sample design is outlined in detail in *Sampling and Analysis Plan for K-770 Soils for Waste Acceptance Criteria Attainment East Tennessee Technology Park, Oak Ridge, Tennessee,* BJC/OR-3088. The hypothesis test is completed in the Data Quality Assessment phase of the project to verify that the baseline condition remains valid. The following table documents the Data Quality Objectives process used to characterize the waste in this waste lot. Appendix G documents the assessment of the quality of the characterization data.

Table F.1. Waste Lot 4.12 Data Quality Objectives Checklist

1. State the Problem and the Decision (DQO Steps 1 and 2)	
What is the description of the waste?	The waste lot consists of soil, concrete, incidental scrap metal, wood, vegetation, and personal protective equipment generated during soil/concrete sampling events and soil removal action activities at the K-770 Scrap Yard. This waste was assigned EMWMF Waste Lot 4.12
Who needs information about the waste?	The ETTP D&D/RA Project, Environmental Management Waste Management Facility (EMWMF) Waste Acceptance Criteria (WAC) Attainment Team, and EMWMF Operations.
What are the contaminants of interest?	Radiological Parameters, Total/TCLP Metals, Total Volatile Organics, Total/TCLP Semi-Volatile Organics, and individual/Total PCBs.
What decisions need to be made regarding the waste?	The waste must be disposed of at an approved disposal facility. The decision to be made is whether or not the waste lot meets the EMWMF disposal criteria contained in the EMWMF WAC and the Project Execution Plan (BJC/OR-1091). If the waste does not meet EMWMF WAC, the data will be evaluated to satisfy off-site disposal facility WAC.
2. Inputs to the Decision (DQO Step 3)	
What historical data exist?	Radiation walkover surveys and intrusive analytical data collected in the mid-1990s and in late 2004/early 2005. Intrusive biased samples of soil for radiological parameters (primarily U-238 pCi/g concentrations) were used to develop the sampling program. Historical data also exist in a K-770 site summary document (BJC/OR-1296) and a K-725 Beryllium Building site summary document (BJC/OR-1298/D1). These samples were not included in the dataset used to characterize this waste lot because the Project concluded that they were not representative of the final waste form. Additionally, alpha and beta-gamma surveys were conducted to determine if K-770 scrap waste items meet free release criteria.
What process knowledge exists?	Process knowledge included in the approved sample and analysis plan (BJC/OR-3088), the approved K-770 Scrap Yard waste handling plans (DOE/OR-01-2162&D2, DOE/OR-01-2263&D2, and DOE/OR-01-2148&D2), the approved EMWMF profile for the K-770 scrap metal (BJC/OR-1857) as well as other documents used to assemble Appendix B of this profile were used to identify analytes of concern and to determine the number and type of intrusive samples to be collected to support the waste determination.
What additional data must be collected?	Intrusive samples have been collected and analyzed in accordance with the SAP Analytical data collected in accordance with the SAP are sufficient to adequately characterize the radiological and chemical characteristics for compliance with EMMWF WAC. Dose rate surveys will be collected to support decisions on size reduction, packaging, and transportation. No additional sampling is required.

Table F.1. Waste Lot 4.12 Data Quality Objectives Checklist (cont.)

3. Physical Boundaries to be Considered (DQO Step 4)	
What is the potential contamination?	Radiological, chemical (organics and inorganics).
What consideration affects the number of samples?	Section 4.8 of the SAP provides the basis for sample size determination. Historical U-238 pCi/g data from the late-2004/early-2005 Dynamic Verification Sampling campaign were used to determine number of intrusive radiological and chemical samples, respectively.
Are there any sampling problems?	All samples prescribed in the SAP have been collected and analyzed, with the exception of 1 random composite soil samples that was to be collected for Total VOA analysis. Total VOA data indicate 100% non-detect rate for all VOA constituents, except for 2-Butanone (MEK), Acetone, and Chloroform. Maximum detected results for these VOA constituents is less than 1 mg/kg. Therefore, not collecting the 1 omitted sample has no impact to EMWMF Analytical, Hazard Index, or Administrative WAC. Two samples excluded from Waste Lot 4.12 Controlled Data Set and Data Quality Assessment due to elevated Tc-99 results. Soils in areas related to these samples have been identified as anomalous waste for Waste Lot 4.12. Np-237 results for one sample and duplicate were rejected due to Relative Percent Difference out of range, possibly due to uranium interference. Select Total VOA, Total SVOA, and PCB samples exhibited multiple results and detection limits due to varying sample dilution factors. Only validated data from Sample Management Organization with apprpriate data use flag was used to construct the Waste Lot 4.12 Controlled Data Set and Data Quality Assessment.
Are there other sampling constraints, such as temporal, schedule, or seasonal concerns, regulatory requirements, etc.?	No.

Table F.1. Waste Lot 4.12 Data Quality Objectives Checklist (cont.)

4. Decision Statement and Uncertainty (DQO Steps 5 and 6)	
What are the allowable decision errors	Alpha = 0.05 and beta = 0.20
What are the steps to be taken after the analytical results are received?	The Project Environmental Measurements System database will be used as a repository for sample results. Data generated from this sampling will not be exported to the Oak Ridge Environmental Information System . A turnaround time of 30 days will be requested for analytical results from the laboratories unless accelerated turn-around is approved by the Project Manager. Contract compliance verification and a hardcopy to electronic deliverable comparison will be performed on each data package received from the laboratories. Level 3 validation (quality control summary validation) will be performed on 10% of the data generated from the characterization. [100% of the data were validated.] In addition, BJC project personnel will conduct a limited data assessment on each data package to determine the usability of the results. Waste Management personnel will use the data to construct waste profiles in accordance with the *Waste Management Plan for ETTP Closure and ETTP D&D Projects* (BJC 2004a).
5. Develop the Data Sampling Design (DQO Step 7)	
State the type of data to be obtained.	Analytical Support Level 3 data for radiological parameters and organic/inorganic parameters. Level 3 validation (quality control summary validation) will be performed on 10% of the data generated from the characterization. In addition, BJC project personnel will conduct a limited data assessment on each data package to determine the usability of the results
State the approach to sample selection.	Sample design was included in Section 4.8of the SAP. Visual Sample Plan software was used to determine the sample size based on U-238 data. Systematic random and biased composite soil and concrete samples have been collected for radiological and chemical analyses in accordance with Section Table A.1 of the SAP.

BJC = Bechtel Jacobs Company
D&D/RA = Decontamination and Decommissioning/Remedial Action
EMWMF = Environmental Management Waste Management Facility
ETTP = East Tennessee Technology Park
TCLP = Toxicity Characteristic Leachate Procedure
WAC = waste acceptance criteria

APPENDIX G
DATA QUALITY ASSESSMENT

APPENDIX G: DATA QUALITY ASSESSMENT

DQA Summary

Waste Lot 4.12 (titled K-770 Scrap Yard Soils) includes the soils, concrete, and residual metallic/other miscellaneous debris, and secondary generated during the remediation of the K-770 Scrap Yard at the East Tennessee Technology Park. This waste lot profile describes and characterizes this waste for disposal in the Environmental Management Waste Management Facility (EMWMF). The total volume of all waste in Waste Lot 4.12 is approximately 17,000 yd^3. This appendix assesses the quality of the data used to characterize the waste in this profile.

Radiation walkdown surveys, process knowledge for debris origin, and historical analytical data were used to establish the baseline for identifying and quantifying the radiological contamination expected to be present in the soil, concrete, and on the miscellaneous debris originating at the K-770 Scrap Yard. The types of radiological contaminants that could be present in K-770 Scrap Yard waste items are Co-60, Cs-137, K-40, Tc-99, Th-228, Th-232, U-234, U-235, and U-238.

Analytical data used to evaluate acceptability of K-770 Scrap Yard Soils profile (Waste Lot 4.12) waste for disposal in the EMWMF are in the controlled data set. To obtain the radiological data, a total of 32 systematic random composite and 13 biased composite samples were collected from K-770 soils that make up Waste Lot 4.12. In addition, 14 systematic random samples were collected from K-770 concrete pads distributed throughout the K-770 Scrap Yard. These analytical data were sufficient for use in establishing the expected pCi/g activity for each radionuclide detected and the values were supported by radiation walkdown surveys and historical Dynamic Verification Sampling data, which established the baseline for characterization activities. Radiological data for two biased composite soil samples (Z1-EU33BW-442 and Z1-EU33BW-445) were excluded from the Controlled Data Set in Appendix C due to elevated Tc-99 pCi/g results that were found to exceed 10 times the EMWMF Carcinogenic waste acceptance criteria (WAC) limit of 172 pCi/g for Tc-99. Soils within these areas have been identified as anomalous waste (see Appendix A of this profile). Therefore, a total of 57 radiological samples are included in the controlled data set and were used in this Data Quality Asssessment (DQA).

It is noted that all samples prescribed in the SAP have been collected and analyzed, with the exception of 1 random composite soil sample (Z1-EU29W-401) that was to be collected for Total VOA analysis. Total VOA data indicate 100% non-detect rate for all VOA constituents, except for 2-Butanone (MEK), Acetone, and Chloroform. Maximum detected results for these VOA constituents is less than 1 mg/kg. Therefore, not collecting the 1 omitted sample has no impact to EMWMF Analytical, Hazard Index, or Administrative WAC.

To quantify the chemical (inorganic and organic) contaminants that are associated with Waste Lot 4.12, process knowledge (e.g., Material Safety Data Sheets, historical document reviews, previously approved EMWMF profiles, visual inspections, etc.) and analytical data were used. In general, 32 systematic random composite and 13 biased composite soil samples were submitted for Total/TCLP SVOA analysis, Total/TCLP Metals analysis, and individual/Total PCB analysis. 31 systematic random composite and 13 biased composite soil samples were submitted for Total VOA analysis. In addition, 14 systematic random concrete samples were colleted for Total Metals analysis, and individual/Total PCB analysis. Appendix C contains the analytical results from chemical analyses and Appendix B contains the process knowledge used to quantify the chemical contaminants present.

Soil samples collected to characterize this waste lot were not analyzed for the metals strontium and tin. Historical data indicate that these metals may be present in the waste lot soils at very low concentrations. However, for the reasons cited in Appendix B, historical data are not considered reliable and were not used to quantitatively characterize this waste lot. To characterize these two metals in the soils in this waste lot, the EMWMF Waste Lot 65.1 profile (BJC 2004) was reviewed (see Appendix B). Samples of metallic debris in the scrap yard were analyzed for strontium and tin in the EMWMF Waste Lot 65.1 profile. Strontium was not detected. Based on these results, the Project concluded that strontium was not present in the waste lot soils. Tin was detected in the EMWMF Waste Lot 65.1 profile. Based on these results, the Project concluded that tin was present in the waste lot soils. Tin was quantitatively characterized for this waste lot by incorporating the input values for tin in the Waste Lot 65.1 Waste Acceptance Criteria Forecasting Analysis Capability Systems (WACFACS) in the WACFACS input for this waste lot.

The purpose of the DQA is to identify Site Related Contaminants (SRC), evaluate the usability of the data for the intended purpose, and determine the representative average concentration of each SRC and the associated uncertainties. This information is used to provide inputs to WACFACS so that a Sum of Fractions (SOF) and a Volume Weighted Sum of Fractions (VWSF) for the period FY09-FY11 can be calculated.

The technical approach used to perform the DQA followed guidance provided in the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2001a) and *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (EPA 2000). Where applicable, ProUCL V.4.00.02 Software, and "Upper 95th Confidence Interval Calculations for a PERT Beta PDF" (Redus & Associates) were used for all statistical analyses.

The technical approach of this DQA and the results and conclusions of the evaluation for EMWMF waste acceptance are summarized below.

Technical Approach

The approach used to perform the DQA and to calculate the SOF for Waste Lot 4.12 includes the following:

- Confirm that project SRC data meet data validation/verification requirements and Data Quality Objectives (DQOs)
    - Obtain sample data sets
    - Review the SRC data and confirm all data is verified and properly validated
    - Eliminate reported short-lived (half-life < 2 months) radionuclides, plus those radionuclides not detected from further statistical evaluation.
    - Confirm the SRC data meet the DQOs.
- Conduct a preliminary SRC review
    - Examine statistical parameters (means, variances, coefficients of variation, etc.) and graphical behavior of SRC data to identify suspected anomalies and/or multiple populations based upon either operational interpretation (e.g., nuclide relationships, SRC impacts to the analytic WAC based on activity values, and expected mean based on statistical distribution outcome) or statistical interpretation (e.g., SRC sample result is many times larger than median of all observations).
- Select appropriate statistical tests

- Apply suitable transformations of data (e.g., use detection limit as proxy value for all negative values if statistical analysis is performed on natural logarithms of SRC data)

- Perform Goodness-of-Fit (GOF) tests using the Shapiro-Wilk test statistic (or other appropriate statistical test) to identify the underlying probability density function that describes the mean concentration of each SRC (BJC 2001)

- Perform statistical analysis techniques, as required, to identify SRCs that exhibit marked outliers or unusual variation.

■ Verify assumptions

  - Examine data to confirm sampling requirements/DQOs followed (DOE 2001)
  - Confirm random samples were obtained.

■ Draw conclusions

  - Determine GOF for SRCs
  - Complete WACFACS inputs.

Summary of Results

Radiological and organic/inorganic chemical data associated with the waste are presented in Sections 3 and 4 of the profile, including all other SRCs (as discussed in DOE 2001a), that were eliminated by Process Knowledge.

Waste Lot 4.12 K-770 Scrap Yard Soils – Appendix G, Site Related Contaminant (SRC) Elimination Listing

Chemical Name	Units	SRC Elimination Justification
1,1,1-Trichloroethane	ug/kg	100% Non-detect rate
1,1,2,2-Tetrachloroethane	ug/kg	100% Non-detect rate
1,1,2-Trichloroethane	ug/kg	100% Non-detect rate
1,1-Dichloroethane	ug/kg	100% Non-detect rate
1,1-Dichloroethene	ug/kg	100% Non-detect rate
1,2,4-Trichlorobenzene	ug/kg	100% Non-detect rate
1,2-Dichlorobenzene	ug/kg	100% Non-detect rate
1,2-Dichloroethane	ug/kg	100% Non-detect rate
1,2-Dichloroethene	ug/kg	100% Non-detect rate
1,2-Dichloropropane	ug/kg	100% Non-detect rate
1,3-Dichlorobenzene	ug/kg	100% Non-detect rate
1,4-Dichlorobenzene	ug/kg, mg/L	100% Non-detect rate
2,3,4,6-Tetrachlorophenol	ug/kg	100% Non-detect rate
2,4,5-T		Process Knowledge
2,4,5-Trichlorophenol	ug/kg, mg/L	100% Non-detect rate
2,4,6-Trichlorophenol	ug/kg, mg/L	100% Non-detect rate
2,4-D		Process knowledge
2,4-Dichlorophenol	ug/kg	100% Non-detect rate
2,4-Dimethylphenol	ug/kg	<5% detects and < 2x DL
2,4-Dinitrophenol	ug/kg	100% Non-detect rate
2,4-Dinitrotoluene	ug/kg, mg/L	100% Non-detect rate

Waste Lot 4.12 K-770 Scrap Yard Soils – Appendix G, Site Related Contaminant (SRC) Elimination Listing

Chemical Name	Units	SRC Elimination Justification
2,6-Dinitrotoluene	ug/kg	100% Non-detect rate
2-Chloronaphthalene	ug/kg	100% Non-detect rate
2-Chlorophenol	ug/kg	100% Non-detect rate
2-Hexanone	ug/kg	<20% J-flagged
2-Methyl-4,6-dinitrophenol	ug/kg	100% Non-detect rate
2-Methylphenol	mg/L	100% Non-detect rate
2-Methylphenol	ug/kg	<20% J-flagged
2-Nitrobenzenamine	ug/kg	100% Non-detect rate
2-Nitrophenol	ug/kg	100% Non-detect rate
3,3'-Dichlorobenzidine	ug/kg	100% Non-detect rate
3-Nitrobenzenamine	ug/kg	100% Non-detect rate
3 & 4-Methylphenol	mg/L	100% Non-detect rate
4-Bromophenyl phenyl ether	ug/kg	100% Non-detect rate
4-chlorobenzamine	ug/kg	100% Non-detect rate
4-chloro-3-methylphenol	ug/kg	100% Non-detect rate
4-Chlorophenyl phenyl ether	ug/kg	100% Non-detect rate
4-Methyl-2-pentanone (Methyl Isobutyl Ketone)	ug/kg	100% Non-detect rate
4-Nitrobenzamine	ug/kg	100% Non-detect rate
4-Nitrophenol	ug/kg	100% Non-detect rate
Ac-228	pCi/g	Th-232 Decay Series Daughter
Aldrin		Process Knowledge
Alpha activity	pCi/g	Total Alpha activity reference only
alpha-BHC		Process Knowledge
Aniline	ug/kg	100% Non-detect rate
Antimony	ug/L	Not in Admin/Analytic/ASA WAC
Aresenic	ug/L	100% Non-detect rate
Benzene	ug/kg	<20% J-flagged
Benzenemethanol	ug/kg	100% Non-detect rate
Beta activity	pCi/g	Total Beta Activity reference only
beta-BHC		Process Knowledge
Bi-214	pCi/g	U-238 Decay Series Daughter
Bis(2-chloroethoxy)methane	ug/kg	100% Non-detect rate
Bis(2-chloroethyl) ether	ug/kg,	100% Non-detect rate
Bis(2-chloroisopropyl) ether	ug/kg	100% Non-detect rate
Bromodichloromethane	ug/kg	100% Non-detect rate
Bromoform	ug/kg	100% Non-detect rate
Bromomethane	ug/kg	100% Non-detect rate
Carbon disulfide	ug/kg	100% Non-detect rate
Carbon tetrachloride	ug/kg	100% Non-detect rate
Chlordane		Process Knowledge
Chlorobenzene	ug/kg	100% Non-detect rate
Chloroethane (Ethylchloride)	ug/kg	100% Non-detect rate
Chloroform	ug/kg	<20% J-flagged
Chloromethane	ug/kg	100% Non-detect rate
cis-1,2-Dichloroethene	ug/kg	100% Non-detect rate

Waste Lot 4.12 K-770 Scrap Yard Soils – Appendix G, Site Related Contaminant (SRC) Elimination Listing

Chemical Name	Units	SRC Elimination Justification
cis-1,3-Dichloropropene	ug/kg	100% Non-detect rate
Cyanide		Process Knowledge
DDD		Process Knowledge
DDE		Process Knowledge
delta-BHC		Process Knowledge
Dibromochloromethane	ug/kg	100% Non-detect rate
Dieldrin		Process Knowledge
Diethyl phthalate	ug/kg	100% Non-detect rate
Dimethyl phthalate	ug/kg	<20% J-flagged
Endrin		Process Knowledge
Endrin Aldehyde		Process Knowledge
Endrin Ketone		Process Knowledge
Endosulfan and Metabolites		Process Knowledge
Ethylbenzene	ug/kg	<20% J-flagged
Heptachlor		Process Knowledge
Heptachlor Epoxide		Process Knowledge
Hexachlorobenzene	mg/L	100% Non-detect rate
Hexachlorobenzene	ug/kg	<20% J-flagged
Hexachlorobutadiene	ug/kg, mg/L	100% Non-detect rate
Hexachlorocyclopentadiene	ug/kg	100% Non-detect rate
Hexachloroethane	ug/kg, mg/L	100% Non-detect rate
Isophorone	ug/kg	100% Non-detect rate
Lindane		Process Knowledge
Lead-212	pCi/g	Th-232 Decay Series Daughter
Lead-214	pCi/g	U-238 Decay Series Daughter
Methylene chloride	ug/kg	Laboratory Contaminant, 100% Non-detect rate
Np-237	pCi/g	<20% J-flagged
Nitrobenzene	ug/kg, mg/L	100% Non-detect rate
N-Nitroso-di-n-propylamine	ug/kg	100% Non-detect rate
N-Nitrosodiphenylamine	ug/kg	100% Non-detect rate
PCB-1016	ug/kg	100% Non-detect rate
PCB-1221	ug/kg	100% Non-detect rate
PCB-1232	ug/kg	100% Non-detect rate
PCB-1242	ug/kg	100% Non-detect rate
Pentachlorophenol	ug/kg, mg/L	100% Non-detect rate
Pa-234m	pCi/g	U-238 Decay Series Daughter
Pyridine	ug/kg, mg/L	100% Non-detect rate
Ra-226	pCi/g	U-238 Decay Series Daughter
Selenium	ug/L	100% Non-detect rate
Silver	ug/L	<5% detects and < 2x DL
Strontium		Process Knowledge- non-detect in Waste Lot 65.1 profile
Styrene	ug/kg	100% Non-detect rate
Tetrachloroethene	ug/kg	<20% J-flagged
Thallium	mg/kg	<5% detects and < 2x DL

Waste Lot 4.12 K-770 Scrap Yard Soils – Appendix G, Site Related Contaminant (SRC) Elimination Listing

Chemical Name	Units	SRC Elimination Justification
Tl-208	pCi/g	Th-232 Decay Series Daughter
Th-230	pCi/g	U-238/U-234 Decay Series Daughter
		Th-232 + Daughter Reference
Th-232 Corrected	pCi/g	Information Only
Th-234	pCi/g	U-238 Decay Series Daughter
Toluene	ug/kg	<20% J-flagged
Total Xylene	ug/kg	<20% J-flagged
trans-1,2-Dichloroethene	ug/kg	100% Non-detect rate
trans-1,3-Dichloropropene	ug/kg	100% Non-detect rate
Trichloroethene	ug/kg	100% Non-detect rate
Vinyl chloride	ug/kg	100% Non-detect rate

The WACFACS Input Sheet, SRC Summary Statistic Spreadsheet, computer generated output sheets, and the individual SRC mean calculation spreadsheets, included in this appendix, plus Sections 3 and 4 of the profile package provide summary statistics for the Analytic WAC and the Auditable Safety Analysis SRCs. The expected concentration and the UCL_{95} for the expected concentration of the SRCs are calculated based on the results of the GOF tests. The results are summarized in the WACFACS Input Sheet (Appendix H), SRC Summary Statistic Spreadsheet (Appendix G), Table 6 (Section 3.0) and Tables 7 and 8 in Section 4.1 and 4.2, respectively, of the profile package.

Sum of Fractions For Waste Lot 4.12

The following information is provided for Waste Lot 4.12, K-770 Scrap Yard Soils profile for the 3-year window FY09 – FY11 as calculated by WACFACS, Version 1.0, Q1 FY08 Rev 08-05.

Waste Lot 4.12 Carcinogenic SOF
E (Waste Lot 4.12 Carcinogenic SOF) = 0.668

Waste Lot 4.12 HI SOF
E (Waste Lot 4.12 HI SOF) = 0.172

The information contained in the WACFACS Input Sheet will be provided in this profile for the UCL_{95} (WL 4.12 Carcinogenic SOF) and UCL_{95} (Waste Lot 4.12 HI SOF) to be calculated by WACFACS, Version 1.0, Q1 FY08 Rev 08-05. The output information will be included in Appendix H for reference.

Volume Weighted Sum of Fractions For Waste Lot 4.12

The information contained in the WACFACS Input Sheet will be provided for Waste Lot 4.12, K-770 Scrap Yard Soiils Profile in order for the 3-year window FY09 – FY11 to be calculated by WACFACS, Version 1.0, Q1 FY08 Rev 08-05. The output information will be included in Appendix H for reference.

REFERENCES

BJC (Bechtel Jacobs Company LLC) 2004. *Waste Profile for: Disposal of the Scrap Metal Project Waste Lot 65.1 East Tennessee Technology Park, Oak Ridge, Tennessee*, BJC/OR-1857, Rev. 1, Bechtel Jacobs Company LLC, Oak Ridge, TN. July.

BJC 2001. Implementation Plan and User's Guide for the Waste Acceptance Criteria Forecasting and Analysis Capability System (WACFACS) Version 1.0, BJC/OR-1089.

DOE (US Department of Energy) 2001. Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee, DOE/OR/01-1909&D3.

EPA (US Environmental Protection Agency) 2000. Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, EPA/600/R-96/084 (QA00 Update), July 2000.

WL 4.12 K-770 Scrap Yard Soils
EMWMF SRC Summary Statistics

SRC	Units	N	Detects	Minimum	Median	Maximum	Arithmetic Mean	PDF	LN Mean	Standard Deviation	E(X)	UCL95	HI SOF	CA SOF
Cs-137	pCi/g	57	33	0.030	0.190	28.600	0.79	B			4.90	13.07		
Co-60	pCi/g	57	5	0.030	0.080	1.870	0.13	LN	-2.426	0.748	0.12	0.14		
K-40	pCi/g	57	57	1.380	10.200	16.800	9.77	B			9.83	14.45		
Tc-99	pCi/g	57	37	1.290	4.310	629.000	20.26	B			107.92	287.20		0.627
Th-228	pCi/g	57	57	0.240	1.090	3.530	1.09	N		0.666	1.09	1.24		
Th-232	pCi/g	57	57	0.200	0.990	3.330	1.00	N		0.574	1.00	1.13		
U-233/234	pCi/g	57	56	0.110	10.200	1360.000	39.45	LN	2.061	1.626	29.50	54.43	0.000	0.017
U-235	pCi/g	57	44	0.050	1.080	185.000	5.07	LN	-0.120	1.647	3.44	6.45	0.000	0.002
U-238	pCi/g	57	57	0.430	7.650	1150.000	33.45	LN	1.841	1.659	25.00	47.09	0.017	0.021
Aluminum	mg/kg	57	57	4400.000	12300.000	21400.000	12261.05	B			12500.00	17857.28		
Antimony	mg/kg	57	35	0.115	0.500	65.100	2.01	B			11.20	29.79	0.070	
Arsenic	mg/kg	57	57	2.900	6.600	18.400	7.27	LN	1.889	0.437	7.28	8.10		
Barium	mg/kg	57	57	31.300	71.500	395.000	80.37	B			118.72	231.67	0.001	
Barium	mg/L	43	43	0.223	0.531	1.770	0.64	LN	-0.597	0.548	0.64	0.75		
Beryllium	mg/kg	57	57	0.140	0.400	1.800	0.43	B			0.59	1.12		
Boron	mg/kg	57	57	1.900	5.900	39.100	7.43	LN	1.798	0.625	7.34	8.64	0.000	
Cadmium	mg/kg	57	54	0.020	0.750	14.200	1.52	LN	-0.525	1.562	2.01	3.56		
Cadmium	mg/L	43	25	0.002	0.008	0.096	0.015	B			0.020	0.05		
Calcium	mg/kg	57	57	1860	58200	254000	79296	B			81443.33	162846.39		
Chromium	mg/kg	57	57	9.700	26.000	2880.000	102.74	B			498.95	1319.51	0.004	
Chromium	mg/L	43	7	0.002	0.006	0.030	0.01	B			0.01	0.02		
Cobalt	mg/kg	57	57	1.500	9.000	41.900	9.04	B			13.23	26.16		
Copper	mg/kg	57	57	3.500	83.000	4780.000	284.53	LN	4.226	1.722	301.00	592.50		
Iron	mg/kg	57	57	4630.000	24700.000	155000.000	27793.51	B			43071.87	90299.55		
Lead	mg/kg	57	57	2.900	36.600	733.000	60.60	LN	3.380	1.279	66.50	97.11	0.044	
Lead	mg/L	43	11	0.009	0.017	0.599	0.04	B			0.11	0.28		
Lithium	mg/kg	57	57	5.300	12.300	68.000	14.69	B			20.42	39.90		
Magnesium	mg/kg	57	57	1060.000	6350.000	73800.000	14335.61	LN	8.918	1.160	14600.00	38631.00		
Manganese	mg/kg	57	57	59.200	496.000	2210.000	618.75	LN	6.192	0.734	640.00	781.20	0.002	
Mercury	mg/kg	57	46	0.0050	0.360	4.400	0.88	LN	-1.628	2.468	4.13	7.80		
Mercury	mg/L	43	6	3.000E-05	3.000E-05	1.500E-04	4.000E-05	B			5.000E-05	8.410E-05		
Molybdenum	mg/kg	57	57	0.690	2.700	69.200	5.56	B			13.45	33.51	0.003	
Nickel	mg/kg	57	57	4.200	48.900	1700.000	127.18	LN	3.814	1.478	135.00	220.10		
Potassium	mg/kg	57	57	482.000	838.000	1940.000	880.44	B			962.330	1434.51		
Selenium	mg/kg	57	12	0.230	0.275	25.700	0.82	B			4.51	11.75	0.003	
Silver	mg/kg	57	25	0.040	0.050	1.400	0.24	B			0.27	0.66		
Sodium	mg/kg	57	50	0.750	75.400	481.000	124.410	LN	3.933	1.960	349.000	418.700		
Tin	mg/kg	42	14	15.500	23.200	232.000	37.400	B			56.700	120.000	0.026	
Vanadium	mg/kg	57	57	8.000	21.800	52.900	22.29	N		9.428	22.29	24.38	0.001	
Zinc	mg/kg	57	57	9.300	110.000	1040.000	186.21	LN	4.667	1.139	203.00	571.60		
PCB-1248	mg/kg	57	6	0.008	0.110	13.000	1.77	B			2.24	5.96		

WL 4.12 K-770 Scrap Yard Soils
EMWMF SRC Summary Statistics

SRC	Units	N	Detects	Minimum	Median	Maximum	Arithmetic Mean	PDF	LN Mean	Standard Deviation	E(X)	UCL95	HI SOF	CA SOF
PCB-1254	mg/kg	57	46	0.008	0.39	7.30	1.35	B			1.48	3.66		
PCB-1260	mg/kg	57	43	0.006	0.20	2.80	0.49	B			0.60	1.45		
Total PCBs	mg/kg	57	46	0.024	0.590	23.000	3.58	B			4.23	10.90		
2-Butanone	mg/kg	42	14	0.000	0.005	0.045	0.01	B			0.01	0.02		
2-Methylnaphthalene	mg/kg	43	30	0.020	0.071	0.300	0.10	B			0.10	0.19	0.000	
3 & 4 Methylphenol	mg/kg	43	4	0.019	0.190	0.580	0.19	B			0.23	0.41	0.001	
Acenaphthene	mg/kg	43	14	0.019	0.185	1.200	0.17	B			0.33	0.70	0.000	
Acenaphthylene	mg/kg	43	5	0.019	0.190	0.205	0.17	B			0.16	0.20	0.000	
Acetone	mg/kg	42	31	0.004	0.026	0.260	0.06	B			0.06	0.14	0.000	
Anthracene	mg/kg	43	25	0.019	0.110	3.200	0.19	B			0.61	1.54		
Benz(a)anthracene	mg/kg	43	37	0.024	0.160	10.000	0.37	B			1.78	4.65		
Benzo(a)pyrene	mg/kg	43	39	0.021	0.150	8.200	0.33	B			1.47	3.83		
Benzo(b)fluoranthene	mg/kg	43	39	0.024	0.140	7.400	0.31	B			1.33	3.46		
Benzo(ghi)perylene	mg/kg	43	39	0.035	0.140	5.500	0.26	B			1.02	2.60		
Benzo(k)fluoranthene	mg/kg	43	38	0.025	0.150	8.000	0.32	B			1.44	3.74		
Benzoic Acid	mg/kg	43	17	0.022	0.185	0.290	0.15	B			0.18	0.25	0.000	
Bis(2-ethylhexyl)phthalate	mg/kg	43	11	0.180	0.200	140.000	3.85	B			23.50	63.20		
Butyl benzyl phthalate	mg/kg	43	5	0.026	0.190	14.000	0.50	B			2.46	6.49		
Carbazole	mg/kg	43	16	0.021	0.190	1.100	0.16	B			0.31	0.66		0.000
Chrysene	mg/kg	43	39	0.020	0.160	9.700	0.38	B			1.73	4.52		
Dibenz(a,h)anthracene	mg/kg	43	27	0.019	0.080	2.200	0.16	B			0.42	1.06		
Dibenzofuran	mg/kg	43	17	0.021	0.185	0.520	0.14	B			0.21	0.38		
Di-n-octylphthalate	mg/kg	43	3	0.027	0.190	0.590	0.19	B			0.23	0.41		
Fluoranthene	mg/kg	43	39	0.025	0.180	26.000	0.83	B			4.46	11.90		
Fluorene	mg/kg	43	10	0.021	0.190	1.200	0.19	B			0.33	0.70		
Indeno(1,2,3-cd)pyrene	mg/kg	43	38	0.024	0.120	5.000	0.23	B			0.92	2.36		
Naphthalene	mg/kg	43	21	0.019	0.180	0.205	0.12	B			0.16	0.20	0.000	
Phenanthrene	mg/kg	43	38	0.029	0.170	11.000	0.45	B			1.95	5.11		
Phenol	mg/kg	43	7	0.023	0.190	1.100	0.19	B			0.31	0.66	0.000	
Pyrene	mg/kg	43	39	0.021	0.195	16.000	0.61	B			2.80	7.39		
													0.172	0.668

Notes:
SRC = Site Related Contaminant
PDF = Probability Density Function
LN = Lognormal, N = Normal, B = PERT Beta
N = Number of Samples
pCi/g = picoCurie/gram
mg/kg = milligram/kilogram
E(X) = Expected Concentration in Waste Lot
UCL95 = 95% Upper Confidence Limit on the Mean
Standard Deviation = Standard deviation from arithmetic mean for Normal distributions and standard deviation from log transformed mean for Lognormal distributions.

Statistical Summary for Cs-137 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	0.09	U	U	0.16	0.16	-1.832581464
Z1-EU29W-401	S	REG	0.22		=	0.04	0.22	-1.514127733
Z1-EU29W-402	S	REG	0.08	J	U	0.09	0.09	-2.407945609
Z1-EU29W-403	S	REG	3.48		=	0.05	3.48	1.247032294
Z1-EU29W-404	S	REG	0.39		=	0.06	0.39	-0.94160854
Z1-EU29W-405 + Dup	S	REG	0.1	J	J	0.05	0.1	-2.302585093
Z1-EU29W-406	S	REG	0.02	U	U	0.09	0.09	-2.407945609
Z1-EU29W-407	S	REG	0.22		=	0.06	0.22	-1.514127733
Z1-EU29W-408	S	REG	0.02	U	U	0.1	0.1	-2.302585093
Z1-EU29W-409	S	REG	0.11	J	J	0.06	0.11	-2.207274913
Z1-EU30BW-411	B	REG	2.05		=	0.05	2.05	0.717839793
Z1-EU30C-444	C	REG	0	U	U	0.04	0.04	-3.218875825
Z1-EU30C-445	C	REG	-0.01	U L	UJ	0.03	0.03	-3.506557897
Z1-EU30C-446	C	REG	-0.02	U L	UJ	0.04	0.04	-3.218875825
Z1-EU30C-447	C	REG	0.01	U	U	0.04	0.04	-3.218875825
Z1-EU30C-448 + Dup	C	REG	0.15		=	0.03	0.15	-1.897119985
Z1-EU30C-449	C	REG	0.04	J	U	0.04	0.04	-3.218875825
Z1-EU30C-450	C	REG	-0.01	U L	UJ	0.04	0.04	-3.218875825
Z1-EU30C-451	C	REG	0	U	U	0.03	0.03	-3.506557897
Z1-EU30C-452	C	REG	0	U	U	0.04	0.04	-3.218875825
Z1-EU30C-453	C	REG	0.02	U	U	0.04	0.04	-3.218875825
Z1-EU30C-454	C	REG	0.03	U	U	0.03	0.03	-3.506557897
Z1-EU31BW-415	B	REG	0.14	J	J	0.17	0.14	-1.966112856
Z1-EU31BW-416	B	REG	0.09	U	U	0.26	0.26	-1.347073648
Z1-EU31BW-417	B	REG	0.42		=	0.1	0.42	-0.867500568
Z1-EU31W-412	S	REG	0.28		=	0.12	0.28	-1.272965676
Z1-EU31W-413	S	REG	0.08	J	J	0.08	0.08	-2.525728644
Z1-EU31W-414	S	REG	0.07	J	U	0.07	0.07	-2.659260037
Z1-EU32BW-431	B	REG	0.74		=	0.28	0.74	-0.301105093
Z1-EU32BW-432	B	REG	0.32		=	0.09	0.32	-1.139434283
Z1-EU32BW-433 + Dup	B	REG	0.74	J	J	0.55	0.74	-0.301105093
Z1-EU32BW-434	B	REG	0.12		=	0.06	0.12	-2.120263536
Z1-EU32C-455	C	REG	0.01	U	U	0.04	0.04	-3.218875825
Z1-EU32C-456	C	REG	-0.01	U L	UJ	0.04	0.04	-3.218875825
Z1-EU32MW-420	S	REG	0.18	J	J	0.14	0.18	-1.714798428
Z1-EU32MW-426	S	REG	0.29		=	0.09	0.29	-1.237874356
Z1-EU32W-418	S	REG	0.24		J	0.12	0.24	-1.427116356
Z1-EU32W-419 + Dup	S	FR	0.38		J	0.08	0.38	-0.967584026
Z1-EU32W-421	S	REG	0.64		=	0.1	0.64	-0.446287103
Z1-EU32W-422	S	REG	0.28		=	0.08	0.28	-1.272965676
Z1-EU32W-423	S	REG	28.6		=	0.13	28.6	3.353406718
Z1-EU32W-424	S	REG	0.08	U	U	0.23	0.23	-1.46967597
Z1-EU32W-425	S	REG	0.15	J	J	0.09	0.15	-1.897119985
Z1-EU32W-427	S	REG	0.02	U	U	0.14	0.14	-1.966112856
Z1-EU32W-428	S	REG	0.08	U	U	0.21	0.21	-1.560647748
Z1-EU32W-429	S	REG	0.21		=	0.09	0.21	-1.560647748
Z1-EU32W-430	S	REG	0.24		=	0.08	0.24	-1.427116356
Z1-EU33BW-443	B	REG	0.11	J	J	0.1	0.11	-2.207274913
Z1-EU33BW-444	B	REG	0.04	U	U	0.19	0.19	-1.660731207
Z1-EU33C-457	C	REG	0.01	U	U	0.03	0.03	-3.506557897
Z1-EU33W-435	S	REG	-0.01	U L	U	0.19	0.19	-1.660731207
Z1-EU33W-436	S	REG	0.2		=	0.07	0.2	-1.609437912
Z1-EU33W-437	S	REG	0.2		=	0.08	0.2	-1.609437912
Z1-EU33W-438	S	REG	0.33		=	0.15	0.33	-1.108662625
Z1-EU33W-439	S	REG	0.27		=	0.09	0.27	-1.30933332
Z1-EU33W-440	S	REG	0.26		=	0.06	0.26	-1.347073648
Z1-EU33W-441	S	REG	0.85		=	0.08	0.85	-0.162518929

Number of Samples	57
Number of Detects	33
Minimum	0.03
Median	0.19
Maximum	28.6
Average	0.7929825
Standard Deviation	3.7856453
PERT-Beta Mean	4.8983333
Lognormal Mean	-1.774201
Lognormal Standard Deviation	1.263908

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Cs-137 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	33
Raw Statistics		**Log-transformed Statistics**	
Minimum	0.03	Minimum of Log Data	-3.507
Maximum	28.6	Maximum of Log Data	3.353
Mean	0.793	Mean of log Data	-1.774
Median	0.19	SD of log Data	1.264
SD	3.786		
Coefficient of Variation	4.774		
Skewness	7.337		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.441	Lilliefors Test Statistic	0.125
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	1.632	95% H-UCL	0.556
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.708
95% Adjusted-CLT UCL	2.138	97.5% Chebyshev (MVUE) UCL	0.855
95% Modified-t UCL	1.713	99% Chebyshev (MVUE) UCL	1.143
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.412	Data do not follow a Discernable Distribution (0.05)	
Theta Star	1.923		
nu star	47		
Approximate Chi Square Value (.05)	32.27	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	1.618
Adjusted Chi Square Value	31.95	95% Jackknife UCL	1.632
		95% Standard Bootstrap UCL	1.586
Anderson-Darling Test Statistic	7.842	95% Bootstrap-t UCL	9.632
Anderson-Darling 5% Critical Value	0.834	95% Hall's Bootstrap UCL	5.097
Kolmogorov-Smirnov Test Statistic	0.315	95% Percentile Bootstrap UCL	1.765
Kolmogorov-Smirnov 5% Critical Value	0.126	95% BCA Bootstrap UCL	2.413
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	2.979
		97.5% Chebyshev(Mean, Sd) UCL	3.924
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	5.782
95% Approximate Gamma UCL	1.155		
95% Adjusted Gamma UCL	1.166		

		Potential UCL to Use						Use 97.5% Chebyshev (Mean, Sd) UCL			3.924

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT							Calculations				
	STEP 10	STEP 11	STEP 12		OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)		0.95	α_1	α_2	Variance	Max - Min
Cs-137 (pCi/g)	0.0300	0.1900	28.6000	4.90	13.07	2.67		13.07	1.02	4.98	19.8698	28.6

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \qquad MIN < Most\,likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ is the Beta Function and $B_z(\alpha_1,\alpha_2)$ is the Incomplete Beta Function
α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95 α_1 α_2 MIN MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Co-60 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	-0.04	U L	U	0.13	0.13	-2.040220829
Z1-EU29W-401	S	REG	0	U	U	0.05	0.05	-2.995732274
Z1-EU29W-402	S	REG	0.01	U	U	0.07	0.07	-2.659260037
Z1-EU29W-403	S	REG	-0.03	U L	U	0.06	0.06	-2.813410717
Z1-EU29W-404	S	REG	0.03	U	U	0.06	0.06	-2.813410717
Z1-EU29W-405 + Dup	S	FR	0.03	U	U	0.06	0.06	-2.813410717
Z1-EU29W-406	S	REG	0	U	U	0.09	0.09	-2.407945609
Z1-EU29W-407	S	REG	-0.01	U L	U	0.07	0.07	-2.659260037
Z1-EU29W-408	S	REG	-0.01	U L	U	0.09	0.09	-2.407945609
Z1-EU29W-409	S	REG	0.01	U	U	0.06	0.06	-2.813410717
Z1-EU30BW-411	B	REG	0.01	U	U	0.06	0.06	-2.813410717
Z1-EU30C-444	C	REG	0.01	U	U	0.04	0.04	-3.218875825
Z1-EU30C-445	C	REG	-0.01	U L	UJ	0.03	0.03	-3.506557897
Z1-EU30C-446	C	REG	-0.01	U L	UJ	0.04	0.04	-3.218875825
Z1-EU30C-447	C	REG	-0.01	U L	UJ	0.04	0.04	-3.218875825
Z1-EU30C-448 + Dup	C	REG	0.01	U	U	0.04	0.04	-3.218875825
Z1-EU30C-449	C	REG	-0.02	U L	UJ	0.04	0.04	-3.218875825
Z1-EU30C-450	C	REG	0.01	U	U	0.04	0.04	-3.218875825
Z1-EU30C-451	C	REG	0	U	U	0.04	0.04	-3.218875825
Z1-EU30C-452	C	REG	-0.02	U L	UJ	0.03	0.03	-3.506557897
Z1-EU30C-453	C	REG	0	U	U	0.04	0.04	-3.218875825
Z1-EU30C-454	C	REG	0.02	U	U	0.04	0.04	-3.218875825
Z1-EU31BW-415	B	REG	-0.02	U L	U	0.13	0.13	-2.040220829
Z1-EU31BW-416	B	REG	-0.1	U L	U	0.19	0.19	-1.660731207
Z1-EU31BW-417	B	REG	0	U	U	0.11	0.11	-2.207274913
Z1-EU31W-412	S	REG	-0.01	U L	U	0.18	0.18	-1.714798428
Z1-EU31W-413	S	REG	-0.05	U L	U	0.07	0.07	-2.659260037
Z1-EU31W-414	S	REG	-0.02	U L	U	0.06	0.06	-2.813410717
Z1-EU32BW-431	B	REG	1.87		=	0.15	1.87	0.625938431
Z1-EU32BW-432	B	REG	0.31		=	0.19	0.31	-1.171182982
Z1-EU32BW-433 + Dup	B	REG	-0.06	U L	U	0.3	0.3	-1.203972804
Z1-EU32BW-434	B	REG	0.02	U	U	0.07	0.07	-2.659260037
Z1-EU32C-455	C	REG	-0.01	U L	UJ	0.04	0.04	-3.218875825
Z1-EU32C-456	C	REG	0.03	U	U	0.04	0.04	-3.218875825
Z1-EU32MW-420	S	REG	0.05	U	U	0.18	0.18	-1.714798428
Z1-EU32MW-426	S	REG	0.02	U	U	0.1	0.1	-2.302585093
Z1-EU32W-418	S	REG	0.03	U	U	0.12	0.12	-2.120263536
Z1-EU32W-419 + Dup	S	FR	0.2		J	0.08	0.2	-1.609437912
Z1-EU32W-421	S	REG	0.04	U	U	0.13	0.13	-2.040220829
Z1-EU32W-422	S	REG	0.17		=	0.08	0.17	-1.771956842
Z1-EU32W-423	S	REG	0.09	J	U	0.14	0.14	-1.966112856
Z1-EU32W-424	S	REG	0.09	U	U	0.23	0.23	-1.46967597
Z1-EU32W-425	S	REG	-0.04	U L	U	0.1	0.1	-2.302585093
Z1-EU32W-427	S	REG	0.12	J	U	0.15	0.15	-1.897119985
Z1-EU32W-428	S	REG	0.03	U	U	0.2	0.2	-1.609437912
Z1-EU32W-429	S	REG	0	U	U	0.09	0.09	-2.407945609
Z1-EU32W-430	S	REG	-0.01	U L	U	0.08	0.08	-2.525728644
Z1-EU33BW-443	B	REG	0.01	U	U	0.08	0.08	-2.525728644
Z1-EU33BW-444	B	REG	0.24	J	J	0.18	0.24	-1.427116356
Z1-EU33C-457	C	REG	0	U	U	0.03	0.03	-3.506557897
Z1-EU33W-435	S	REG	-0.01	U L	U	0.18	0.18	-1.714798428
Z1-EU33W-436	S	REG	0.04	U	U	0.1	0.1	-2.302585093
Z1-EU33W-437	S	REG	-0.01	U L	U	0.08	0.08	-2.525728644
Z1-EU33W-438	S	REG	-0.05	U L	U	0.12	0.12	-2.120263536
Z1-EU33W-439	S	REG	0.06	J	U	0.1	0.1	-2.302585093
Z1-EU33W-440	S	REG	0.01	U	U	0.07	0.07	-2.659260037
Z1-EU33W-441	S	REG	0.01	U	U	0.1	0.1	-2.302585093

Number of Samples	57
Number of Detects	5
Minimum	0.03
Median	0.08
Maximum	1.87
Average	0.1329825
Standard Deviation	0.2436256
PERT-Beta Mean	0.37
Lognormal Mean	-2.426095
Lognormal Standard Deviation	0.7482546

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Co-60 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	22

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.03	Minimum of Log Data	-3.507
Maximum	1.87	Maximum of Log Data	0.626
Mean	0.133	Mean of log Data	-2.426
Median	0.08	SD of log Data	0.748
SD	0.244		
Coefficient of Variation	1.832		
Skewness	6.703		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.336	Lilliefors Test Statistic	0.101
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.187	95% H-UCL	0.144
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.172
95% Adjusted-CLT UCL	0.217	97.5% Chebyshev (MVUE) UCL	0.196
95% Modified-t UCL	0.192	99% Chebyshev (MVUE) UCL	0.243

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	1.306	Data appear Lognormal at 5% Significance Level	
Theta Star	0.102		
nu star	148.9		
Approximate Chi Square Value (.05)	121.7	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	0.186
Adjusted Chi Square Value	121.1	95% Jackknife UCL	0.187
		95% Standard Bootstrap UCL	0.185
Anderson-Darling Test Statistic	2.866	95% Bootstrap-t UCL	0.299
Anderson-Darling 5% Critical Value	0.771	95% Hall's Bootstrap UCL	0.387
Kolmogorov-Smirnov Test Statistic	0.159	95% Percentile Bootstrap UCL	0.195
Kolmogorov-Smirnov 5% Critical Value	0.12	95% BCA Bootstrap UCL	0.234
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.274
		97.5% Chebyshev(Mean, Sd) UCL	0.335
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	0.454
95% Approximate Gamma UCL	0.163		
95% Adjusted Gamma UCL	0.164		

		Potential UCL to Use							Use 95% H-UCL		0.144

Statistical Summary for K-40 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	11.5		=	1.18	11.5	2.442347035
Z1-EU29W-401	S	REG	8.53		=	0.31	8.53	2.143589362
Z1-EU29W-402	S	REG	11.7		=	0.44	11.7	2.459588842
Z1-EU29W-403	S	REG	13.9		=	0.44	13.9	2.63188884
Z1-EU29W-404	S	REG	13		=	0.43	13	2.564949357
Z1-EU29W-405 + Dup	S	FR	9.2		J	0.5	9.2	2.219203484
Z1-EU29W-406	S	REG	16.3		=	0.63	16.3	2.791165108
Z1-EU29W-407	S	REG	12.3		=	0.53	12.3	2.509599262
Z1-EU29W-408	S	REG	13.5		=	0.78	13.5	2.602689685
Z1-EU29W-409	S	REG	10.1		=	0.36	10.1	2.312535424
Z1-EU30BW-411	B	REG	9.31		=	0.39	9.31	2.231089091
Z1-EU30C-444	C	REG	6.51		=	0.33	6.51	1.873339456
Z1-EU30C-445	C	REG	2.18		=	0.28	2.18	0.779324877
Z1-EU30C-446	C	REG	1.72		=	0.41	1.72	0.542324291
Z1-EU30C-447	C	REG	1.69		=	0.39	1.69	0.524728529
Z1-EU30C-448 + Dup	C	REG	7.44		=	0.36	7.44	2.006870849
Z1-EU30C-449	C	REG	6.25		=	0.28	6.25	1.832581464
Z1-EU30C-450	C	REG	1.73		=	0.36	1.73	0.548121409
Z1-EU30C-451	C	REG	7.11		=	0.27	7.11	1.961502244
Z1-EU30C-452	C	REG	1.89		=	0.28	1.89	0.636576829
Z1-EU30C-453	C	REG	1.38		=	0.28	1.38	0.322083499
Z1-EU30C-454	C	REG	2.54		=	0.3	2.54	0.932164081
Z1-EU31BW-415	B	REG	13.1		=	0.93	13.1	2.57261223
Z1-EU31BW-416	B	REG	9.41		=	1.66	9.41	2.241772954
Z1-EU31BW-417	B	REG	12.4		=	0.9	12.4	2.517696473
Z1-EU31W-412	S	REG	10.3		=	1.14	10.3	2.332143895
Z1-EU31W-413	S	REG	10.2		=	0.55	10.2	2.32238772
Z1-EU31W-414	S	REG	14.9		=	0.51	14.9	2.701361213
Z1-EU32BW-431	B	REG	10.5		=	1.27	10.5	2.351375257
Z1-EU32BW-432	B	REG	12.5		=	0.73	12.5	2.525728644
Z1-EU32BW-433 + Dup	B	FR	16.8		=	2.07	16.8	2.821378886
Z1-EU32BW-434	B	REG	11.9		=	0.5	11.9	2.4765384
Z1-EU32C-455	C	REG	1.98		=	0.36	1.98	0.683096845
Z1-EU32C-456	C	REG	1.56		=	0.3	1.56	0.444685821
Z1-EU32MW-420	S	REG	7.1		=	1.33	7.1	1.960094784
Z1-EU32MW-426	S	REG	15		=	0.67	15	2.708050201
Z1-EU32W-418	S	REG	15.3		=	0.91	15.3	2.727852828
Z1-EU32W-419 + Dup	S	FR	10.2		=	0.64	10.2	2.32238772
Z1-EU32W-421	S	REG	13.2		=	0.91	13.2	2.58021683
Z1-EU32W-422	S	REG	12.5		=	0.46	12.5	2.525728644
Z1-EU32W-423	S	REG	9.72		=	0.78	9.72	2.274185618
Z1-EU32W-424	S	REG	14		=	1.89	14	2.63905733
Z1-EU32W-425	S	REG	15.3		=	0.73	15.3	2.727852828
Z1-EU32W-427	S	REG	14.4		=	1.09	14.4	2.667228207
Z1-EU32W-428	S	REG	10.2		=	1.91	10.2	2.32238772
Z1-EU32W-429	S	REG	13.2		=	0.73	13.2	2.58021683
Z1-EU32W-430	S	REG	8.73		=	0.64	8.73	2.16676537
Z1-EU33BW-443	B	REG	9.41		=	0.63	9.41	2.241772954
Z1-EU33BW-444	B	REG	8.31		=	1.52	8.31	2.117459609
Z1-EU33C-457	C	REG	4.65		J	0.23	4.65	1.53686722
Z1-EU33W-435	S	REG	14.8		=	1.43	14.8	2.694627181
Z1-EU33W-436	S	REG	11.2		=	0.72	11.2	2.415913778
Z1-EU33W-437	S	REG	10.5		=	0.57	10.5	2.351375257
Z1-EU33W-438	S	REG	9.32		=	1.14	9.32	2.232162629
Z1-EU33W-439	S	REG	13.5		=	0.5	13.5	2.602689685
Z1-EU33W-440	S	REG	9.97		=	0.55	9.97	2.299580584
Z1-EU33W-441	S	REG	10.8		=	0.73	10.8	2.379546134

Number of Samples	57
Number of Detects	57
Minimum	1.38
Median	10.2
Maximum	16.8
Average	9.765614
Standard Deviation	4.3216548
PERT-Beta Mean	9.83
Lognormal Mean	2.1040888
Lognormal Standard Deviation	0.7064048

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

K-40 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	49

Raw Statistics		**Log-transformed Statistics**	
Minimum	1.38	Minimum of Log Data	0.322
Maximum	16.8	Maximum of Log Data	2.821
Mean	9.766	Mean of log Data	2.104
Median	10.2	SD of log Data	0.706
SD	4.322		
Coefficient of Variation	0.443		
Skewness	-0.636		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.132	Lilliefors Test Statistic	0.249
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	10.72	95% H-UCL	12.73
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	15.16
95% Adjusted-CLT UCL	10.66	97.5% Chebyshev (MVUE) UCL	17.18
95% Modified-t UCL	10.71	99% Chebyshev (MVUE) UCL	21.17
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	2.87	Data do not follow a Discernable Distribution (0.05)	
Theta Star	3.403		
nu star	327.2		
Approximate Chi Square Value (.05)	286.3	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	10.71
Adjusted Chi Square Value	285.3	95% Jackknife UCL	10.72
		95% Standard Bootstrap UCL	10.69
Anderson-Darling Test Statistic	4.018	95% Bootstrap-t UCL	10.66
Anderson-Darling 5% Critical Value	0.758	95% Hall's Bootstrap UCL	10.65
Kolmogorov-Smirnov Test Statistic	0.221	95% Percentile Bootstrap UCL	10.71
Kolmogorov-Smirnov 5% Critical Value	0.119	95% BCA Bootstrap UCL	10.64
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	12.26
		97.5% Chebyshev(Mean, Sd) UCL	13.34
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	15.46
95% Approximate Gamma UCL	11.16		
95% Adjusted Gamma UCL	11.2		

		Potential UCL to Use						Use 95% Chebyshev (Mean, Sd) UCL			12.26

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells	
Report OUTPUT UCL-95	

		WACFACS WL L SRC INPUT			OUTPUT			Calculations				
		STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
	SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
K-40 (pCi/g)		1.3800	10.2000	16.8000	9.83	14.45	1.47	14.45	3.29	2.71	18.6141	15.4

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ *is the Beta Function and* $B_z(\alpha_1, \alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Tc-99 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	8.28		J	1.52	8.28	2.113842968
Z1-EU29W-401	S	REG	1.94	J	J	1.51	1.94	0.662687973
Z1-EU29W-402	S	REG	4.25		J	1.47	4.25	1.446918983
Z1-EU29W-403	S	REG	8.38		J	1.53	8.38	2.125847914
Z1-EU29W-404	S	REG	23.8		J	1.51	23.8	3.169685581
Z1-EU29W-405 + Dup	S	REG	5.33		J	1.51	5.33	1.673351238
Z1-EU29W-406	S	REG	2.92		U	1.39	1.39	0.329303747
Z1-EU29W-407	S	REG	8.74		J	1.43	8.74	2.16791019
Z1-EU29W-408	S	REG	3.34		U	1.37	1.37	0.31481074
Z1-EU29W-409	S	REG	4.35		J	1.5	4.35	1.470175845
Z1-EU30BW-411	B	REG	16.2		J	1.48	16.2	2.785011242
Z1-EU30C-444	C	REG	-0.52	U	U	1.62	1.62	0.482426149
Z1-EU30C-445	C	REG	-0.49	U	U	1.53	1.53	0.425267735
Z1-EU30C-446	C	REG	0	U	U	1.6	1.6	0.470003629
Z1-EU30C-447	C	REG	0	U	U	1.54	1.54	0.431782416
Z1-EU30C-448 + Dup	C	REG	-0.48	U	U	1.49	1.49	0.39877612
Z1-EU30C-449	C	REG	-0.94	U	U	1.47	1.47	0.385262401
Z1-EU30C-450	C	REG	-0.51	U	U	1.58	1.58	0.457424847
Z1-EU30C-451	C	REG	0	U	U	1.47	1.47	0.385262401
Z1-EU30C-452	C	REG	0	U	U	1.49	1.49	0.39877612
Z1-EU30C-453	C	REG	-0.99	U	U	1.54	1.54	0.431782416
Z1-EU30C-454	C	REG	0.51	U	U	1.58	1.58	0.457424847
Z1-EU31BW-415	B	REG	3.63		U	1.3	1.3	0.262364264
Z1-EU31BW-416	B	REG	9.4		=	1.35	9.4	2.240709689
Z1-EU31BW-417	B	REG	7.94		=	1.42	7.94	2.071913275
Z1-EU31W-412	S	REG	2.34		U	1.34	1.34	0.292669614
Z1-EU31W-413	S	REG	31.8		=	1.36	31.8	3.45946629
Z1-EU31W-414	S	REG	5.42		J	1.53	5.42	1.690095815
Z1-EU32BW-431	B	REG	87		J	1.47	87	4.465908119
Z1-EU32BW-432	B	REG	13.7		=	1.46	13.7	2.617395833
Z1-EU32BW-433 + Dup	B	REG	629		J	1.45	629	6.444131257
Z1-EU32BW-434	B	REG	2.44		U	1.4	1.4	0.336472237
Z1-EU32C-455	C	REG	-0.52	U	U	1.61	1.61	0.476234179
Z1-EU32C-456	C	REG	-0.48	U	U	1.49	1.49	0.39877612
Z1-EU32MW-420	S	REG	5.7		J	1.45	5.7	1.740466175
Z1-EU32MW-426	S	REG	5.43		J	1.51	5.43	1.691939134
Z1-EU32W-418	S	REG	4.11		J	1.39	4.11	1.413423029
Z1-EU32W-419 + Dup	S	FR	15.5		J	1.43	15.5	2.740840024
Z1-EU32W-421	S	REG	20		J	1.39	20	2.995732274
Z1-EU32W-422	S	REG	20.4		J	1.38	20.4	3.015534901
Z1-EU32W-423	S	REG	40.1		J	1.46	40.1	3.691376334
Z1-EU32W-424	S	REG	2.38		J	1.45	2.38	0.867100488
Z1-EU32W-425	S	REG	7.24		J	1.47	7.24	1.979621206
Z1-EU32W-427	S	REG	9.23		J	1.48	9.23	2.222459049
Z1-EU32W-428	S	REG	13.6		J	1.48	13.6	2.610069793
Z1-EU32W-429	S	REG	2.34		J	1.43	2.34	0.850150929
Z1-EU32W-430	S	REG	1.9	J	J	1.45	1.9	0.641853886
Z1-EU33BW-443	B	REG	17.8		=	1.27	17.8	2.879198457
Z1-EU33BW-444	B	REG	60.1		=	1.68	60.1	4.096009842
Z1-EU33C-457	C	REG	1.25	J	U	1.29	1.29	0.254642218
Z1-EU33W-435	S	REG	0.96	J	U	1.43	1.43	0.357674444
Z1-EU33W-436	S	REG	1.49	J	J	1.48	1.49	0.39877612
Z1-EU33W-437	S	REG	4.14		=	1.55	4.14	1.420695788
Z1-EU33W-438	S	REG	12.4		=	1.49	12.4	2.517696473
Z1-EU33W-439	S	REG	4.31		=	1.43	4.31	1.460937904
Z1-EU33W-440	S	REG	6.71		=	1.54	6.71	1.903598951
Z1-EU33W-441	S	REG	4.74		=	1.58	4.74	1.556037136

Number of Samples	57
Number of Detects	37
Minimum	1.29
Median	4.31
Maximum	629
Average	20.257544
Standard Deviation	83.412099
PERT-Beta Mean	107.92167
Lognormal Mean	1.5972931
Lognormal Standard Deviation	1.3060875

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Tc-99 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	51

Raw Statistics		**Log-transformed Statistics**	
Minimum	1.29	Minimum of Log Data	0.255
Maximum	629	Maximum of Log Data	6.444
Mean	20.26	Mean of log Data	1.597
Median	4.31	SD of log Data	1.306
SD	83.41		
Coefficient of Variation	4.118		
Skewness	7.198		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.41	Lilliefors Test Statistic	0.172
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	38.74	95% H-UCL	16.67
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	22.17
95% Adjusted-CLT UCL	49.69	97.5% Chebyshev (MVUE) UCL	26.88
95% Modified-t UCL	40.49	99% Chebyshev (MVUE) UCL	36.13
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.444	Data do not follow a Discernable Distribution (0.05)	
Theta Star	45.6		
nu star	50.64		
Approximate Chi Square Value (.05)	35.3	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	38.43
Adjusted Chi Square Value	34.97	95% Jackknife UCL	38.74
		95% Standard Bootstrap UCL	38.56
Anderson-Darling Test Statistic	6.244	95% Bootstrap-t UCL	128.6
Anderson-Darling 5% Critical Value	0.826	95% Hall's Bootstrap UCL	100
Kolmogorov-Smirnov Test Statistic	0.233	95% Percentile Bootstrap UCL	42.48
Kolmogorov-Smirnov 5% Critical Value	0.125	95% BCA Bootstrap UCL	54.35
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	68.42
		97.5% Chebyshev(Mean, Sd) UCL	89.25
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	130.2
95% Approximate Gamma UCL	29.06		
95% Adjusted Gamma UCL	29.34		

		Potential UCL to Use						Use 97.5% Chebyshev (Mean, Sd) UCL			89.25

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005 | R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Tc-99 (pCi/g)	1.2900	4.3100	629.0000	107.92	**287.20**	2.66	287.20	1.02	4.98	9561.9662	627.7

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ *is the Beta Function and* $B_z(\alpha_1, \alpha_2)$ *is the Incomplete Beta Function*
α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®™ function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Th-228 pCi/g

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	1.64		=	0.12	1.64	0.494696242
Z1-EU29W-401	S	REG	0.52		=	0.1	0.52	-0.653926467
Z1-EU29W-402	S	REG	1.67		=	0.23	1.67	0.512823626
Z1-EU29W-403	S	REG	1.5		=	0.12	1.5	0.405465108
Z1-EU29W-404	S	REG	1.23		=	0.15	1.23	0.207014169
Z1-EU29W-405 + Dup	S	FR	3.53		J	0.13	3.53	1.261297871
Z1-EU29W-406	S	REG	1.45		=	0.1	1.45	0.371563556
Z1-EU29W-407	S	REG	1.77		=	0.24	1.77	0.570979547
Z1-EU29W-408	S	REG	1.46		=	0.11	1.46	0.378436436
Z1-EU29W-409	S	REG	1.53		=	0.04	1.53	0.425267735
Z1-EU30BW-411	B	REG	0.86		=	0.15	0.86	-0.15082289
Z1-EU30C-444	C	REG	0.52		=	0.14	0.52	-0.653926467
Z1-EU30C-445	C	REG	0.24		=	0.09	0.24	-1.427116356
Z1-EU30C-446	C	REG	0.32		=	0.15	0.32	-1.139434283
Z1-EU30C-447	C	REG	0.29		=	0.14	0.29	-1.237874356
Z1-EU30C-448 + Dup	C	REG	0.39		=	0.14	0.39	-0.94160854
Z1-EU30C-449	C	REG	0.37		=	0.09	0.37	-0.994252273
Z1-EU30C-450	C	REG	0.27		=	0.12	0.27	-1.30933332
Z1-EU30C-451	C	REG	0.48		=	0.11	0.48	-0.733969175
Z1-EU30C-452	C	REG	0.4		=	0.12	0.4	-0.916290732
Z1-EU30C-453	C	REG	0.29		=	0.11	0.29	-1.237874356
Z1-EU30C-454	C	REG	0.34		=	0.1	0.34	-1.078809661
Z1-EU31BW-415	B	REG	1.11		=	0.17	1.11	0.104360015
Z1-EU31BW-416	B	REG	1.45		=	0.1	1.45	0.371563556
Z1-EU31BW-417	B	REG	1.62		=	0.07	1.62	0.482426149
Z1-EU31W-412	S	REG	0.68		=	0.11	0.68	-0.385662481
Z1-EU31W-413	S	REG	0.71		=	0.12	0.71	-0.342490309
Z1-EU31W-414	S	REG	2.15		=	0.15	2.15	0.765467842
Z1-EU32BW-431	B	REG	0.89		=	0.05	0.89	-0.116533816
Z1-EU32BW-432	B	REG	0.47		=	0.1	0.47	-0.755022584
Z1-EU32BW-433 + Dup	B	FR	2.99		=	0.23	2.99	1.095273387
Z1-EU32BW-434	B	REG	0.84		=	0.12	0.84	-0.174353387
Z1-EU32C-455	C	REG	0.35		=	0.09	0.35	-1.049822124
Z1-EU32C-456	C	REG	0.24		=	0.1	0.24	-1.427116356
Z1-EU32MW-420	S	REG	0.93		=	0.13	0.93	-0.072570693
Z1-EU32MW-426	S	REG	1.5		=	0.16	1.5	0.405465108
Z1-EU32W-418	S	REG	1.28		=	0.12	1.28	0.246860078
Z1-EU32W-419 + Dup	S	FR	1.65		=	0.13	1.65	0.500775288
Z1-EU32W-421	S	REG	1.2		=	0.24	1.2	0.182321557
Z1-EU32W-422	S	REG	1.1		=	0.2	1.1	0.09531018
Z1-EU32W-423	S	REG	1.01		=	0.21	1.01	0.009950331
Z1-EU32W-424	S	REG	1.7		=	0.12	1.7	0.530628251
Z1-EU32W-425	S	REG	1.13		=	0.13	1.13	0.122217633
Z1-EU32W-427	S	REG	2.18		=	0.14	2.18	0.779324877
Z1-EU32W-428	S	REG	1.82		=	0.18	1.82	0.598836501
Z1-EU32W-429	S	REG	1.29		=	0.1	1.29	0.254642218
Z1-EU32W-430	S	REG	1.09		=	0.09	1.09	0.086177696
Z1-EU33BW-443	B	REG	0.85		=	0.12	0.85	-0.162518929
Z1-EU33BW-444	B	REG	0.98		=	0.12	0.98	-0.020202707
Z1-EU33C-457	C	REG	0.27 J		J	0.16	0.27	-1.30933332
Z1-EU33W-435	S	REG	1.08		=	0.08	1.08	0.076961041
Z1-EU33W-436	S	REG	1.15		=	0.07	1.15	0.139761942
Z1-EU33W-437	S	REG	1.16		=	0.05	1.16	0.148420005
Z1-EU33W-438	S	REG	1.09		=	0.15	1.09	0.086177696
Z1-EU33W-439	S	REG	0.9		=	0.11	0.9	-0.105360516
Z1-EU33W-440	S	REG	0.97		=	0.06	0.97	-0.030459207
Z1-EU33W-441	S	REG	1.25		=	0.16	1.25	0.223143551

Number of Samples	57
Number of Detects	57
Minimum	0.24
Median	1.09
Maximum	3.53
Average	1.0903509
Standard Deviation	0.6658747
PERT-Beta Mean	1.355
Lognormal Mean	-0.113914
Lognormal Standard Deviation	0.6769965

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Th-228 pCi/g

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	50
Raw Statistics		**Log-transformed Statistics**	
Minimum	0.24	Minimum of Log Data	-1.427
Maximum	3.53	Maximum of Log Data	1.261
Mean	1.09	Mean of log Data	-0.114
Median	1.09	SD of log Data	0.677
SD	0.666		
Coefficient of Variation	0.611		
Skewness	1.2		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.101	Lilliefors Test Statistic	0.149
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data appear Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	1.238	95% H-UCL	1.344
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	1.593
95% Adjusted-CLT UCL	1.25	97.5% Chebyshev (MVUE) UCL	1.799
95% Modified-t UCL	1.24	99% Chebyshev (MVUE) UCL	2.204
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	2.522	Data appear Normal at 5% Significance Level	
Theta Star	0.432		
nu star	287.5		
Approximate Chi Square Value (.05)	249.2	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	1.235
Adjusted Chi Square Value	248.3	95% Jackknife UCL	1.238
		95% Standard Bootstrap UCL	1.231
Anderson-Darling Test Statistic	0.878	95% Bootstrap-t UCL	1.252
Anderson-Darling 5% Critical Value	0.76	95% Hall's Bootstrap UCL	1.27
Kolmogorov-Smirnov Test Statistic	0.106	95% Percentile Bootstrap UCL	1.228
Kolmogorov-Smirnov 5% Critical Value	0.119	95% BCA Bootstrap UCL	1.239
ollow Appr. Gamma Distribution at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	1.475
		97.5% Chebyshev(Mean, Sd) UCL	1.641
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1.968
95% Approximate Gamma UCL	1.258		
95% Adjusted Gamma UCL	1.262		

		Potential UCL to Use							Use 95% Student's-t UCL		1.238

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Statistical Summary for Molybdenum mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	17.2		=	0.27	17.2	2.844909384
Z1-EU29W-401	S	REG	2.7		=	0.23	2.7	0.993251773
Z1-EU29W-402	S	REG	3.1		=	0.29	3.1	1.131402111
Z1-EU29W-403	S	REG	1.5		=	0.24	1.5	0.405465108
Z1-EU29W-404	S	REG	6.6		=	0.27	6.6	1.887069649
Z1-EU29W-405 + Dup	S	REG	3.1		=	0.26	3.1	1.131402111
Z1-EU29W-406	S	REG	1.7		=	0.24	1.7	0.530628251
Z1-EU29W-407	S	REG	6.3		=	0.27	6.3	1.840549633
Z1-EU29W-408	S	REG	1.4		=	0.26	1.4	0.336472237
Z1-EU29W-409	S	REG	4.9		=	0.26	4.9	1.589235205
Z1-EU30BW-411	B	REG	9.3		=	0.26	9.3	2.2300144
Z1-EU30C-444	C	REG	0.69	B	=	0.3	0.69	-0.371063681
Z1-EU30C-445	C	REG	1.2		=	0.26	1.2	0.182321557
Z1-EU30C-446	C	REG	1.1		=	0.31	1.1	0.09531018
Z1-EU30C-447	C	REG	1.2		=	0.31	1.2	0.182321557
Z1-EU30C-448 + Dup	C	FR	0.71	B	=	0.28	0.71	-0.342490309
Z1-EU30C-449	C	REG	0.98	B	=	0.3	0.98	-0.020202707
Z1-EU30C-450	C	REG	1.5		=	0.3	1.5	0.405465108
Z1-EU30C-451	C	REG	0.79	B	=	0.3	0.79	-0.235722334
Z1-EU30C-452	C	REG	0.79	B	=	0.3	0.79	-0.235722334
Z1-EU30C-453	C	REG	1.3		=	0.32	1.3	0.262364264
Z1-EU30C-454	C	REG	1.9		=	0.3	1.9	0.641853886
Z1-EU31BW-415	B	REG	3.4		=	0.27	3.4	1.223775432
Z1-EU31BW-416	B	REG	3.1		=	0.28	3.1	1.131402111
Z1-EU31BW-417	B	REG	18		=	0.24	18	2.890371758
Z1-EU31W-412	S	REG	1.8		=	0.27	1.8	0.587786665
Z1-EU31W-413	S	REG	11.6		=	0.23	11.6	2.451005098
Z1-EU31W-414	S	REG	3.6		=	0.27	3.6	1.280933845
Z1-EU32BW-431	B	REG	4.7		=	0.26	4.7	1.547562509
Z1-EU32BW-432	B	REG	7.9		=	0.23	7.9	2.066862759
Z1-EU32BW-433 + Dup	B	FR	2		=	0.26	2	0.693147181
Z1-EU32BW-434	B	REG	1.3		=	0.24	1.3	0.262364264
Z1-EU32C-455	C	REG	0.93	B	=	0.31	0.93	-0.072570693
Z1-EU32C-456	C	REG	0.97	B	=	0.32	0.97	-0.030459207
Z1-EU32MW-420	S	REG	2.8		=	0.26	2.8	1.029619417
Z1-EU32MW-426	S	REG	6.4		=	0.27	6.4	1.85629799
Z1-EU32W-418	S	REG	1.5		=	0.32	1.5	0.405465108
Z1-EU32W-419 + Dup	S	FR	7.3		=	0.26	7.3	1.987874348
Z1-EU32W-421	S	REG	5.4		=	0.27	5.4	1.686398954
Z1-EU32W-422	S	REG	6.1		=	0.25	6.1	1.808288771
Z1-EU32W-423	S	REG	7.6		=	0.25	7.6	2.028148247
Z1-EU32W-424	S	REG	1.4		=	0.27	1.4	0.336472237
Z1-EU32W-425	S	REG	4.2		=	0.28	4.2	1.435084525
Z1-EU32W-427	S	REG	1.9		=	0.26	1.9	0.641853886
Z1-EU32W-428	S	REG	1.7		=	0.28	1.7	0.530628251
Z1-EU32W-429	S	REG	1.4		=	0.26	1.4	0.336472237
Z1-EU32W-430	S	REG	1.6		=	0.23	1.6	0.470003629
Z1-EU33BW-443	B	REG	15.6		=	0.25	15.6	2.747270914
Z1-EU33BW-444	B	REG	2.2		=	0.26	2.2	0.78845736
Z1-EU33C-457	C	REG	4.1		=	0.29	4.1	1.410986974
Z1-EU33W-435	S	REG	1.4		=	0.27	1.4	0.336472237
Z1-EU33W-436	S	REG	1.3		=	0.27	1.3	0.262364264
Z1-EU33W-437	S	REG	7.2		=	0.3	7.2	1.974081026
Z1-EU33W-438	S	REG	28.3		=	0.26	28.3	3.342861805
Z1-EU33W-439	S	REG	3		=	0.25	3	1.098612289
Z1-EU33W-440	S	REG	69.2		=	0.25	69.2	4.237000863
Z1-EU33W-441	S	REG	6.1		=	0.24	6.1	1.808288771

Number of Samples	57
Number of Detects	57
Minimum	0.69
Median	2.7
Maximum	69.2
Average	5.5607018
Standard Deviation	9.9810218
PERT-Beta Mean	13.448333
Lognormal Mean	1.089053
Lognormal Standard Deviation	1.0033012

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Mo mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	43

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.69	Minimum of Log Data	-0.371
Maximum	69.2	Maximum of Log Data	4.237
Mean	5.561	Mean of log Data	1.089
Median	2.7	SD of log Data	1.003
SD	9.981		
Coefficient of Variation	1.795		
Skewness	5.064		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.313	Lilliefors Test Statistic	0.128
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	7.772	95% H-UCL	11.79
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	8.176
95% Adjusted-CLT UCL	8.683	97.5% Chebyshev (MVUE) UCL	9.614
95% Modified-t UCL	7.92	99% Chebyshev (MVUE) UCL	12.44
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.892	Data do not follow a Discernable Distribution (0.05)	
Theta Star	6.234		
nu star	101.7		
Approximate Chi Square Value (.05)	79.42	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	7.735
Adjusted Chi Square Value	78.91	95% Jackknife UCL	7.772
		95% Standard Bootstrap UCL	7.763
Anderson-Darling Test Statistic	2.758	95% Bootstrap-t UCL	10.51
Anderson-Darling 5% Critical Value	0.783	95% Hall's Bootstrap UCL	16.85
Kolmogorov-Smirnov Test Statistic	0.157	95% Percentile Bootstrap UCL	7.961
Kolmogorov-Smirnov 5% Critical Value	0.122	95% BCA Bootstrap UCL	8.85
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	11.32
		97.5% Chebyshev(Mean, Sd) UCL	13.82
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	18.71
95% Approximate Gamma UCL	7.12		
95% Adjusted Gamma UCL	7.166		

		Potential UCL to Use					Use 97.5% Chebyshev (Mean, Sd) UCL				13.82

12/29/2005	R1.3

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Molybdenum (mg/kg)	0.6900	2.7	69.2	13.45	33.51	2.49	33.51	1.12	4.88	124.8676	68.5

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \qquad MIN < Most\,likely < MAX$$

$$F(x) = \frac{B_x(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\,Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ *is the Beta Function and* $B_x(\alpha_1, \alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Nickel mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	289	N *	=	0.18	289	5.666426688
Z1-EU29W-401	S	REG	67.5	N *	J	0.16	67.5	4.212127598
Z1-EU29W-402	S	REG	144	N *	=	0.19	144	4.9698133
Z1-EU29W-403	S	REG	50.3	N *	=	0.16	50.3	3.918005077
Z1-EU29W-404	S	REG	57.6	N *	=	0.18	57.6	4.053522568
Z1-EU29W-405 + Dup	S	REG	93.8	N *	=	0.17	93.8	4.541164856
Z1-EU29W-406	S	REG	12	N *	=	0.16	12	2.48490665
Z1-EU29W-407	S	REG	96.2	N *	=	0.18	96.2	4.566429358
Z1-EU29W-408	S	REG	8.3	N *	=	0.18	8.3	2.116255515
Z1-EU29W-409	S	REG	203	N *	=	0.17	203	5.313205979
Z1-EU30BW-411	B	REG	297	N *	=	0.17	297	5.693732139
Z1-EU30C-444	C	REG	6.1		=	0.2	6.1	1.808288771
Z1-EU30C-445	C	REG	4.2		=	0.17	4.2	1.435084525
Z1-EU30C-446	C	REG	8.7		=	0.21	8.7	2.163323026
Z1-EU30C-447	C	REG	9		=	0.21	9	2.197224577
Z1-EU30C-448 + Dup	C	FR	7.5		=	0.19	7.5	2.014903021
Z1-EU30C-449	C	REG	6.9		=	0.2	6.9	1.931521412
Z1-EU30C-450	C	REG	8.2		=	0.2	8.2	2.104134154
Z1-EU30C-451	C	REG	7		=	0.2	7	1.945910149
Z1-EU30C-452	C	REG	5.9		=	0.2	5.9	1.774952351
Z1-EU30C-453	C	REG	8.7		=	0.21	8.7	2.163323026
Z1-EU30C-454	C	REG	17.5		=	0.2	17.5	2.862200881
Z1-EU31BW-415	B	REG	575	N *	=	0.18	575	6.354370041
Z1-EU31BW-416	B	REG	184	N *	=	0.19	184	5.214935758
Z1-EU31BW-417	B	REG	1700	N *	=	0.16	1700	7.43838353
Z1-EU31W-412	S	REG	23.9	N *	=	0.18	23.9	3.173878459
Z1-EU31W-413	S	REG	296	N *	=	0.15	296	5.690359454
Z1-EU31W-414	S	REG	84.1	N *	=	0.18	84.1	4.432006567
Z1-EU32BW-431	B	REG	65	*	=	0.17	65	4.17438727
Z1-EU32BW-432	B	REG	111	*	=	0.16	111	4.709530201
Z1-EU32BW-433 + Dup	B	REG	207	*	=	0.17	207	5.332718793
Z1-EU32BW-434	B	REG	24.5	N *	=	0.16	24.5	3.198673118
Z1-EU32C-455	C	REG	6.2		=	0.2	6.2	1.824549292
Z1-EU32C-456	C	REG	5.4		=	0.21	5.4	1.686398954
Z1-EU32MW-420	S	REG	35.8	*	=	0.17	35.8	3.577947893
Z1-EU32MW-426	S	REG	221	*	=	0.18	221	5.398162702
Z1-EU32W-418	S	REG	30.6	*	J	0.21	30.6	3.421000009
Z1-EU32W-419 + Dup	S	REG	153	*	=	0.17	153	5.030437921
Z1-EU32W-421	S	REG	172	*	=	0.18	172	5.147494477
Z1-EU32W-422	S	REG	99.4	*	=	0.16	99.4	4.599152114
Z1-EU32W-423	S	REG	275	*	=	0.17	275	5.616771098
Z1-EU32W-424	S	REG	48.9	*	=	0.18	48.9	3.889777396
Z1-EU32W-425	S	REG	70.5	*	=	0.18	70.5	4.25561271
Z1-EU32W-427	S	REG	15.8	*	=	0.17	15.8	2.76000994
Z1-EU32W-428	S	REG	19.2	*	=	0.19	19.2	2.954910279
Z1-EU32W-429	S	REG	13.8	*	=	0.17	13.8	2.624668592
Z1-EU32W-430	S	REG	19.1	*	=	0.15	19.1	2.949688335
Z1-EU33BW-443	B	REG	326	N *	=	0.17	326	5.786897381
Z1-EU33BW-444	B	REG	34.2	*	=	0.17	34.2	3.532225644
Z1-EU33C-457	C	REG	11.7		=	0.2	11.7	2.459588842
Z1-EU33W-435	S	REG	16.2	*	=	0.18	16.2	2.785011242
Z1-EU33W-436	S	REG	18.8	*	=	0.18	18.8	2.93385687
Z1-EU33W-437	S	REG	84.4	*	=	0.2	84.4	4.435567402
Z1-EU33W-438	S	REG	478	*	=	0.18	478	6.169610732
Z1-EU33W-439	S	REG	33.4	*	=	0.16	33.4	3.5085559
Z1-EU33W-440	S	REG	251	*	=	0.17	251	5.525452939
Z1-EU33W-441	S	REG	131	*	=	0.16	131	4.875197323

Number of Samples	57
Number of Detects	57
Minimum	4.2
Median	48.9
Maximum	1700
Average	127.1807
Standard Deviation	245.46609
PERT-Beta Mean	316.63333
Lognormal Mean	3.8141096
Lognormal Standard Deviation	1.477612

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Ni mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	56

Raw Statistics		**Log-transformed Statistics**	
Minimum	4.2	Minimum of Log Data	1.435
Maximum	1700	Maximum of Log Data	7.438
Mean	127.2	Mean of log Data	3.814
Median	48.9	SD of log Data	1.478
SD	245.5		
Coefficient of Variation	1.93		
Skewness	5.018		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.308	Lilliefors Test Statistic	0.106
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	181.6	95% H-UCL	220.1
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	278
95% Adjusted-CLT UCL	203.7	97.5% Chebyshev (MVUE) UCL	342
95% Modified-t UCL	185.2	99% Chebyshev (MVUE) UCL	467.7

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.579	Data appear Lognormal at 5% Significance Level	
Theta Star	219.5		
nu star	66.04		
Approximate Chi Square Value (.05)	48.34	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	180.7
Adjusted Chi Square Value	47.95	95% Jackknife UCL	181.6
		95% Standard Bootstrap UCL	181.2
Anderson-Darling Test Statistic	1.486	95% Bootstrap-t UCL	235.1
Anderson-Darling 5% Critical Value	0.806	95% Hall's Bootstrap UCL	402.5
Kolmogorov-Smirnov Test Statistic	0.129	95% Percentile Bootstrap UCL	185.1
Kolmogorov-Smirnov 5% Critical Value	0.124	95% BCA Bootstrap UCL	217.6
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	268.9
		97.5% Chebyshev(Mean, Sd) UCL	330.2
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	450.7
95% Approximate Gamma UCL	173.7		
95% Adjusted Gamma UCL	175.2		

		Potential UCL to Use								Use 95% H-UCL	220.1

Statistical Summary for Potassium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	786		=	44.4	786	6.666956792
Z1-EU29W-401	S	REG	691		=	38.5	691	6.538139824
Z1-EU29W-402	S	REG	813		=	47.1	813	6.70073111
Z1-EU29W-403	S	REG	838		=	39.3	838	6.7310181
Z1-EU29W-404	S	REG	991		=	44.4	991	6.898714534
Z1-EU29W-405 + Dup	S	FR	1940		=	40.4	1940	7.570443252
Z1-EU29W-406	S	REG	855		=	38.9	855	6.751101469
Z1-EU29W-407	S	REG	1080		=	45	1080	6.98471632
Z1-EU29W-408	S	REG	818		=	43.2	818	6.706862337
Z1-EU29W-409	S	REG	911		=	42.4	911	6.814542897
Z1-EU30BW-411	B	REG	680		=	42.6	680	6.522092798
Z1-EU30C-444	C	REG	847	E	J	3.9	847	6.741700695
Z1-EU30C-445	C	REG	914	E	=	3.5	914	6.817830571
Z1-EU30C-446	C	REG	1240	E	=	4.1	1240	7.122866659
Z1-EU30C-447	C	REG	557	E	=	4.2	557	6.32256524
Z1-EU30C-448 + Dup	C	FR	1240	E	=	3.8	1240	7.122866659
Z1-EU30C-449	C	REG	1220	E	=	4	1220	7.106606138
Z1-EU30C-450	C	REG	769	E	=	4	769	6.64509097
Z1-EU30C-451	C	REG	1200	E	=	4	1200	7.090076836
Z1-EU30C-452	C	REG	1500	E	=	4	1500	7.313220387
Z1-EU30C-453	C	REG	1180	E	=	4.2	1180	7.073269717
Z1-EU30C-454	C	REG	916	E	=	4.1	916	6.820016365
Z1-EU31BW-415	B	REG	747		=	44.3	747	6.616065185
Z1-EU31BW-416	B	REG	778		=	46	778	6.656726524
Z1-EU31BW-417	B	REG	693		=	40	693	6.541029999
Z1-EU31W-412	S	REG	867		=	43.8	867	6.765038977
Z1-EU31W-413	S	REG	535		=	38.1	535	6.282266747
Z1-EU31W-414	S	REG	880		=	45.1	880	6.779921907
Z1-EU32BW-431	B	REG	879		=	3.4	879	6.778784898
Z1-EU32BW-432	B	REG	823		=	3.1	823	6.712956201
Z1-EU32BW-433 + Dup	B	REG	1090		=	3.5	1090	6.993932975
Z1-EU32BW-434	B	REG	1130		=	39	1130	7.029972912
Z1-EU32C-455	C	REG	886	E	=	4.1	886	6.786716951
Z1-EU32C-456	C	REG	732	E	=	4.3	732	6.595780514
Z1-EU32MW-420	S	REG	589		=	42.3	589	6.378426184
Z1-EU32MW-426	S	REG	897		=	44.6	897	6.799055862
Z1-EU32W-418	S	REG	890		=	52.1	890	6.791221463
Z1-EU32W-419 + Dup	S	REG	846		=	42	846	6.74051936
Z1-EU32W-421	S	REG	778		=	44.6	778	6.656726524
Z1-EU32W-422	S	REG	777		=	40.6	777	6.65544035
Z1-EU32W-423	S	REG	951		=	41	951	6.857514063
Z1-EU32W-424	S	REG	566		=	44.6	566	6.338594078
Z1-EU32W-425	S	REG	841		=	45.2	841	6.73459166
Z1-EU32W-427	S	REG	685		=	42.3	685	6.529418838
Z1-EU32W-428	S	REG	889		=	46.5	889	6.790097236
Z1-EU32W-429	S	REG	776		=	42	776	6.65415252
Z1-EU32W-430	S	REG	482		=	3	482	6.177944114
Z1-EU33BW-443	B	REG	732		=	41.5	732	6.595780514
Z1-EU33BW-444	B	REG	628		=	3.5	628	6.442540166
Z1-EU33C-457	C	REG	1570	E	=	3.9	1570	7.358830898
Z1-EU33W-435	S	REG	905		=	3.5	905	6.807934944
Z1-EU33W-436	S	REG	637		=	3.6	637	6.456769656
Z1-EU33W-437	S	REG	813		=	4	813	6.70073111
Z1-EU33W-438	S	REG	802		=	3.5	802	6.687108608
Z1-EU33W-439	S	REG	832		=	3.3	832	6.723832441
Z1-EU33W-440	S	REG	510		=	10.1	510	6.234410726
Z1-EU33W-441	S	REG	763		=	3.2	763	6.637258031

Number of Samples	57
Number of Detects	57
Minimum	482
Median	838
Maximum	1940
Average	880.4386
Standard Deviation	262.62269
PERT-Beta Mean	962.33333
Lognormal Mean	6.7429741
Lognormal Standard Deviation	0.2690246

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

K mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	53

Raw Statistics		Log-transformed Statistics	
Minimum	482	Minimum of Log Data	6.178
Maximum	1940	Maximum of Log Data	7.57
Mean	880.4	Mean of log Data	6.743
Median	838	SD of log Data	0.269
SD	262.6		
Coefficient of Variation	0.298		
Skewness	1.694		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Lilliefors Test Statistic	0.218	Lilliefors Test Statistic	0.159
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	938.6	95% H-UCL	935.8
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	1017
95% Adjusted-CLT UCL	946	97.5% Chebyshev (MVUE) UCL	1077
95% Modified-t UCL	939.9	99% Chebyshev (MVUE) UCL	1195

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	12.82	Data do not follow a Discernable Distribution (0.05)	
Theta Star	68.69		
nu star	1461		
Approximate Chi Square Value (.05)	1373	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	937.7
Adjusted Chi Square Value	1371	95% Jackknife UCL	938.6
		95% Standard Bootstrap UCL	937.9
Anderson-Darling Test Statistic	1.24	95% Bootstrap-t UCL	951.2
Anderson-Darling 5% Critical Value	0.75	95% Hall's Bootstrap UCL	959.4
Kolmogorov-Smirnov Test Statistic	0.178	95% Percentile Bootstrap UCL	940.2
Kolmogorov-Smirnov 5% Critical Value	0.118	95% BCA Bootstrap UCL	949.5
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	1032
		97.5% Chebyshev(Mean, Sd) UCL	1098
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1227
95% Approximate Gamma UCL	936.7		
95% Adjusted Gamma UCL	938.2		

		Potential UCL to Use							Use 95% Student's-t UCL		938.6
									or 95% Modified-t UCL		939.9

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Potassium (mg/kg)	482.0000	838	1940	962.33	**1434.51**	1.49	1434.51	1.98	4.02	100046.5714	1458.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_z(\alpha_1, \alpha_2)$ is the Incomplete Beta Function

α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95 α_1 α_2 MIN MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Selenium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	0.64	B	=	0.54	0.64	-0.446287103
Z1-EU29W-401	S	REG	0.47	U	U	0.47	0.235	-1.448169765
Z1-EU29W-402	S	REG	0.57	U	U	0.57	0.285	-1.255266099
Z1-EU29W-403	S	REG	0.48	U	U	0.48	0.24	-1.427116356
Z1-EU29W-404	S	REG	0.54	U	U	0.54	0.27	-1.30933332
Z1-EU29W-405 + Dup	S	REG	0.51	U	U	0.51	0.255	-1.366491734
Z1-EU29W-406	S	REG	0.47	U	U	0.47	0.235	-1.448169765
Z1-EU29W-407	S	REG	1	B	=	0.55	1	0
Z1-EU29W-408	S	REG	0.53	U	U	0.53	0.265	-1.328025453
Z1-EU29W-409	S	REG	0.52	U	U	0.52	0.26	-1.347073648
Z1-EU30BW-411	B	REG	0.52	U	U	0.52	0.26	-1.347073648
Z1-EU30C-444	C	REG	0.59	U N	UJ	0.59	0.295	-1.220779923
Z1-EU30C-445	C	REG	0.52	U N	U	0.52	0.26	-1.347073648
Z1-EU30C-446	C	REG	0.62	U N	U	0.62	0.31	-1.171182982
Z1-EU30C-447	C	REG	0.63	U N	U	0.63	0.315	-1.15518264
Z1-EU30C-448 + Dup	C	FR	0.57	U N	U	0.57	0.285	-1.255266099
Z1-EU30C-449	C	REG	0.6	U N	U	0.6	0.3	-1.203972804
Z1-EU30C-450	C	REG	0.6	U N	U	0.6	0.3	-1.203972804
Z1-EU30C-451	C	REG	0.6	U N	U	0.6	0.3	-1.203972804
Z1-EU30C-452	C	REG	0.61	U N	U	0.61	0.305	-1.187443502
Z1-EU30C-453	C	REG	0.64	B N	=	0.64	0.64	-0.446287103
Z1-EU30C-454	C	REG	0.61	U N	U	0.61	0.305	-1.187443502
Z1-EU31BW-415	B	REG	0.54	U	U	0.54	0.27	-1.30933332
Z1-EU31BW-416	B	REG	0.56	U	U	0.56	0.28	-1.272965676
Z1-EU31BW-417	B	REG	1.1	B	=	0.49	1.1	0.09531018
Z1-EU31W-412	S	REG	0.62	B	=	0.53	0.62	-0.478035801
Z1-EU31W-413	S	REG	0.46	U	U	0.46	0.23	-1.46967597
Z1-EU31W-414	S	REG	0.55	U	U	0.55	0.275	-1.290984181
Z1-EU32BW-431	B	REG	0.51	U	U	0.51	0.255	-1.366491734
Z1-EU32BW-432	B	REG	0.47	U	U	0.47	0.235	-1.448169765
Z1-EU32BW-433 + Dup	B	FR	0.53	U	U	0.53	0.265	-1.328025453
Z1-EU32BW-434	B	REG	0.47	U	U	0.48	0.24	-1.427116356
Z1-EU32C-455	C	REG	0.61	U N	U	0.61	0.305	-1.187443502
Z1-EU32C-456	C	REG	0.64	U N	U	0.64	0.32	-1.139434283
Z1-EU32MW-420	S	REG	0.51	U	U	0.51	0.255	-1.366491734
Z1-EU32MW-426	S	REG	0.54	U	U	0.54	0.27	-1.30933332
Z1-EU32W-418	S	REG	0.63	U	U	0.63	0.315	-1.15518264
Z1-EU32W-419 + Dup	S	REG	25.7		=	0.51	25.7	3.246490992
Z1-EU32W-421	S	REG	0.54	U	U	0.54	0.27	-1.30933332
Z1-EU32W-422	S	REG	0.5	U	U	0.5	0.25	-1.386294361
Z1-EU32W-423	S	REG	0.5	U	U	0.5	0.25	-1.386294361
Z1-EU32W-424	S	REG	0.54	U	U	0.54	0.27	-1.30933332
Z1-EU32W-425	S	REG	0.55	U	U	0.55	0.275	-1.290984181
Z1-EU32W-427	S	REG	0.51	U	U	0.51	0.255	-1.366491734
Z1-EU32W-428	S	REG	0.57	U	U	0.57	0.285	-1.255266099
Z1-EU32W-429	S	REG	0.51	U	U	0.51	0.255	-1.366491734
Z1-EU32W-430	S	REG	0.46	U	U	0.46	0.23	-1.46967597
Z1-EU33BW-443	B	REG	0.51	U	U	0.51	0.255	-1.366491734
Z1-EU33BW-444	B	REG	0.72	B	=	0.52	0.72	-0.328504067
Z1-EU33C-457	C	REG	0.59	U N	U	0.59	0.295	-1.220779923
Z1-EU33W-435	S	REG	0.53	U	U	0.53	0.265	-1.328025453
Z1-EU33W-436	S	REG	0.64	B	=	0.53	0.64	-0.446287103
Z1-EU33W-437	S	REG	1.2	B	=	0.6	1.2	0.182321557
Z1-EU33W-438	S	REG	0.81	B	=	0.53	0.81	-0.210721031
Z1-EU33W-439	S	REG	0.94	B	=	0.49	0.94	-0.061875404
Z1-EU33W-440	S	REG	0.51	U	U	0.51	0.255	-1.366491734
Z1-EU33W-441	S	REG	0.69	B	=	0.48	0.69	-0.371063681

Number of Samples	57
Number of Detects	12
Minimum	0.23
Median	0.275
Maximum	25.7
Average	0.8228947
Standard Deviation	3.3621521
PERT-Beta Mean	4.505
Lognormal Mean	-1.020536
Lognormal Standard Deviation	0.7297484

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Se mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	27

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.23	Minimum of Log Data	-1.47
Maximum	25.7	Maximum of Log Data	3.246
Mean	0.823	Mean of log Data	-1.021
Median	0.275	SD of log Data	0.73
SD	3.362		
Coefficient of Variation	4.086		
Skewness	7.493		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.438	Lilliefors Test Statistic	0.354
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	1.568	95% H-UCL	0.574
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.685
95% Adjusted-CLT UCL	2.028	97.5% Chebyshev (MVUE) UCL	0.779
95% Modified-t UCL	1.641	99% Chebyshev (MVUE) UCL	0.964
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.701	Data do not follow a Discernable Distribution (0.05)	
Theta Star	1.173		
nu star	79.96		
Approximate Chi Square Value (.05)	60.36	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	1.555
Adjusted Chi Square Value	59.92	95% Jackknife UCL	1.568
		95% Standard Bootstrap UCL	1.552
Anderson-Darling Test Statistic	13.43	95% Bootstrap-t UCL	9.097
Anderson-Darling 5% Critical Value	0.794	95% Hall's Bootstrap UCL	4.628
Kolmogorov-Smirnov Test Statistic	0.401	95% Percentile Bootstrap UCL	1.709
Kolmogorov-Smirnov 5% Critical Value	0.123	95% BCA Bootstrap UCL	2.176
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	2.764
		97.5% Chebyshev(Mean, Sd) UCL	3.604
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	5.254
95% Approximate Gamma UCL	1.09		
95% Adjusted Gamma UCL	1.098		

		Potential UCL to Use						Use 95% Chebyshev (Mean, Sd) UCL			2.764

Statistical Summary for Silver mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	0.15	B	=	0.09	0.15	-1.897119985
Z1-EU29W-401	S	REG	0.12	B	=	0.08	0.12	-2.120263536
Z1-EU29W-402	S	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU29W-403	S	REG	1.2		=	0.08	1.2	0.182321557
Z1-EU29W-404	S	REG	0.43	B	=	0.09	0.43	-0.84397007
Z1-EU29W-405 + Dup	S	REG	0.09	U	U	0.09	0.045	-3.101092789
Z1-EU29W-406	S	REG	0.08	U	U	0.08	0.04	-3.218875825
Z1-EU29W-407	S	REG	0.39	B	=	0.09	0.39	-0.94160854
Z1-EU29W-408	S	REG	0.09	U	U	0.09	0.045	-3.101092789
Z1-EU29W-409	S	REG	0.09	U	U	0.09	0.045	-3.101092789
Z1-EU30BW-411	B	REG	0.57		=	0.09	0.57	-0.562118918
Z1-EU30C-444	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU30C-445	C	REG	0.09	U	U	0.09	0.045	-3.101092789
Z1-EU30C-446	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU30C-447	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU30C-448 + Dup	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU30C-449	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU30C-450	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU30C-451	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU30C-452	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU30C-453	C	REG	0.11	U	U	0.11	0.055	-2.900422094
Z1-EU30C-454	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU31BW-415	B	REG	0.91		=	0.09	0.91	-0.094310679
Z1-EU31BW-416	B	REG	0.21	B	=	0.09	0.21	-1.560647748
Z1-EU31BW-417	B	REG	0.08	U	U	0.08	0.04	-3.218875825
Z1-EU31W-412	S	REG	0.09	U	U	0.09	0.045	-3.101092789
Z1-EU31W-413	S	REG	0.17	B	=	0.08	0.17	-1.771956842
Z1-EU31W-414	S	REG	0.09	U	U	0.09	0.045	-3.101092789
Z1-EU32BW-431	B	REG	0.57		=	0.09	0.57	-0.562118918
Z1-EU32BW-432	B	REG	0.67		=	0.08	0.67	-0.400477567
Z1-EU32BW-433 + Dup	B	FR	0.09	U	U	0.09	0.045	-3.101092789
Z1-EU32BW-434	B	REG	0.08	U	U	0.08	0.04	-3.218875825
Z1-EU32C-455	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU32C-456	C	REG	0.11	U	U	0.11	0.055	-2.900422094
Z1-EU32MW-420	S	REG	0.09	B *	=	0.09	0.09	-2.407945609
Z1-EU32MW-426	S	REG	0.32	B *	=	0.09	0.32	-1.139434283
Z1-EU32W-418	S	REG	0.11	U *	UJ	0.11	0.055	-2.900422094
Z1-EU32W-419 + Dup	S	REG	0.73	*	=	0.09	0.73	-0.314710745
Z1-EU32W-421	S	REG	0.54	*	=	0.09	0.54	-0.616186139
Z1-EU32W-422	S	REG	0.49	*	=	0.08	0.49	-0.713349888
Z1-EU32W-423	S	REG	1.1	*	=	0.08	1.1	0.09531018
Z1-EU32W-424	S	REG	0.09	U *	U	0.09	0.045	-3.101092789
Z1-EU32W-425	S	REG	0.18	B *	=	0.09	0.18	-1.714798428
Z1-EU32W-427	S	REG	0.09	U *	U	0.09	0.045	-3.101092789
Z1-EU32W-428	S	REG	0.09	U *	U	0.09	0.045	-3.101092789
Z1-EU32W-429	S	REG	0.09	U *	U	0.09	0.045	-3.101092789
Z1-EU32W-430	S	REG	0.08	U	U	0.08	0.04	-3.218875825
Z1-EU33BW-443	B	REG	0.77		=	0.08	0.77	-0.261364764
Z1-EU33BW-444	B	REG	0.09	U	U	0.09	0.045	-3.101092789
Z1-EU33C-457	C	REG	0.1	U	U	0.1	0.05	-2.995732274
Z1-EU33W-435	S	REG	0.09	U	U	0.09	0.045	-3.101092789
Z1-EU33W-436	S	REG	0.09	U	U	0.09	0.045	-3.101092789
Z1-EU33W-437	S	REG	0.15	B	=	0.1	0.15	-1.897119985
Z1-EU33W-438	S	REG	0.76		=	0.09	0.76	-0.274436846
Z1-EU33W-439	S	REG	0.24	B	=	0.08	0.24	-1.427116356
Z1-EU33W-440	S	REG	1.4		=	0.08	1.4	0.336472237
Z1-EU33W-441	S	REG	0.12	B	=	0.08	0.12	-2.120263536

Number of Samples	57
Number of Detects	25
Minimum	0.04
Median	0.05
Maximum	1.4
Average	0.2427193
Standard Deviation	0.3319855
PERT-Beta Mean	0.2733333
Lognormal Mean	-2.174878
Lognormal Standard Deviation	1.1719912

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Ag mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	25

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.04	Minimum of Log Data	-3.219
Maximum	1.4	Maximum of Log Data	0.336
Mean	0.243	Mean of log Data	-2.175
Median	0.05	SD of log Data	1.172
SD	0.332		
Coefficient of Variation	1.368		
Skewness	1.87		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.293	Lilliefors Test Statistic	0.311
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.316	95% H-UCL	0.57
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.407
95% Adjusted-CLT UCL	0.327	97.5% Chebyshev (MVUE) UCL	0.487
95% Modified-t UCL	0.318	99% Chebyshev (MVUE) UCL	0.644
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.754	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.322		
nu star	86.01		
Approximate Chi Square Value (.05)	65.63	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	0.315
Adjusted Chi Square Value	65.17	95% Jackknife UCL	0.316
		95% Standard Bootstrap UCL	0.314
Anderson-Darling Test Statistic	6.033	95% Bootstrap-t UCL	0.336
Anderson-Darling 5% Critical Value	0.791	95% Hall's Bootstrap UCL	0.321
Kolmogorov-Smirnov Test Statistic	0.321	95% Percentile Bootstrap UCL	0.316
Kolmogorov-Smirnov 5% Critical Value	0.122	95% BCA Bootstrap UCL	0.322
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.434
		97.5% Chebyshev(Mean, Sd) UCL	0.517
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	0.68
95% Approximate Gamma UCL	0.318		
95% Adjusted Gamma UCL	0.32		

		Potential UCL to Use						Use 97.5% Chebyshev (Mean, Sd) UCL			0.517

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

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12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT			OUTPUT			Calculations				
	STEP 10	STEP 11	STEP 12				Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Silver (mg/kg)	0.0400	0.05	1.4	0.27	0.66	2.43	0.66	1.03	4.97	0.0453	1.4

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \qquad MIN < Most\,likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ is the Beta Function and $B_z(\alpha_1,\alpha_2)$ is the Incomplete Beta Function
α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Sodium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	21.9	E	=	1.8	21.9	3.086486637
Z1-EU29W-401	S	REG	113	E	J	1.6	113	4.727387819
Z1-EU29W-402	S	REG	34.3	E	=	1.9	34.3	3.535145354
Z1-EU29W-403	S	REG	51.5	E	=	1.6	51.5	3.941581808
Z1-EU29W-404	S	REG	30.6	E	=	1.8	30.6	3.421000009
Z1-EU29W-405 + Dup	S	FR	252	E	=	1.6	252	5.529429088
Z1-EU29W-406	S	REG	49.9	E	=	1.6	49.9	3.910021003
Z1-EU29W-407	S	REG	50.3	E	=	1.8	50.3	3.918005077
Z1-EU29W-408	S	REG	41.7	E	=	1.8	41.7	3.730501129
Z1-EU29W-409	S	REG	78.6	E	=	1.7	78.6	4.364371699
Z1-EU30BW-411	B	REG	113	E	=	1.7	113	4.727387819
Z1-EU30C-444	C	REG	257	E	J	2	257	5.549076085
Z1-EU30C-445	C	REG	311	E	=	1.7	311	5.739792912
Z1-EU30C-446	C	REG	417	E	=	2.1	417	6.033086222
Z1-EU30C-447	C	REG	166	E	=	2.1	166	5.111987788
Z1-EU30C-448 + Dup	C	FR	378	E	=	1.9	378	5.934894196
Z1-EU30C-449	C	REG	481	E	=	2	481	6.17586727
Z1-EU30C-450	C	REG	359	E	=	2	359	5.883322388
Z1-EU30C-451	C	REG	356	E	=	2	356	5.874930731
Z1-EU30C-452	C	REG	287	E	=	2	287	5.659482216
Z1-EU30C-453	C	REG	257	E	=	2.1	257	5.549076085
Z1-EU30C-454	C	REG	302	E	=	2	302	5.710427017
Z1-EU31BW-415	B	REG	34.5	E	=	1.8	34.5	3.540959324
Z1-EU31BW-416	B	REG	45.7	E	=	1.9	45.7	3.822098298
Z1-EU31BW-417	B	REG	39.3	E	=	1.6	39.3	3.671224519
Z1-EU31W-412	S	REG	70.3	E	=	1.8	70.3	4.252771799
Z1-EU31W-413	S	REG	51.9	E	=	1.5	51.9	3.94931879
Z1-EU31W-414	S	REG	31.7	E	=	1.8	31.7	3.456316681
Z1-EU32BW-431	B	REG	151	*	=	1.7	151	5.017279837
Z1-EU32BW-432	B	REG	112	*	=	1.6	112	4.718498871
Z1-EU32BW-433 + Dup	B	REG	38.9	*	=	1.7	38.9	3.660994251
Z1-EU32BW-434	B	REG	83.9	E	=	1.6	83.9	4.429625613
Z1-EU32C-455	C	REG	214	E	=	2	214	5.365976015
Z1-EU32C-456	C	REG	166	E	=	2.1	166	5.111987788
Z1-EU32MW-420	S	REG	63.1	*	=	1.7	63.1	4.14472077
Z1-EU32MW-426	S	REG	73.9	*	=	1.8	73.9	4.302712828
Z1-EU32W-418	S	REG	88.8	*	J	2.1	88.8	4.48638665
Z1-EU32W-419 + Dup	S	REG	96.5	*	=	1.7	96.5	4.569543008
Z1-EU32W-421	S	REG	80.5	*	=	1.8	80.5	4.388257184
Z1-EU32W-422	S	REG	87.2	*	=	1.6	87.2	4.468204331
Z1-EU32W-423	S	REG	95.3	*	=	1.7	95.3	4.557029811
Z1-EU32W-424	S	REG	46.7	*	U	1.8	0.9	-0.105360516
Z1-EU32W-425	S	REG	57.5	*	U	1.8	0.9	-0.105360516
Z1-EU32W-427	S	REG	49.7	*	U	1.7	0.85	-0.162518929
Z1-EU32W-428	S	REG	46.5	*	U	1.9	0.95	-0.051293294
Z1-EU32W-429	S	REG	89.6	*	=	1.7	89.6	4.49535532
Z1-EU32W-430	S	REG	27.5	*	UJ	1.5	0.75	-0.287682072
Z1-EU33BW-443	B	REG	68	E	=	1.7	68	4.219507705
Z1-EU33BW-444	B	REG	36	*	U	1.7	0.85	-0.162518929
Z1-EU33C-457	C	REG	449	E	=	2	449	6.107022888
Z1-EU33W-435	S	REG	70.5	*	=	1.8	70.5	4.25561271
Z1-EU33W-436	S	REG	32.3	*	U	1.8	0.9	-0.105360516
Z1-EU33W-437	S	REG	75.4	*	=	2	75.4	4.322807275
Z1-EU33W-438	S	REG	104	*	=	1.8	104	4.644390899
Z1-EU33W-439	S	REG	41.9	*	=	1.6	41.9	3.735285827
Z1-EU33W-440	S	REG	74.3	*	=	5.1	74.3	4.308110952
Z1-EU33W-441	S	REG	48.7	*	=	1.6	48.7	3.88567903

Number of Samples	57
Number of Detects	50
Minimum	0.75
Median	75.4
Maximum	481
Average	123.85614
Standard Deviation	126.2382
PERT-Beta Mean	130.55833
Lognormal Mean	4.0179096
Lognormal Standard Deviation	1.7522032

Goodness-of-Fit Test Statistics for Data Sets with Non-Detects

User Selected Options	
From File	P:\Waste Generator Services\EMWMF Profiles\WL 4.12\March 2009 revision\revised total metals to test c
Full Precision	OFF
Confidence Coefficient	0.9

Na mg/kg

	Num Obs	Num Miss	Num Valid	Detects	NDs	% NDs
Raw Statistics	57	0	57	50	7	12.28%

	Number	Minimum	Maximum	Mean	Median	SD
Statistics (Non-Detects Only)	7	0.75	0.95	0.871	0.9	0.0636
Statistics (Detects Only)	50	21.9	481	141.1	85.55	125.5
Statistics (All: NDs treated as DL value)	57	0.75	481	123.9	75.4	126.2
Statistics (All: NDs treated as DL/2 value)	57	0.375	481	123.8	75.4	126.3
Statistics (Normal ROS Estimated Data)	57	-170.6	481	108.4	75.4	147.1
Statistics (Gamma ROS Estimated Data)	57	1.0000E-9	481	123.7	75.4	126.3
Statistics (Lognormal ROS Estimated Data)	57	11.22	481	125.7	75.4	124.5

	K Hat	K Star	Theta Hat	Log Mean	Log Stdv	Log CV
Statistics (Detects Only)	1.578	1.506	89.42	4.6	0.832	0.181
Statistics (NDs = DL)	0.748	0.72	165.7	4.018	1.752	0.436
Statistics (NDs = DL/2)	0.684	0.66	180.9	3.933	1.96	0.498
Statistics (Gamma ROS Estimates)	0.218	0.218	567.3	--	--	--
Statistics (Lognormal ROS Estimates)	--	--	--	4.371	0.996	0.228

Normal Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Normal ROS
Correlation Coefficient R	0.896	0.903	0.903	0.958

	Test value	Crit. (0.1)	Conclusion with Alpha(0.1)
Shapiro-Wilks (Detects Only)	0.79	0.955	Data Not Normal
Lilliefors (Detects Only)	0.269	0.114	Data Not Normal
Lilliefors (NDs = DL)	0.254	0.107	Data Not Normal
Lilliefors (NDs = DL/2)	0.253	0.107	Data Not Normal
Lilliefors (Normal ROS Estimates)	0.207	0.107	Data Not Normal

Gamma Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Gamma ROS
Correlation Coefficient R	0.972	0.971	0.968	0.891

	Test value	Crit. (0.1)	Conclusion with Alpha(0.1)
Anderson-Darling (Detects Only)	1.783	0.642	
Kolmogorov-Smirnov (Detects Only)	0.179	0.117	Data Not Gamma Distributed
Anderson-Darling (NDs = DL)	1.484	0.661	
Kolmogorov-Smirnov (NDs = DL)	0.145	0.112	Data Not Gamma Distributed
Anderson-Darling (NDs = DL/2)	1.853	0.666	
Kolmogorov-Smirnov (NDs = DL/2)	0.166	0.113	Data Not Gamma Distributed

Anderson-Darling (Gamma ROS Estimates)	12.54	0.74	
Kolmogorov-Smirnov (Gamma ROS Est.)	0.433	0.119	Data Not Gamma Distributed

Lognormal Distribution Test Results

	No NDs	NDs = DL	NDs = DL/2	Log ROS
Correlation Coefficient R	0.977	0.896	0.873	0.988

	Test value	Crit. (0.1)	Conclusion with Alpha(0.1)
Shapiro-Wilks (Detects Only)	0.936	0.955	Data Not Lognormal
Lilliefors (Detects Only)	0.119	0.114	Data Not Lognormal
Lilliefors (NDs = DL)	0.226	0.107	Data Not Lognormal
Lilliefors (NDs = DL/2)	0.257	0.107	Data Not Lognormal
Lilliefors (Lognormal ROS Estimates)	0.0882	0.107	Data Appear Lognormal

Note: Substitution methods such as DL or DL/2 are not recommended.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	P:\Waste Generator Services\EMWMF Profiles\WL 4.12\March 2009 revision\revised total metals to test d
Full Precision	OFF
Confidence Coefficient	95%
Nu.. .er of Bootstrap Operations	2000

Na mg/kg

General Statistics

Number of Valid Data	57	Number of Detected Data	50
Number of Distinct Detected Data	47	Number of Non-Detect Data	7
		Percent Non-Detects	12.28%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	21.9	Minimum Detected	3.086
Maximum Detected	481	Maximum Detected	6.176
Mean of Detected	141.1	Mean of Detected	4.6
SD of Detected	125.5	SD of Detected	0.832
Minimum Non-Detect	0.75	Minimum Non-Detect	-0.288
Maximum Non-Detect	0.95	Maximum Non-Detect	-0.0513

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	7
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	50
Obs~rvations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	12.28%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Lilliefors Test Statistic	0.79	Lilliefors Test Statistic	0.936
5% Lilliefors Critical Value	0.947	5% Lilliefors Critical Value	0.947
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	123.8	Mean	3.933
SD	126.3	SD	1.96
95% DL/2 (t) UCL	151.8	95% H-Stat (DL/2) UCL	418.7
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	114.3	Mean in Log Scale	4.371
SD	138.5	SD in Log Scale	0.996
95% MLE (t) UCL	145	Mean in Original Scale	125.7
95% MLE (Tiku) UCL	144.4	SD in Original Scale	124.5
		95% Percentile Bootstrap UCL	153.8
		95% BCA Bootstrap UCL	157.2

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	1.496	Data do not follow a Discernable Distribution (0.05)
Theta Star	94.28	
nu star	149.6	

A-D Test Statistic	1.783
5% A-D Critical Value	0.767
K-S Test Statistic	0.767
5% K-S Critical Value	0.127

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data

Minimum	1.0000E-9
Maximum	481
Mean	123.7
Median	75.4
SD	126.3
k star	0.218
Theta star	566.8
Nu star	24.89
AppChi2	14.53
95% Gamma Approximate UCL	212
95% Adjusted Gamma UCL	215.1

Note: DL/2 is not a recommended method.

Nonparametric Statistics

Kaplan-Meier (KM) Method

Mean	126.4
SD	122.8
SE of Mean	16.42
95% KM (t) UCL	153.9
95% KM (z) UCL	153.5
95% KM (jackknife) UCL	153.1
95% KM (bootstrap t) UCL	157.2
95% KM (BCA) UCL	154.4
95% KM (Percentile Bootstrap) UCL	156.6
95% KM (Chebyshev) UCL	198
97.5% KM (Chebyshev) UCL	229
99% KM (Chebyshev) UCL	289.9

Potential UCLs to Use

95% KM (Chebyshev) UCL	198

Statistical Summary for Vanadium mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	35.7 *		=	0.13	35.7	3.575150689
Z1-EU29W-401	S	REG	9.5 *		=	0.11	9.5	2.251291799
Z1-EU29W-402	S	REG	37.4 *		=	0.13	37.4	3.621670704
Z1-EU29W-403	S	REG	29.9 *		=	0.11	29.9	3.39785848
Z1-EU29W-404	S	REG	30.3 *		=	0.13	30.3	3.411147713
Z1-EU29W-405 + Dup	S	REG	15.5 *		=	0.12	15.5	2.740840024
Z1-EU29W-406	S	REG	31.8 *		=	0.11	31.8	3.45946629
Z1-EU29W-407	S	REG	37.3 *		=	0.13	37.3	3.618993327
Z1-EU29W-408	S	REG	36.5 *		=	0.12	36.5	3.597312261
Z1-EU29W-409	S	REG	29.6 *		=	0.12	29.6	3.387774361
Z1-EU30BW-411	B	REG	14.8 *		=	0.12	14.8	2.694627181
Z1-EU30C-444	C	REG	8		=	0.14	8	2.079441542
Z1-EU30C-445	C	REG	10.6		=	0.12	10.6	2.360854001
Z1-EU30C-446	C	REG	12		=	0.14	12	2.48490665
Z1-EU30C-447	C	REG	13.3		=	0.15	13.3	2.587764035
Z1-EU30C-448 + Dup	C	FR	10.4		=	0.13	10.4	2.341805806
Z1-EU30C-449	C	REG	9.7		=	0.14	9.7	2.272125886
Z1-EU30C-450	C	REG	11.9		=	0.14	11.9	2.4765384
Z1-EU30C-451	C	REG	8.9		=	0.14	8.9	2.186051277
Z1-EU30C-452	C	REG	13		=	0.14	13	2.564949357
Z1-EU30C-453	C	REG	15.7		=	0.15	15.7	2.753660712
Z1-EU30C-454	C	REG	16.8		=	0.14	16.8	2.821378886
Z1-EU31BW-415	B	REG	31.5 *		=	0.13	31.5	3.449987546
Z1-EU31BW-416	B	REG	38.1 *		=	0.13	38.1	3.640214282
Z1-EU31BW-417	B	REG	52.9 *		=	0.11	52.9	3.968403339
Z1-EU31W-412	S	REG	17.1 *		=	0.12	17.1	2.839078464
Z1-EU31W-413	S	REG	18.8 *		=	0.11	18.8	2.93385687
Z1-EU31W-414	S	REG	38.2 *		=	0.13	38.2	3.642835516
Z1-EU32BW-431	B	REG	17.3		=	0.12	17.3	2.850706502
Z1-EU32BW-432	B	REG	17.3		=	0.11	17.3	2.850706502
Z1-EU32BW-433 + Dup	B	FR	27.8		=	0.12	27.8	3.325036021
Z1-EU32BW-434	B	REG	14.9 *		=	0.11	14.9	2.701361213
Z1-EU32C-455	C	REG	14.6		=	0.14	14.6	2.681021529
Z1-EU32C-456	C	REG	10.9		=	0.15	10.9	2.388762789
Z1-EU32MW-420	S	REG	22.5		=	0.12	22.5	3.113515309
Z1-EU32MW-426	S	REG	20		=	0.13	20	2.995732274
Z1-EU32W-418	S	REG	21.1		=	0.15	21.1	3.04927304
Z1-EU32W-419 + Dup	S	FR	23.5		=	0.12	23.5	3.157000421
Z1-EU32W-421	S	REG	18.4		=	0.13	18.4	2.912350665
Z1-EU32W-422	S	REG	16.6		=	0.12	16.6	2.809402695
Z1-EU32W-423	S	REG	18.1		=	0.12	18.1	2.895911938
Z1-EU32W-424	S	REG	23.3		=	0.13	23.3	3.148453361
Z1-EU32W-425	S	REG	18.2		=	0.13	18.2	2.901421594
Z1-EU32W-427	S	REG	26.8		=	0.12	26.8	3.288401888
Z1-EU32W-428	S	REG	22.1		=	0.13	22.1	3.095577609
Z1-EU32W-429	S	REG	22.9		=	0.12	22.9	3.131136911
Z1-EU32W-430	S	REG	22.1		=	0.11	22.1	3.095577609
Z1-EU33BW-443	B	REG	26 *		=	0.12	26	3.258096538
Z1-EU33BW-444	B	REG	21.8		=	0.12	21.8	3.08190997
Z1-EU33C-457	C	REG	34.8		=	0.14	34.8	3.549617387
Z1-EU33W-435	S	REG	32.8		=	0.12	32.8	3.490428515
Z1-EU33W-436	S	REG	23.2		=	0.12	23.2	3.144152279
Z1-EU33W-437	S	REG	23.7		=	0.14	23.7	3.165475048
Z1-EU33W-438	S	REG	25.4		=	0.12	25.4	3.234749174
Z1-EU33W-439	S	REG	26.3		=	0.12	26.3	3.269568939
Z1-EU33W-440	S	REG	17.9		=	0.12	17.9	2.884800713
Z1-EU33W-441	S	REG	25.1		=	0.11	25.1	3.222867846

Number of Samples	57
Number of Detects	57
Minimum	8
Median	21.8
Maximum	52.9
Average	22.291228
Standard Deviation	9.4280789
PERT-Beta Mean	24.683333
Lognormal Mean	3.0149649
Lognormal Standard Deviation	0.43374

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

V mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	55

Raw Statistics		**Log-transformed Statistics**	
Minimum	8	Minimum of Log Data	2.079
Maximum	52.9	Maximum of Log Data	3.968
Mean	22.29	Mean of log Data	3.015
Median	21.8	SD of log Data	0.434
SD	9.428		
Coefficient of Variation	0.423		
Skewness	0.76		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.101	Lilliefors Test Statistic	0.0701
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	24.38	95% H-UCL	24.9
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	28.18
95% Adjusted-CLT UCL	24.48	97.5% Chebyshev (MVUE) UCL	30.7
95% Modified-t UCL	24.4	99% Chebyshev (MVUE) UCL	35.64
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	5.473	Data appear Normal at 5% Significance Level	
Theta Star	4.073		
nu star	624		
Approximate Chi Square Value (.05)	567	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	24.35
Adjusted Chi Square Value	565.6	95% Jackknife UCL	24.38
		95% Standard Bootstrap UCL	24.29
Anderson-Darling Test Statistic	0.229	95% Bootstrap-t UCL	24.49
Anderson-Darling 5% Critical Value	0.753	95% Hall's Bootstrap UCL	24.45
Kolmogorov-Smirnov Test Statistic	0.0584	95% Percentile Bootstrap UCL	24.39
Kolmogorov-Smirnov 5% Critical Value	0.118	95% BCA Bootstrap UCL	24.33
ta appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	27.73
		97.5% Chebyshev(Mean, Sd) UCL	30.09
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	34.72
95% Approximate Gamma UCL	24.53		
95% Adjusted Gamma UCL	24.59		

		Potential UCL to Use							Use 95% Student's-t UCL		24.38

Statistical Summary for Zinc mg/kg

Location ID	Sample Lot	Sample Type	Result	Result Qualifier	Validation	Detection Limit	Proxy Value	LN Proxy Value
Z1-EU29BW-410	B	REG	181	N	=	0.54	181	5.198497031
Z1-EU29W-401	S	REG	225	N	=	0.47	225	5.416100402
Z1-EU29W-402	S	REG	161	N	=	0.57	161	5.081404365
Z1-EU29W-403	S	REG	84.9	N	=	0.48	84.9	4.441474093
Z1-EU29W-404	S	REG	233	N	=	0.54	233	5.451038454
Z1-EU29W-405 + Dup	S	REG	303	N	=	0.51	303	5.713732806
Z1-EU29W-406	S	REG	40	N	=	0.47	40	3.688879454
Z1-EU29W-407	S	REG	372	N	=	0.55	372	5.918893854
Z1-EU29W-408	S	REG	34	N	=	0.53	34	3.526360525
Z1-EU29W-409	S	REG	174	N	=	0.52	174	5.159055299
Z1-EU30BW-411	B	REG	458	N	=	0.52	458	6.126869184
Z1-EU30C-444	C	REG	52	N	J	0.59	52	3.951243719
Z1-EU30C-445	C	REG	9.3	N	=	0.52	9.3	2.2300144
Z1-EU30C-446	C	REG	26.1	N	=	0.62	26.1	3.261935314
Z1-EU30C-447	C	REG	20.4	N	=	0.63	20.4	3.015534901
Z1-EU30C-448 + Dup	C	FR	58.1	N	=	0.57	58.1	4.062165664
Z1-EU30C-449	C	REG	68.5	N	=	0.6	68.5	4.226833745
Z1-EU30C-450	C	REG	13.5	N	=	0.6	13.5	2.602689685
Z1-EU30C-451	C	REG	51.7	N	=	0.6	51.7	3.945457782
Z1-EU30C-452	C	REG	22.7	N	=	0.61	22.7	3.122364924
Z1-EU30C-453	C	REG	41.3	N	=	0.64	41.3	3.7208625
Z1-EU30C-454	C	REG	17.3	N	=	0.61	17.3	2.850706502
Z1-EU31BW-415	B	REG	95.9	N	=	0.54	95.9	4.563305982
Z1-EU31BW-416	B	REG	138	N	=	0.56	138	4.927253685
Z1-EU31BW-417	B	REG	218	N	=	0.49	218	5.384495063
Z1-EU31W-412	S	REG	80.7	N	=	0.53	80.7	4.390738575
Z1-EU31W-413	S	REG	234	N	=	0.46	234	5.455321115
Z1-EU31W-414	S	REG	110	N	=	0.55	110	4.700480366
Z1-EU32BW-431	B	REG	286	N	=	0.51	286	5.655991811
Z1-EU32BW-432	B	REG	318	N	=	0.47	318	5.762051383
Z1-EU32BW-433 + Dup	B	REG	170	N	=	0.52	170	5.135798437
Z1-EU32BW-434	B	REG	73.7	N	=	0.48	73.7	4.300002799
Z1-EU32C-455	C	REG	15.4	N	=	0.61	15.4	2.734367509
Z1-EU32C-456	C	REG	13.1	N	=	0.64	13.1	2.57261223
Z1-EU32MW-420	S	REG	137	N	=	0.51	137	4.919980926
Z1-EU32MW-426	S	REG	231	N	=	0.54	231	5.442417711
Z1-EU32W-418	S	REG	88.8	N	J	0.63	88.8	4.48638665
Z1-EU32W-419 + Dup	S	REG	350	N	=	0.51	350	5.857933154
Z1-EU32W-421	S	REG	345	N	=	0.54	345	5.843544417
Z1-EU32W-422	S	REG	315	N	=	0.5	315	5.752572639
Z1-EU32W-423	S	REG	348	N	=	0.5	348	5.85220248
Z1-EU32W-424	S	REG	41.1	N	=	0.54	41.1	3.716008122
Z1-EU32W-425	S	REG	168	N	=	0.55	168	5.123963979
Z1-EU32W-427	S	REG	46.2	N	=	0.51	46.2	3.832979798
Z1-EU32W-428	S	REG	60.6	N	=	0.57	60.6	4.104294893
Z1-EU32W-429	S	REG	80.2	N	=	0.51	80.2	4.384523515
Z1-EU32W-430	S	REG	57.6	N	J	0.46	57.6	4.053522568
Z1-EU33BW-443	B	REG	902	N	=	1.5	902	6.80461452
Z1-EU33BW-444	B	REG	125	N	=	0.52	125	4.828313737
Z1-EU33C-457	C	REG	26.4	N	=	0.59	26.4	3.27336401
Z1-EU33W-435	S	REG	66.9	N	=	0.53	66.9	4.203198967
Z1-EU33W-436	S	REG	63.3	N	=	0.53	63.3	4.147885329
Z1-EU33W-437	S	REG	530	N	=	0.6	530	6.272877007
Z1-EU33W-438	S	REG	1040	N	=	1.6	1040	6.946975992
Z1-EU33W-439	S	REG	344	N	=	0.49	344	5.840641657
Z1-EU33W-440	S	REG	514	N	=	0.51	514	6.242223265
Z1-EU33W-441	S	REG	334	N	=	0.48	334	5.811140993

Number of Samples	57
Number of Detects	57
Minimum	9.3
Median	110
Maximum	1040
Average	186.20526
Standard Deviation	204.1501
PERT-Beta Mean	248.21667
Lognormal Mean	4.6673
Lognormal Standard Deviation	1.1388204

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Zn mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	57

Raw Statistics		**Log-transformed Statistics**	
Minimum	9.3	Minimum of Log Data	2.23
Maximum	1040	Maximum of Log Data	6.947
Mean	186.2	Mean of log Data	4.667
Median	110	SD of log Data	1.139
SD	204.2		
Coefficient of Variation	1.096		
Skewness	2.255		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.193	Lilliefors Test Statistic	0.0865
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	231.4	95% H-UCL	571.6
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	360.8
95% Adjusted-CLT UCL	239.3	97.5% Chebyshev (MVUE) UCL	430.5
95% Modified-t UCL	232.8	99% Chebyshev (MVUE) UCL	567.3

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.986	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	188.9		
nu star	112.4		
Approximate Chi Square Value (.05)	88.91	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	230.7
Adjusted Chi Square Value	88.37	95% Jackknife UCL	231.4
		95% Standard Bootstrap UCL	231
Anderson-Darling Test Statistic	0.526	95% Bootstrap-t UCL	245
Anderson-Darling 5% Critical Value	0.779	95% Hall's Bootstrap UCL	250.9
Kolmogorov-Smirnov Test Statistic	0.0997	95% Percentile Bootstrap UCL	233.4
Kolmogorov-Smirnov 5% Critical Value	0.121	95% BCA Bootstrap UCL	241.9
·ta appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	304.1
		97.5% Chebyshev(Mean, Sd) UCL	355.1
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	455.3
95% Approximate Gamma UCL	235.4		
95% Adjusted Gamma UCL	236.8		

		Potential UCL to Use						Use 95% Approximate Gamma UCL			235.4

Statistical Summary for PCB-1248 mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
Z1-EU29BW-410	B	REG	320	U	UJ	320	0.16	-1.832581464
Z1-EU29W-401	S	REG	110		=	58	0.11	-2.207274913
Z1-EU29W-402	S	REG	80	U	U	80	0.04	-3.218875825
Z1-EU29W-403	S	REG	86		=	30	0.086	-2.453407983
Z1-EU29W-404	S	REG	2000		=	160	2	0.693147181
Z1-EU29W-405 + Dup	S	FR	980		J	74	0.98	-0.020202707
Z1-EU29W-406	S	REG	16	U	U	16	0.008	-4.828313737
Z1-EU29W-407	S	REG	700		=	64	0.7	-0.356674944
Z1-EU29W-408	S	REG	16	U	U	16	0.008	-4.828313737
Z1-EU29W-409	S	REG	150	U	U	150	0.075	-2.590267165
Z1-EU30BW-411	B	REG	2300		J	760	2.3	0.832909123
Z1-EU30C-444	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-445	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-446	C	REG	150	U	U	150	0.075	-2.590267165
Z1-EU30C-447	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-448 + Dup	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-449	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-450	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-451	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-452	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-453	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-454	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU31BW-415	B	REG	210		=	32	0.21	-1.560647748
Z1-EU31BW-416	B	REG	610		J	80	0.61	-0.494296322
Z1-EU31BW-417	B	REG	600		=	81	0.6	-0.510825624
Z1-EU31W-412	S	REG	16	U	U	16	0.008	-4.828313737
Z1-EU31W-413	S	REG	32	U	U	32	0.016	-4.135166557
Z1-EU31W-414	S	REG	16	U	U	16	0.008	-4.828313737
Z1-EU32BW-431	B	REG	9900		=	810	9.9	2.292534757
Z1-EU32BW-432	B	REG	3600		=	370	3.6	1.280933845
Z1-EU32BW-433 + Dup	B	REG	390	U	U	390	0.195	-1.63475572
Z1-EU32BW-434	B	REG	15	U	U	15	0.0075	-4.892852258
Z1-EU32C-455	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU32C-456	C	REG	150	U	U	150	0.075	-2.590267165
Z1-EU32MW-420	S	REG	2500		=	150	2.5	0.916290732
Z1-EU32MW-426	S	REG	3700		=	300	3.7	1.30833282
Z1-EU32W-418	S	REG	2800		=	160	2.8	1.029619417
Z1-EU32W-419 + Dup	S	FR	8500		=	1400	8.5	2.140066163
Z1-EU32W-421	S	REG	13000		=	1200	13	2.564949357
Z1-EU32W-422	S	REG	7100		=	720	7.1	1.960094784
Z1-EU32W-423	S	REG	7800		=	1400	7.8	2.054123734
Z1-EU32W-424	S	REG	87		=	15	0.087	-2.44184716
Z1-EU32W-425	S	REG	2000		=	300	2	0.693147181
Z1-EU32W-427	S	REG	60		=	15	0.06	-2.813410717
Z1-EU32W-428	S	REG	54		=	15	0.054	-2.918771232
Z1-EU32W-429	S	REG	30		=	15	0.03	-3.506557897
Z1-EU32W-430	S	REG	460		=	73	0.46	-0.776528789
Z1-EU33BW-443	B	REG	7600		J	620	7.6	2.028148247
Z1-EU33BW-444	B	REG	2500		=	300	2.5	0.916290732
Z1-EU33C-457	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU33W-435	S	REG	78		=	16	0.078	-2.551046452
Z1-EU33W-436	S	REG	200		=	30	0.2	-1.609437912
Z1-EU33W-437	S	REG	3500		=	410	3.5	1.252762968
Z1-EU33W-438	S	REG	5100		=	610	5.1	1.62924054
Z1-EU33W-439	S	REG	3900		=	380	3.9	1.360976553
Z1-EU33W-440	S	REG	4700		=	580	4.7	1.547562509
Z1-EU33W-441	S	REG	2400		=	300	2.4	0.875468737

Number of Samples	57
Number of Detects	32
Minimum	0.0075
Median	0.11
Maximum	13
Average	1.7663246
Standard Deviation	2.9114791
PERT-Beta Mean	2.24125
Lognormal Mean	-1.255329
Lognormal Standard Deviation	2.194857

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

PCB-1248 mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	39

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.0075	Minimum of Log Data	-4.893
Maximum	13	Maximum of Log Data	2.565
Mean	1.766	Mean of log Data	-1.255
Median	0.11	SD of log Data	2.195
SD	2.911		
Coefficient of Variation	1.648		
Skewness	2.067		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.292	Lilliefors Test Statistic	0.197
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	2.411	95% H-UCL	8.857
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	8.187
95% Adjusted-CLT UCL	2.513	97.5% Chebyshev (MVUE) UCL	10.53
95% Modified-t UCL	2.429	99% Chebyshev (MVUE) UCL	15.12
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.358	Data do not follow a Discernable Distribution (0.05)	
Theta Star	4.929		
nu star	40.86		
Approximate Chi Square Value (.05)	27.21	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	2.401
Adjusted Chi Square Value	26.92	95% Jackknife UCL	2.411
		95% Standard Bootstrap UCL	2.386
Anderson-Darling Test Statistic	3.111	95% Bootstrap-t UCL	2.533
Anderson-Darling 5% Critical Value	0.847	95% Hall's Bootstrap UCL	2.531
Kolmogorov-Smirnov Test Statistic	0.234	95% Percentile Bootstrap UCL	2.433
Kolmogorov-Smirnov 5% Critical Value	0.127	95% BCA Bootstrap UCL	2.562
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	3.447
		97.5% Chebyshev(Mean, Sd) UCL	4.175
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	5.603
95% Approximate Gamma UCL	2.652		
95% Adjusted Gamma UCL	2.681		

		Potential UCL to Use						Use 99% Chebyshev (Mean, Sd) UCL			5.603

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
PCB-1248 (mg/kg)	7.50E-03	1.10E-01	1.30E+01	2.24E+00	5.96E+00	2.66	5.96	1.03	4.97	4.1460	13.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \quad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ *is the Beta Function and* $B_z(\alpha_1,\alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for PCB-1254 mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
Z1-EU29BW-410	B	REG	2100		J	320	2.1	0.741937345
Z1-EU29W-401	S	REG	440		=	58	0.44	-0.820980552
Z1-EU29W-402	S	REG	880		=	80	0.88	-0.127833372
Z1-EU29W-403	S	REG	280		=	30	0.28	-1.272965676
Z1-EU29W-404	S	REG	1800		=	160	1.8	0.587786665
Z1-EU29W-405 + Dup	S	FR	820		J	74	0.82	-0.198450939
Z1-EU29W-406	S	REG	26		=	16	0.026	-3.649658741
Z1-EU29W-407	S	REG	1000		=	64	1	0
Z1-EU29W-408	S	REG	16	U	U	16	0.008	-4.828313737
Z1-EU29W-409	S	REG	810		=	150	0.81	-0.210721031
Z1-EU30BW-411	B	REG	4600		J	760	4.6	1.526056303
Z1-EU30C-444	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-445	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-446	C	REG	150	U	U	150	0.075	-2.590267165
Z1-EU30C-447	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-448 + Dup	C	FR	49	J	J	140	0.049	-3.015934981
Z1-EU30C-449	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-450	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-451	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-452	C	REG	43	J	J	140	0.043	-3.146555163
Z1-EU30C-453	C	REG	110	J	J	140	0.11	-2.207274913
Z1-EU30C-454	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU31BW-415	B	REG	170		=	32	0.17	-1.771956842
Z1-EU31BW-416	B	REG	940		J	80	0.94	-0.061875404
Z1-EU31BW-417	B	REG	540		=	81	0.54	-0.616186139
Z1-EU31W-412	S	REG	40		=	16	0.04	-3.218875825
Z1-EU31W-413	S	REG	390		=	32	0.39	-0.94160854
Z1-EU31W-414	S	REG	130		=	16	0.13	-2.040220829
Z1-EU32BW-431	B	REG	7300		=	810	7.3	1.987874348
Z1-EU32BW-432	B	REG	2800		=	370	2.8	1.029619417
Z1-EU32BW-433 + Dup	B	FR	550		J	390	0.55	-0.597837001
Z1-EU32BW-434	B	REG	21		=	15	0.021	-3.863232841
Z1-EU32C-455	C	REG	190		=	140	0.19	-1.660731207
Z1-EU32C-456	C	REG	150	U	U	150	0.075	-2.590267165
Z1-EU32MW-420	S	REG	1500		=	150	1.5	0.405465108
Z1-EU32MW-426	S	REG	3700		=	300	3.7	1.30833282
Z1-EU32W-418	S	REG	1400		=	160	1.4	0.336472237
Z1-EU32W-419 + Dup	S	FR	5300		=	1400	5.3	1.667706821
Z1-EU32W-421	S	REG	6600		=	1200	6.6	1.887069649
Z1-EU32W-422	S	REG	4900		=	720	4.9	1.589235205
Z1-EU32W-423	S	REG	6000		=	1400	6	1.791759469
Z1-EU32W-424	S	REG	45		=	15	0.045	-3.101092789
Z1-EU32W-425	S	REG	990		=	300	0.99	-0.010050336
Z1-EU32W-427	S	REG	59		=	15	0.059	-2.830217835
Z1-EU32W-428	S	REG	94		=	15	0.094	-2.364460497
Z1-EU32W-429	S	REG	18		=	15	0.018	-4.017383521
Z1-EU32W-430	S	REG	270		=	73	0.27	-1.30933332
Z1-EU33BW-443	B	REG	2200		J	620	2.2	0.78845736
Z1-EU33BW-444	B	REG	2200		=	300	2.2	0.78845736
Z1-EU33C-457	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU33W-435	S	REG	88		=	16	0.088	-2.430418465
Z1-EU33W-436	S	REG	130		=	30	0.13	-2.040220829
Z1-EU33W-437	S	REG	3400		=	410	3.4	1.223775432
Z1-EU33W-438	S	REG	3000		=	610	3	1.098612289
Z1-EU33W-439	S	REG	1800		=	380	1.8	0.587786665
Z1-EU33W-440	S	REG	4200		=	580	4.2	1.435084525
Z1-EU33W-441	S	REG	2100		=	300	2.1	0.741937345

Number of Samples	57
Number of Detects	46
Minimum	0.008
Median	0.39
Maximum	7.3
Average	1.3463333
Standard Deviation	1.8801573
PERT-Beta Mean	1.478
Lognormal Mean	-1.00501
Lognormal Standard Deviation	1.8547127

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

PCB-1254 mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	45

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.008	Minimum of Log Data	-4.828
Maximum	7.3	Maximum of Log Data	1.988
Mean	1.346	Mean of log Data	-1.005
Median	0.39	SD of log Data	1.855
SD	1.88		
Coefficient of Variation	1.397		
Skewness	1.652		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.24	Lilliefors Test Statistic	0.137
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	1.763	95% H-UCL	4.416
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	4.83
95% Adjusted-CLT UCL	1.814	97.5% Chebyshev (MVUE) UCL	6.101
95% Modified-t UCL	1.772	99% Chebyshev (MVUE) UCL	8.596

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.475	Data do not follow a Discernable Distribution (0.05)	
Theta Star	2.833		
nu star	54.18		
Approximate Chi Square Value (.05)	38.27	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	1.756
Adjusted Chi Square Value	37.92	95% Jackknife UCL	1.763
		95% Standard Bootstrap UCL	1.745
Anderson-Darling Test Statistic	1.767	95% Bootstrap-t UCL	1.854
Anderson-Darling 5% Critical Value	0.818	95% Hall's Bootstrap UCL	1.792
Kolmogorov-Smirnov Test Statistic	0.171	95% Percentile Bootstrap UCL	1.771
Kolmogorov-Smirnov 5% Critical Value	0.125	95% BCA Bootstrap UCL	1.841
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	2.432
		97.5% Chebyshev(Mean, Sd) UCL	2.902
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	3.824
95% Approximate Gamma UCL	1.906		
95% Adjusted Gamma UCL	1.924		

		Potential UCL to Use					Use 97.5% Chebyshev (Mean, Sd) UCL				2.902

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
PCB-1254 (mg/kg)	8.00E-03	3.90E-01	7.30E+00	1.48E+00	**3.66E+00**	2.47	3.66	1.21	4.79	1.5313	7.3

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ *is the Beta Function and* $B_z(\alpha_1,\alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95 α_1 α_2 MIN MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for PCB-1260 mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
Z1-EU29BW-410	B	REG	660		J	320	0.66	-0.415515444
Z1-EU29W-401	S	REG	490		J	58	0.49	-0.713349888
Z1-EU29W-402	S	REG	340		=	80	0.34	-1.078809661
Z1-EU29W-403	S	REG	110		=	30	0.11	-2.207274913
Z1-EU29W-404	S	REG	550		=	160	0.55	-0.597837001
Z1-EU29W-405 + Dup	S	FR	440		J	74	0.44	-0.820980552
Z1-EU29W-406	S	REG	7.7	J	J	16	0.0077	-4.86653495
Z1-EU29W-407	S	REG	370		=	64	0.37	-0.994252273
Z1-EU29W-408	S	REG	16	U	U	16	0.008	-4.828313737
Z1-EU29W-409	S	REG	350		=	150	0.35	-1.049822124
Z1-EU30BW-411	B	REG	1900		J	760	1.9	0.641853886
Z1-EU30C-444	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-445	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-446	C	REG	150	U	U	150	0.075	-2.590267165
Z1-EU30C-447	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-448 + Dup	C	FR	70	J	J	140	0.07	-2.659260037
Z1-EU30C-449	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-450	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-451	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-452	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU30C-453	C	REG	47	J	J	140	0.047	-3.057607677
Z1-EU30C-454	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU31BW-415	B	REG	77		=	32	0.077	-2.563949857
Z1-EU31BW-416	B	REG	360		J	80	0.36	-1.021651248
Z1-EU31BW-417	B	REG	360		=	81	0.36	-1.021651248
Z1-EU31W-412	S	REG	28		=	16	0.028	-3.575550769
Z1-EU31W-413	S	REG	200		=	32	0.2	-1.609437912
Z1-EU31W-414	S	REG	120		=	16	0.12	-2.120263536
Z1-EU32BW-431	B	REG	2100		=	810	2.1	0.741937345
Z1-EU32BW-432	B	REG	830		=	370	0.83	-0.186329578
Z1-EU32BW-433 + Dup	B	REG	390	U	U	390	0.195	-1.63475572
Z1-EU32BW-434	B	REG	14	J	J	15	0.014	-4.268697949
Z1-EU32C-455	C	REG	340		=	140	0.34	-1.078809661
Z1-EU32C-456	C	REG	150	U	U	150	0.075	-2.590267165
Z1-EU32MW-420	S	REG	660		=	150	0.66	-0.415515444
Z1-EU32MW-426	S	REG	1600		=	300	1.6	0.470003629
Z1-EU32W-418	S	REG	660		=	160	0.66	-0.415515444
Z1-EU32W-419 + Dup	S	FR	1500		=	1400	1.5	0.405465108
Z1-EU32W-421	S	REG	2800		=	1200	2.8	1.029619417
Z1-EU32W-422	S	REG	1300		=	720	1.3	0.262364264
Z1-EU32W-423	S	REG	2000		=	1400	2	0.693147181
Z1-EU32W-424	S	REG	20		=	15	0.02	-3.912023005
Z1-EU32W-425	S	REG	520		=	300	0.52	-0.653926467
Z1-EU32W-427	S	REG	49		=	15	0.049	-3.015934981
Z1-EU32W-428	S	REG	41		=	15	0.041	-3.194183212
Z1-EU32W-429	S	REG	6.4	J	J	15	0.0064	-5.051457289
Z1-EU32W-430	S	REG	61	J	UJ	73	0.0365	-3.310443018
Z1-EU33BW-443	B	REG	1000		J	620	1	0
Z1-EU33BW-444	B	REG	790		=	300	0.79	-0.235722334
Z1-EU33C-457	C	REG	140	U	U	140	0.07	-2.659260037
Z1-EU33W-435	S	REG	37		=	16	0.037	-3.296837366
Z1-EU33W-436	S	REG	45		=	30	0.045	-3.101092789
Z1-EU33W-437	S	REG	920		=	410	0.92	-0.083381609
Z1-EU33W-438	S	REG	870		=	610	0.87	-0.139262067
Z1-EU33W-439	S	REG	390		=	380	0.39	-0.94160854
Z1-EU33W-440	S	REG	970		=	580	0.97	-0.030459207
Z1-EU33W-441	S	REG	770		=	300	0.77	-0.261364764

Number of Samples	57
Number of Detects	43
Minimum	0.0064
Median	0.2
Maximum	2.8
Average	0.4865193
Standard Deviation	0.6227346
PERT-Beta Mean	0.6010667
Lognormal Mean	-1.67191
Lognormal Standard Deviation	1.5694963

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

PCB-1260 mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	43

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.0064	Minimum of Log Data	-5.051
Maximum	2.8	Maximum of Log Data	1.03
Mean	0.487	Mean of log Data	-1.672
Median	0.2	SD of log Data	1.569
SD	0.623		
Coefficient of Variation	1.28		
Skewness	1.845		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.22	Lilliefors Test Statistic	0.154
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.624	95% H-UCL	1.148
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	1.375
95% Adjusted-CLT UCL	0.644	97.5% Chebyshev (MVUE) UCL	1.703
95% Modified-t UCL	0.628	99% Chebyshev (MVUE) UCL	2.349
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.621	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.784		
nu star	70.77		
Approximate Chi Square Value (.05)	52.4	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	0.622
Adjusted Chi Square Value	51.99	95% Jackknife UCL	0.624
		95% Standard Bootstrap UCL	0.62
Anderson-Darling Test Statistic	1.214	95% Bootstrap-t UCL	0.656
Anderson-Darling 5% Critical Value	0.802	95% Hall's Bootstrap UCL	0.651
Kolmogorov-Smirnov Test Statistic	0.193	95% Percentile Bootstrap UCL	0.627
Kolmogorov-Smirnov 5% Critical Value	0.123	95% BCA Bootstrap UCL	0.651
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.846
		97.5% Chebyshev(Mean, Sd) UCL	1.002
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1.307
95% Approximate Gamma UCL	0.657		
95% Adjusted Gamma UCL	0.662		

		Potential UCL to Use					Use 97.5% Chebyshev (Mean, Sd) UCL				1.002

12/29/2005	R1.3

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
PCB-1260 (mg/kg)	6.40E-03	2.00E-01	2.80E+00	6.01E-01	1.45E+00	2.41	1.45	1.28	4.72	0.2373	2.8

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ *is the Beta Function and* $B_z(\alpha_1, \alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for Total PCBs mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
Z1-EU29BW-410	B	REG	2800		J	950	2.8	1.029619417
Z1-EU29W-401	S	REG	1000		J	170	1	0
Z1-EU29W-402	S	REG	1200		=	240	1.2	0.182321557
Z1-EU29W-403	S	REG	490		=	91	0.49	-0.713349888
Z1-EU29W-404	S	REG	4400		=	470	4.4	1.481604541
Z1-EU29W-405 + Dup	S	FR	2200		J	220	2.2	0.78845736
Z1-EU29W-406	S	REG	33	J	J	48	0.033	-3.411247718
Z1-EU29W-407	S	REG	2100		=	190	2.1	0.741937345
Z1-EU29W-408	S	REG	48	U	U	48	0.024	-3.729701449
Z1-EU29W-409	S	REG	1200		=	450	1.2	0.182321557
Z1-EU30BW-411	B	REG	8700		J	2300	8.7	2.163323026
Z1-EU30C-444	C	REG	430	U	U	430	0.215	-1.537117251
Z1-EU30C-445	C	REG	420	U	U	420	0.21	-1.560647748
Z1-EU30C-446	C	REG	440	U	U	440	0.22	-1.514127733
Z1-EU30C-447	C	REG	430	U	U	430	0.215	-1.537117251
Z1-EU30C-448 + Dup	C	FR	120	J	J	420	0.12	-2.120263536
Z1-EU30C-449	C	REG	420	U	U	420	0.21	-1.560647748
Z1-EU30C-450	C	REG	430	U	U	430	0.215	-1.537117251
Z1-EU30C-451	C	REG	410	U	U	410	0.205	-1.5847453
Z1-EU30C-452	C	REG	43	J	J	430	0.043	-3.146555163
Z1-EU30C-453	C	REG	160	J	J	430	0.16	-1.832581464
Z1-EU30C-454	C	REG	430	U	U	430	0.215	-1.537117251
Z1-EU31BW-415	B	REG	450		=	95	0.45	-0.798507696
Z1-EU31BW-416	B	REG	1900		J	240	1.9	0.641853886
Z1-EU31BW-417	B	REG	1500		=	240	1.5	0.405465108
Z1-EU31W-412	S	REG	68		=	47	0.068	-2.688247574
Z1-EU31W-413	S	REG	590		=	95	0.59	-0.527632742
Z1-EU31W-414	S	REG	250		=	48	0.25	-1.386294361
Z1-EU32BW-431	B	REG	19000		=	2400	19	2.944438979
Z1-EU32BW-432	B	REG	7200		=	1100	7.2	1.974081026
Z1-EU32BW-433 + Dup	B	FR	550	J	J	1200	0.55	-0.597837001
Z1-EU32BW-434	B	REG	35	J	J	45	0.035	-3.352407217
Z1-EU32C-455	C	REG	530		=	430	0.53	-0.634878272
Z1-EU32C-456	C	REG	460	U	U	460	0.23	-1.46967597
Z1-EU32MW-420	S	REG	4600		=	450	4.6	1.526056303
Z1-EU32MW-426	S	REG	8900		=	910	8.9	2.186051277
Z1-EU32W-418	S	REG	4900		=	490	4.9	1.589235205
Z1-EU32W-419 + Dup	S	FR	15000		=	4300	15	2.708050201
Z1-EU32W-421	S	REG	23000		=	3600	23	3.135494216
Z1-EU32W-422	S	REG	13000		=	2200	13	2.564949357
Z1-EU32W-423	S	REG	16000		=	4300	16	2.772588722
Z1-EU32W-424	S	REG	150		=	46	0.15	-1.897119985
Z1-EU32W-425	S	REG	3500		=	900	3.5	1.252762968
Z1-EU32W-427	S	REG	170		=	45	0.17	-1.771956842
Z1-EU32W-428	S	REG	190		=	45	0.19	-1.660731207
Z1-EU32W-429	S	REG	54		J	46	0.054	-2.918771232
Z1-EU32W-430	S	REG	800		=	220	0.8	-0.223143551
Z1-EU33BW-443	B	REG	11000		J	1900	11	2.397895273
Z1-EU33BW-444	B	REG	5500		=	890	5.5	1.704748092
Z1-EU33C-457	C	REG	420	U	U	420	0.21	-1.560647748
Z1-EU33W-435	S	REG	200		=	47	0.2	-1.609437912
Z1-EU33W-436	S	REG	380		=	89	0.38	-0.967584026
Z1-EU33W-437	S	REG	7900		=	1200	7.9	2.066862759
Z1-EU33W-438	S	REG	9000		=	1800	9	2.197224577
Z1-EU33W-439	S	REG	6100		=	1100	6.1	1.808288771
Z1-EU33W-440	S	REG	9800		=	1800	9.8	2.282382386
Z1-EU33W-441	S	REG	5300		=	910	5.3	1.667706821

Number of Samples	57
Number of Detects	46
Minimum	0.024
Median	0.59
Maximum	23
Average	3.5812632
Standard Deviation	5.3086198
PERT-Beta Mean	4.2306667
Lognormal Mean	-0.122658
Lognormal Standard Deviation	1.9100208

Statistical Summary for Total PCBs mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
EU29BW-410	B	REG	2800		J	950	2.8	1.029619417
EU29W-401	S	REG	1000		J	170	1	0
EU29W-402	S	REG	1200		=	240	1.2	0.182321557
EU29W-403	S	REG	490		=	91	0.49	-0.713349888
EU29W-404	S	REG	4400		=	470	4.4	1.481604541
EU29W-405 + Dup	S	FR	2200		J	220	2.2	0.78845736
EU29W-406	S	REG	33 J		J	48	0.033	-3.411247718
EU29W-407	S	REG	2100		=	190	2.1	0.741937345
EU29W-408	S	REG	48 U		U	48	0.024	-3.729701449
EU29W-409	S	REG	1200		=	450	1.2	0.182321557
EU30BW-411	B	REG	8700		J	2300	8.7	2.163323026
EU30C-444	C	REG	430 U		U	430	0.215	-1.537117251
EU30C-445	C	REG	420 U		U	420	0.21	-1.560647748
EU30C-446	C	REG	440 U		U	440	0.22	-1.514127733
EU30C-447	C	REG	430 U		U	430	0.215	-1.537117251
EU30C-448 + Dup	C	FR	120 J		J	420	0.12	-2.120263536
EU30C-449	C	REG	420 U		U	420	0.21	-1.560647748
EU30C-450	C	REG	430 U		U	430	0.215	-1.537117251
EU30C-451	C	REG	410 U		U	410	0.205	-1.5847453
EU30C-452	C	REG	43 J		J	430	0.043	-3.146555163
EU30C-453	C	REG	160 J		J	430	0.16	-1.832581464
EU30C-454	C	REG	430 U		U	430	0.215	-1.537117251
EU31BW-415	B	REG	450		=	95	0.45	-0.798507696
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EU31BW-417	B	REG	1500		=	240	1.5	0.405465108
EU31W-412	S	REG	68		=	47	0.068	-2.688247574
EU31W-413	S	REG	590		=	95	0.59	-0.527632742
EU31W-414	S	REG	250		=	48	0.25	-1.386294361
EU32BW-431	B	REG	19000		=	2400	19	2.944438979
EU32BW-432	B	REG	7200		=	1100	7.2	1.974081026
EU32BW-433 + Dup	B	FR	550 J		J	1200	0.55	-0.597837001
EU32BW-434	B	REG	35 J		J	45	0.035	-3.352407217
EU32C-455	C	REG	530		=	430	0.53	-0.634878272
EU32C-456	C	REG	460 U		U	460	0.23	-1.46967597
EU32MW-420	S	REG	4600		=	450	4.6	1.526056303
EU32MW-426	S	REG	8900		=	910	8.9	2.186051277
EU32W-418	S	REG	4900		=	490	4.9	1.589235205
EU32W-419 + Dup	S	FR	15000		=	4300	15	2.708050201
EU32W-421	S	REG	23000		=	3600	23	3.135494216
EU32W-422	S	REG	13000		=	2200	13	2.564949357
EU32W-423	S	REG	16000		=	4300	16	2.772588722
EU32W-424	S	REG	150		=	46	0.15	-1.897119985
EU32W-425	S	REG	3500		=	900	3.5	1.252762968
EU32W-427	S	REG	170		=	45	0.17	-1.771956842
EU32W-428	S	REG	190		=	45	0.19	-1.660731207
EU32W-429	S	REG	54		J	46	0.054	-2.918771232
EU32W-430	S	REG	800		=	220	0.8	-0.223143551
EU33BW-443	B	REG	11000		J	1900	11	2.397895273
EU33BW-444	B	REG	5500		=	890	5.5	1.704748092
EU33C-457	C	REG	420 U		U	420	0.21	-1.560647748
EU33W-435	S	REG	200		=	47	0.2	-1.609437912
EU33W-436	S	REG	380		=	89	0.38	-0.967584026
EU33W-437	S	REG	7900		=	1200	7.9	2.066862759
EU33W-438	S	REG	9000		=	1800	9	2.197224577
EU33W-439	S	REG	6100		=	1100	6.1	1.808288771
EU33W-440	S	REG	9800		=	1800	9.8	2.282382386
EU33W-441	S	REG	5300		=	910	5.3	1.667706821

Number of Samples	57
Number of Detects	46
Minimum	0.024
Median	0.59
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Average	3.5812632
Standard Deviation	5.3086198
PERT-Beta Mean	4.2306667
Lognormal Mean	-0.122658
Lognormal Standard Deviation	1.9100208

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Total PCBs mg/kg

General Statistics

Number of Valid Observations	57	Number of Distinct Observations	51

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.024	Minimum of Log Data	-3.73
Maximum	23	Maximum of Log Data	3.135
Mean	3.581	Mean of log Data	-0.123
Median	0.59	SD of log Data	1.91
SD	5.309		
Coefficient of Variation	1.482		
Skewness	1.892		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Lilliefors Test Statistic	0.252	Lilliefors Test Statistic	0.149
Lilliefors Critical Value	0.117	Lilliefors Critical Value	0.117
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	4.757	95% H-UCL	12.34
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	13.18
95% Adjusted-CLT UCL	4.926	97.5% Chebyshev (MVUE) UCL	16.7
95% Modified-t UCL	4.787	99% Chebyshev (MVUE) UCL	23.61

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.448	Data do not follow a Discernable Distribution (0.05)	
Theta Star	8		
nu star	51.03		
Approximate Chi Square Value (.05)	35.63	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0458	95% CLT UCL	4.738
Adjusted Chi Square Value	35.29	95% Jackknife UCL	4.757
		95% Standard Bootstrap UCL	4.73
Anderson-Darling Test Statistic	1.914	95% Bootstrap-t UCL	5.021
Anderson-Darling 5% Critical Value	0.825	95% Hall's Bootstrap UCL	4.97
Kolmogorov-Smirnov Test Statistic	0.174	95% Percentile Bootstrap UCL	4.774
Kolmogorov-Smirnov 5% Critical Value	0.125	95% BCA Bootstrap UCL	4.97
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	6.646
		97.5% Chebyshev(Mean, Sd) UCL	7.972
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	10.58
95% Approximate Gamma UCL	5.13		
95% Adjusted Gamma UCL	5.178		

		Potential UCL to Use						Use 97.5% Chebyshev (Mean, Sd) UCL			7.972

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
Total PCBs (mg/kg)	2.40E-02	5.90E-01	2.30E+01	4.23E+00	**1.09E+01**	2.58	10.93	1.10	4.90	13.8075	23.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \qquad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ is the Beta Function and $B_z(\alpha_1,\alpha_2)$ is the Incomplete Beta Function
α_1 and α_2 are calculated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95 α_1 α_2 MIN MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for 2-Butanone mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
Z1-EU29BW-410	B	REG	20	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-402	S	REG	20	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-403	S	REG	2.4	J	J	0.85	0.0024	-6.032286542
Z1-EU29W-404	S	REG	20	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-405 + Dup	S	REG	20	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-406	S	REG	0.96	J	=	0.85	0.00096	-6.948577274
Z1-EU29W-407	S	REG	20	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-408	S	REG	20	U	U	0.85	0.000425	-7.763421389
Z1-EU29W-409	S	REG	20	U	U	0.85	0.000425	-7.763421389
Z1-EU30BW-411	B	REG	20	U	U	0.85	0.000425	-7.763421389
Z1-EU31BW-415	B	REG	11	U	UJ	11	0.0055	-5.203007187
Z1-EU31BW-416	B	REG	11	U	UJ	11	0.0055	-5.203007187
Z1-EU31BW-417	B	REG	23		J	12	0.023	-3.772261063
Z1-EU31W-412	S	REG	10	U	U	10	0.005	-5.298317367
Z1-EU31W-413	S	REG	3.9	J	J	0.85	0.0039	-5.546778726
Z1-EU31W-414	S	REG	20	U	U	0.85	0.000425	-7.763421389
Z1-EU32BW-431	B	REG	9	U	UJ	9	0.0045	-5.403677882
Z1-EU32BW-432	B	REG	10	U	U	10	0.005	-5.298317367
Z1-EU32BW-433 + Dup	B	FR	12		=	9	0.012	-4.422848629
Z1-EU32BW-434	B	REG	9	U	U	9	0.0045	-5.403677882
Z1-EU32MW-420	S	REG	10	U	U	10	0.005	-5.298317367
Z1-EU32MW-426	S	REG	9	U	U	9	0.0045	-5.403677882
Z1-EU32W-418	S	REG	10	U	UJ	10	0.005	-5.298317367
Z1-EU32W-419 + Dup	S	REG	9	U	U	9	0.0045	-5.403677882
Z1-EU32W-421	S	REG	9	U	U	9	0.0045	-5.403677882
Z1-EU32W-422	S	REG	17		=	10	0.017	-4.074541935
Z1-EU32W-423	S	REG	8	U	UJ	8	0.004	-5.521460918
Z1-EU32W-424	S	REG	27		=	10	0.027	-3.611918413
Z1-EU32W-425	S	REG	9	U	U	9	0.0045	-5.403677882
Z1-EU32W-427	S	REG	17		=	10	0.017	-4.074541935
Z1-EU32W-428	S	REG	9	U	U	9	0.0045	-5.403677882
Z1-EU32W-429	S	REG	9	U	U	9	0.0045	-5.403677882
Z1-EU32W-430	S	REG	33		=	9	0.033	-3.411247718
Z1-EU33BW-443	B	REG	45		J	10	0.045	-3.101092789
Z1-EU33BW-444	B	REG	9	U	U	9	0.0045	-5.403677882
Z1-EU33W-435	S	REG	10	U	U	10	0.005	-5.298317367
Z1-EU33W-436	S	REG	20		J	9	0.02	-3.912023005
Z1-EU33W-437	S	REG	27		=	10	0.027	-3.611918413
Z1-EU33W-438	S	REG	10	U	U	10	0.005	-5.298317367
Z1-EU33W-439	S	REG	14		=	9	0.014	-4.268697949
Z1-EU33W-440	S	REG	32		=	9	0.032	-3.442019376
Z1-EU33W-441	S	REG	9	U	U	9	0.0045	-5.403677882

Number of Samples	42
Number of Detects	14
Minimum	0.000425
Median	0.0045
Maximum	0.045
Average	0.0087639
Standard Deviation	0.0106721
PERT-Beta Mean	0.0105708
Lognormal Mean	-5.520374
Lognormal Standard Deviation	1.4203869

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

2-Butanone mg/kg

General Statistics

Number of Valid Observations	42	Number of Distinct Observations	17

Raw Statistics		**Log-transformed Statistics**	
Minimum	4.2500E-4	Minimum of Log Data	-7.763
Maximum	0.045	Maximum of Log Data	-3.101
Mean	0.00876	Mean of log Data	-5.52
Median	0.0045	SD of log Data	1.42
SD	0.0107		
Coefficient of Variation	1.218		
Skewness	1.786		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.709	Shapiro Wilk Test Statistic	0.833
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.0115	95% H-UCL	0.0206
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.0234
95% Adjusted-CLT UCL	0.012	97.5% Chebyshev (MVUE) UCL	0.029
95% Modified-t UCL	0.0116	99% Chebyshev (MVUE) UCL	0.0399

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.724	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.0121		
nu star	60.81		
Approximate Chi Square Value (.05)	43.88	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0443	95% CLT UCL	0.0115
Adjusted Chi Square Value	43.37	95% Jackknife UCL	0.0115
		95% Standard Bootstrap UCL	0.0114
Anderson-Darling Test Statistic	1.848	95% Bootstrap-t UCL	0.0123
Anderson-Darling 5% Critical Value	0.789	95% Hall's Bootstrap UCL	0.0119
Kolmogorov-Smirnov Test Statistic	0.23	95% Percentile Bootstrap UCL	0.0115
Kolmogorov-Smirnov 5% Critical Value	0.142	95% BCA Bootstrap UCL	0.012
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.0159
		97.5% Chebyshev(Mean, Sd) UCL	0.019
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	0.0251
95% Approximate Gamma UCL	0.0121		
95% Adjusted Gamma UCL	0.0123		

Potential UCL to Use	Use 99% Chebyshev (Mean, Sd) UCL	0.0251

12/29/2005	R1.3

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT						Calculations				
	STEP 10	STEP 11	STEP 12	OUTPUT			Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
2-Butanone (mg/kg)	4.25E-04	4.50E-03	4.50E-02	1.06E-02	**2.43E-02**	2.30	0.02	1.37	4.63	0.0001	0.0

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN*, *MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x-MIN)^{\alpha_1-1}(MAX-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(MAX-MIN)^{\alpha_1+\alpha_2-1}} \qquad MIN < Most\,likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1,\alpha_2)}{B(\alpha_1,\alpha_2)}$$

$$E(x) = \frac{MIN + 4\times Most\,Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x)-MIN)\times(MAX-E(x))}{7}$$

$$\alpha_1 = 6\times\left[\frac{E(x)-MIN}{MAX-MIN}\right]$$

$$\alpha_2 = 6\times\left[\frac{MAX-E(x)}{MAX-MIN}\right]$$

$B(\alpha_1,\alpha_2)$ *is the Beta Function and* $B_z(\alpha_1,\alpha_2)$ *is the Incomplete Beta Function*

α_1 *and* α_2 *are calculated parameters*

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Statistical Summary for 2-Methylnaphthalene mg/kg

Location ID	Sample Lot	Sample Type	Result (ug/kg)	Result Qualifier	Validation	Detection Limit (ug/kg)	Proxy Value (mg/kg)	LN Proxy Value
Z1-EU29BW-410	B	REG	39	J	J	400	0.039	-3.244193633
Z1-EU29W-401	S	REG	360	U	U	360	0.18	-1.714798428
Z1-EU29W-402	S	REG	20	J	J	400	0.02	-3.912023005
Z1-EU29W-403	S	REG	380	U	UJ	380	0.19	-1.660731207
Z1-EU29W-404	S	REG	390	U	UJ	390	0.195	-1.63475572
Z1-EU29W-405 + Dup	S	FR	87	J	J	370	0.087	-2.44184716
Z1-EU29W-406	S	REG	400	U	UJ	400	0.2	-1.609437912
Z1-EU29W-407	S	REG	23	J	J	400	0.023	-3.772261063
Z1-EU29W-408	S	REG	20	J	J	400	0.02	-3.912023005
Z1-EU29W-409	S	REG	28	J	J	380	0.028	-3.575550769
Z1-EU30BW-411	B	REG	93	J	J	380	0.093	-2.375155786
Z1-EU31BW-415	B	REG	50	J	J	400	0.05	-2.995732274
Z1-EU31BW-416	B	REG	400	U	UJ	400	0.2	-1.609437912
Z1-EU31BW-417	B	REG	40	J	J	410	0.04	-3.218875825
Z1-EU31W-412	S	REG	300	J	J	390	0.3	-1.203972804
Z1-EU31W-413	S	REG	44	J	J	400	0.044	-3.123565645
Z1-EU31W-414	S	REG	62	J	J	400	0.062	-2.780620894
Z1-EU32BW-431	B	REG	87	J	J	410	0.087	-2.44184716
Z1-EU32BW-432	B	REG	43	J	J	370	0.043	-3.146555163
Z1-EU32BW-433 + Dup	B	REG	390	U	U	390	0.195	-1.63475572
Z1-EU32BW-434	B	REG	130	J	J	370	0.13	-2.040220829
Z1-EU32MW-420	S	REG	33	J	J	370	0.033	-3.411247718
Z1-EU32MW-426	S	REG	24	J	J	380	0.024	-3.729701449
Z1-EU32W-418	S	REG	410	U	UJ	410	0.205	-1.5847453
Z1-EU32W-419 + Dup	S	FR	150	J	J	360	0.15	-1.897119985
Z1-EU32W-421	S	REG	52	J	J	370	0.052	-2.95651156
Z1-EU32W-422	S	REG	41	J	J	360	0.041	-3.194183212
Z1-EU32W-423	S	REG	360	U	U	360	0.18	-1.714798428
Z1-EU32W-424	S	REG	380	U	U	380	0.19	-1.660731207
Z1-EU32W-425	S	REG	29	J	J	380	0.029	-3.540459449
Z1-EU32W-427	S	REG	21	J	J	380	0.021	-3.863232841
Z1-EU32W-428	S	REG	53	J	J	370	0.053	-2.937463365
Z1-EU32W-429	S	REG	380	U	U	380	0.19	-1.660731207
Z1-EU32W-430	S	REG	360	U	UJ	360	0.18	-1.714798428
Z1-EU33BW-443	B	REG	54	J	J	390	0.054	-2.918771232
Z1-EU33BW-444	B	REG	78	J	J	370	0.078	-2.551046452
Z1-EU33W-435	S	REG	390	U	U	390	0.195	-1.63475572
Z1-EU33W-436	S	REG	370	U	U	370	0.185	-1.687399454
Z1-EU33W-437	S	REG	55	J	J	410	0.055	-2.900422094
Z1-EU33W-438	S	REG	45	J	J	380	0.045	-3.101092789
Z1-EU33W-439	S	REG	71	J	J	380	0.071	-2.645075402
Z1-EU33W-440	S	REG	41	J	J	370	0.041	-3.194183212
Z1-EU33W-441	S	REG	120	J	J	380	0.12	-2.120263536

Number of Samples	43
Number of Detects	30
Minimum	0.02
Median	0.071
Maximum	0.3
Average	0.1027442
Standard Deviation	0.0749228
PERT-Beta Mean	0.1006667
Lognormal Mean	-2.573653
Lognormal Standard Deviation	0.8137728

General UCL Statistics for Full Data Sets

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

2_Methylnaphthalene mg/kg

General Statistics

Number of Valid Observations	43	Number of Distinct Observations	33

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.02	Minimum of Log Data	-3.912
Maximum	0.3	Maximum of Log Data	-1.204
Mean	0.103	Mean of log Data	-2.574
Median	0.071	SD of log Data	0.814
SD	0.0749		
Coefficient of Variation	0.729		
Skewness	0.643		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.851	Shapiro Wilk Test Statistic	0.906
Shapiro Wilk Critical Value	0.943	Shapiro Wilk Critical Value	0.943
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	0.122	95% H-UCL	0.139
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.169
95% Adjusted-CLT UCL	0.123	97.5% Chebyshev (MVUE) UCL	0.196
95% Modified-t UCL	0.122	99% Chebyshev (MVUE) UCL	0.25
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	1.714	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.0599		
nu star	147.4		
Approximate Chi Square Value (.05)	120.4	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0444	95% CLT UCL	0.122
Adjusted Chi Square Value	119.5	95% Jackknife UCL	0.122
		95% Standard Bootstrap UCL	0.121
Anderson-Darling Test Statistic	1.658	95% Bootstrap-t UCL	0.123
Anderson-Darling 5% Critical Value	0.762	95% Hall's Bootstrap UCL	0.122
Kolmogorov-Smirnov Test Statistic	0.184	95% Percentile Bootstrap UCL	0.122
Kolmogorov-Smirnov 5% Critical Value	0.137	95% BCA Bootstrap UCL	0.122
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.153
		97.5% Chebyshev(Mean, Sd) UCL	0.174
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	0.216
95% Approximate Gamma UCL	0.126		
95% Adjusted Gamma UCL	0.127		

		Potential UCL to Use						Use 95% Chebyshev (Mean, Sd) UCL			0.153

Upper 95th Confidence Interval Calculations for a PERT Beta PDF

Information: Ken Redus, 865.483.2715 kredus@icx.net

12/29/2005	R1.3

Enter input values in yellow shaded cells
Report OUTPUT UCL-95

	WACFACS WL L SRC INPUT							Calculations				
	STEP 10	STEP 11	STEP 12		OUTPUT		Beta PDF Inverse	PERT BETA			
SRC	MIN	MED	MAX	E(X)	UCL-95	UCL-95 : E(X)	0.95	α_1	α_2	Variance	Max - Min
2-Methylnaphthalene (mg/kg)	2.00E-02	7.10E-02	3.00E-01	1.01E-01	1.90E-01	1.89	0.19	1.73	4.27	0.0032	0.3

The PERT Beta Probability Distribution

The Program Evaluation and Review Technique (PERT)-Beta Probability Distribution (PDF) is an extension of the Beta PDF. The Beta PDF is usually defined over the closed interval [0, 1]. The PERT-Beta PDF is defined over (*MIN, MAX*) where *MIN* < *MAX* and *MIN* denotes the minimum value and *MAX* denotes the maximum value. The PERT Beta PDF is very flexible, and it is often used to describe uncertainties in engineering and economics environments.

WACFACS (Waste Acceptance Forecasting Analysis Capability System) uses the PERT Beta PDF to describe site related contaminant average concentrations when the site related contaminant average concentrations do not follow a normal or a lognormal PDF. One requirement of WACFACS is to provide the 95% upper confidence level (UCL-95) for the site related contaminant average concentration.

The PERT Beta PDF is denoted as $f(x)$ for the random variable, x. The Cumulative Distribution Function (CDF) is denoted as $F(x)$. Functional representations are as follows:

$$f(x) = \frac{(x - MIN)^{\alpha_1 - 1}(MAX - x)^{\alpha_2 - 1}}{B(\alpha_1, \alpha_2)(MAX - MIN)^{\alpha_1 + \alpha_2 - 1}} \quad MIN < Most\ likely < MAX$$

$$F(x) = \frac{B_z(\alpha_1, \alpha_2)}{B(\alpha_1, \alpha_2)}$$

$$E(x) = \frac{MIN + 4 \times Most\ Likely + MAX}{6}$$

$$Var(x) = \frac{(E(x) - MIN) \times (MAX - E(x))}{7}$$

$$\alpha_1 = 6 \times \left[\frac{E(x) - MIN}{MAX - MIN}\right]$$

$$\alpha_2 = 6 \times \left[\frac{MAX - E(x)}{MAX - MIN}\right]$$

$B(\alpha_1, \alpha_2)$ is the Beta Function and $B_z(\alpha_1, \alpha_2)$ is the Incomplete Beta Function

α_1 and α_2 are calculdated parameters

Use the Microsoft Excel ®TM function BETAINV(0.95, α_1, α_2, MIN, MAX) to calculate x such that $F(x) = 0.95$. The result is

Davenport, John M (MDN)

From: Redus, Kenneth S (3KR)
Sent: Tuesday, April 14, 2009 10:38 PM
To: Davenport, John M (MDN); Hanahan, Douglas W. (HGG)
Cc: Hampshire, G John (O57); Hopper Jr, James Guy (HPZ)
Subject: WL 4.12 R0 VWSF Transmittal and Att 3

Attachments: WL 4.12 R0 Att 3 2009 04 14.xls

To the WL - please include this in your Profile. To the WL - please include this in your Profile. These results are based on the data received on 04/13/2009 as WL 4 12_Appendix H_WACFACS Input Sheet (041309 Revision).xls from Marshall Davenport under WACFACS Configuration Control as WL 4.12 K-770 Soils 2009 04 14.xls. If there are changes in WACFACS Input Worksheet, the VWSF statistics will need to be recalculated.

WL 4.12 R0 VWSF Transmittal and Att 3

The following information is provided for WL 4.12 K-770 Scrap Yard Soils and Misc. Debris.

The 3-year window is FY09 – FY11 using WACFACS, Q1 FY09 Rev 0.

WGF Volume = 17500 CY (CIVV = VL for 16200 CY of Soil-Like Waste and CIVV = VL for 1300 CY of Debris-Like Waste)

Expected Total Volume = 20271 CY and UCL-95 Total Volume = 25740 CY

WL 4.12 Carcinogenic SOF

E (WL Carcinogenic SOF) = 0.67

UCL-95 (WL Carcinogenic SOF) = 1.71

WL 4.12 HI SOF

E (WL HI SOF) = 0.17

UCL-95 (WL HI SOF) = 0.37

WL 4.12 Carcinogenic VWSF

E (WL 4.12 Carcinogenic VWSF) = 7.20E-03

WL 4.12 HI VWSF

E (WL 4.12 HI VWSF) = 1.84E-03

EMWMF Carcinogenic VWSF

E (EMWMF Carcinogenic VWSF) = 0.7

UCL-90 (EMWMF Carcinogenic VWSF) = 0.8

EMWMF HI VWSF

E (EMWMF HI VWSF) = 0.5

UCL-90 (EMWMF HI VWSF) = 0.6

If you have any questions, please contact me.

K. S. Redus
EMWMF WAC Attainment Team

WL 4.12 R0 Att 3
2009 04 14.xl...

APPENDIX H
WASTE ACCEPTANCE FORECASTING ANALYSIS CAPABILITY SYSTEMS (WACFACS)

APPENDIX I
APPROVED VARIANCE REQUESTS

ENVIRONMENTAL MANAGEMENT WASTE MANAGEMENT FACILITY

Physical Waste Acceptance Criterion Blanket Variance

Blanket Variance No: EMWMF-BV-07-01
Revision No: 0
Effective Date: 09/23/05

Approval Signature

Blanket Variance Applicable to: Pipe, tubing, and conduit with internal diameter of 6 inches.

Physical Waste Acceptance Criterion No.

Requirement: Piping shall be segregated from other wastes and shall be placed in haulage containers to avoid bridging or otherwise wedging during unloading. Pipe and tubing less than 6-in. diameter is accepted without further restrictions. Pipes between 6-in. and 12-in. diameter shall be crushed, shredded, or filled to minimize void spaces.

Basis: Analysis in the EMWMF Performance Assessment indicates that pipes with excessive internal void must be filled, crushed or split to meet subsidence requirements.

Variance:

Piping, tubing and conduit formed from rigid metal that is 6-inches or less in diameter, which are not placed inside another container for disposal, may be placed in the disposal cell without further treatment.

Justification: The EMWMF Performance Assessment indicates that pipes with internal diameters of 6-inches and less do not substantially affect the long-term performance of the EMWMF and may therefore be disposed without restriction.

3 Conditions of Variance

a. This variance is for 6-inch internal diameter pipe, metal tubing and metal conduit only.
b. Pipe, tubing, and conduit shall be cut in lengths appropriate to the haulage container such that pipe may freely fall during dumping without becoming wedged or jammed.

4 Application of Blanket Variance

a Certification of full compliance with the conditions of this blanket variance, as stated herein, by the waste generator of a specific, approved waste lot fulfills the requirements of a variance to the physical waste acceptance criterion in accordance with *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1909&D3).

b. Generator to reference Blanket Variance EMWMF-BV-07-01 in required sections of the Waste Profile and attach a hard copy when submitting the waste profile to the Waste Acceptance Criteria (WAC) Attainment Team.

c. Generator to attach a hard copy of this blanket variance to Section   of the Readiness to Ship Checklist.

5. Revocation of Blanket Variance:

Upon discovery of waste from a specific waste lot that is not in full compliance with the conditions stated herein, this blanket variance may be revoked by written communications to the generator's BJC responsible contact and the waste declared to be anomalous waste.

ENVIRONMENTAL MANAGEMENT WASTE MANAGEMENT FACILITY
Physical Waste Acceptance Criterion Blanket Variance Approval

Blanket Variance No: EMWMF-BV-08-01
Revision No: 2
Effective Date: 08/11/06

Approval Signature

Blanket Variance Applicable to: Non-friable asbestos-containing transite panels only.

1. Physical Waste Acceptance Criterion No.: 8

   Requirement: Asbestos-containing materials (ACM) shall be wetted, double-bagged and shipped separately or with adequate volumes of soil to facilitate safe transportation and burial. Bags shall be limited to a maximum weight of 40 lbs.

   Basis: General handling/disposal practices associated with building decontamination and demolition work to address asbestos abatement that includes transite panels.

   Note 1: Because this blanket variance does not apply to beryllium dust containing waste as stated in the physical waste acceptance criterion, reference to beryllium has been removed from the requirement above.

2. Variance:

   Alternate packaging for intact (not broken or crumbled) Category II non-friable ACM transite panels in good condition that is in various sizes to: 1) eliminate need for size reduction and placing ACM in double 40-lb bags and 2) change method of shipment to flatbed trailers, shipped without soil.

   Justification: Disposal of whole transite panels is generally more protective of workers health than requiring transite to be cut or broken. Disposal of securely packaged transite panels can also be accomplished with a minimum risk of release if the conditions as stated in Section 3 are followed.

3. Conditions of Variance:

   a. This variance is for intact transite panels that are in good condition only.

   b. Transite panels shall be shipped separately from other waste types and without soil.

   c. Transite panels that are 4-feet wide and up to 12-feet long shall be stacked as follows:
      1. All panels to be stacked shall be of similar length.
      2. Panels shall be stacked in a stable configuration that minimizes void space between panels [e.g., only like panels shall constitute a stack, such as corrugated with corrugated and flat with flat].

3. Panel stacks shall have a uniform shape and be limited to maximum dimensions of 4-feet in height by 4-feet wide and 12-feet in length.
4. Panel stacks shall not exceed 24,000 lbs.
5. Panel stacks shall be banded sufficiently to prevent shifting during transportation and unloading. **[Note: Stacks of 12-feet long transite panels shall also be banded on the long axis in order to prevent draping of material over the forks potentially resulting in breakage during offloading]**.
6. Stacked and banded transite panels shall be wrapped in a single layer of plastic sheeting with a minimum thickness of 6-mil with all flaps folded over and sealed with tape or equivalent, in accordance with 29 CFR 1926.1101(l)(2).

d. Transite panels with dimensions that are ≤ 4-feet wide by 4-feet long shall be stacked as follows:
   1. Panels shall be stacked in a stable configuration that minimizes void space between each individual transite panel (e.g., only like panels shall constitute a stack, suchas corrugated with corrugated and flat with flat).
   2. Panel stacks shall be limited to a maximum height of 4-feet.
   3. Panel stacks shall not exceed 24,000 lbs.
   4. Panel stacks shall be wrapped in a single layer of plastic with a minimum thickness of 6-mil with all flaps folded over and sealed with tape or equivalent, in accordance with 29 CFR 1926.1101(l)(2).
   5. Panel stacks shall be banded to a pallet to prevent shifting during transportation and unloading.

e. Smaller length or broken transite panels (i.e., pieces) that are not conducive to orderly stacking shall be packaged as follow:
   1. Transite panel pieces shall be placed into double-lined supersacks or sealed bladder bags.
   2. Supersacks or bladder bag packages shall be capable of being placed in a nominal 18 inch lift and being sufficiently compacted following placement.

f. The transite packages shall be labeled in accordance with 29 CFR 1926.1101(k)(8).

g. Shipping papers shall include the term "asbestos".

h. Transite panels shall be shipped as follows:
   1. Stacked and banded transite panels greater than 4-feet in length shall be shipped via flatbed truck using bed-mounted dunnage (minimum 4 inch by 4 inch). **[Note: packaging material beneath the stacks shall not obstruct forks during offloading]**.
   2. Stacked transite panels less than 4-feet in length that are strapped to a pallet shall be shipped via flatbed truck **[Note: packaging material beneath the stacks shall not obstruct forks during offloading]**.
   3. Supersack or bladder bag packages shall be shipped in intermodal containers or via flatbed truck when banded to a wooden pallet **[Note: packaging material beneath the stacks shall not obstruct forks during offloading]**.

4. Application of Blanket Variance:

   a. Certification of full compliance with the conditions of this blanket variance, as stated herein, by the waste generator of a specific and approved waste lot fulfills the requirements of a variance to the physical waste acceptance criterion in accordance with *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1909&D3).

   b. Generator to reference Blanket Variance EMWMF-BV-08-01, Revision 2 in required sections of the Waste Profile and attach a hard copy when submitting the waste profile to the Waste Acceptance Criteria (WAC) Attainment Team.

   c. Generator to attach a hard copy of this blanket variance to Section 11 of the Readiness to Ship Checklist.

5. Revocation of Blanket Variance:

   Upon discovery of waste from a specific waste lot that is not in full compliance with the conditions stated herein, the application of this blanket variance may be revoked by written communications to the waste generator's BJC responsible contact and the waste declared to be anomalous waste.

ENVIRONMENTAL MANAGEMENT WASTE MANAGEMENT FACILITY

Physical Waste Acceptance Criterion Blanket Variance Approval

Blanket Variance No: EMWMF-BV-08-02
Revision No: 1
Effective Date: 10/14/05

Approval Signature

Blanket Variance Applicable to: Friable and non-friable asbestos-containing (ACM) including, but not limited to, the following items containing asbestos: insulation, floor tiles, baseboards, roofing materials, miscellaneous building debris, asbestos wrapped pipe ($\leq$2 in. diameter); asbestos-core fire doors, and conduit containing asbestos insulated wire.

Note: Does not apply to transite, instead refer to EMWMF-BV-08-01

Physical Waste Acceptance Criterion No.: 8

Requirement: Asbestos-containing materials shall be wetted, double-bagged and shipped separately or with adequate volumes of soil to facilitate safe transportation and burial. Bags shall be limited to a maximum weight of 40 lbs.

Basis: General handling/disposal practices associated with asbestos abatement work.
Note: No distinction made between friable and non-friable ACM.

Note 1: Because this blanket variance does not apply to beryllium dust containing waste as stated in the physical waste acceptance criterion, reference has been removed from the requirement above.

Note 2: This variance is not applicable to items that cause the package to be larger than 24-inches in height (e.g., tanks, structural members), , and items containing proportionally large voids (e.g., fire safe or filing cabinet, boiler, furnace, dryer, autoclave). Items such as these will require individual PWAC variances.

2 Variance

Alternate packaging for friable and non-friable ACM and asbestos items in lined supersacks, sealed bladder bags, wrapped in double layer of plastic exceeding 40 lbs. or placed in double 10-mil ACM bags exceeding 40-lbs per bag and shipped separately in intermodal containers without soil to facilitate direct dumping or on flatbed trucks for offloading.

Justification: Use of the alternate method for packaging and disposal of ACM as provided in this variance is more protective of disposal workers health as it reduces the potential for ripped ACM containing bags and it eliminates direct handling of bags.

3. Conditions of Variance:

a. Soft asbestos insulation with or without occasional hard asbestos contaminated items (e.g., wood, metal, or plastic), hard asbestos containing items (floor tiles, baseboards, roofing materials, miscellaneous building debris), or other ACM:
   1. Shall be wetted and packaged in double-lined supersacks or sealed bladder bags;
   2. Shall not have sharp points or jagged edges (e.g., no protruding nails, wire or metal) that may puncture or rip the supersack or bladder bag;
   3. Supersacks and bladder bags shall be capable of being placed in a nominal 24 inch lift and being sufficiently compacted following placement;
   4. Supersacks or bladder bags containing ACM shall be properly labeled in accordance with applicable regulatory requirements;
   5. Supersacks and bladder bags shall be shipped in roll-off containers or intermodal containers with other similar packages and without soil or strapped to pallets and shpped on flatbed trailers; or
   6. Shall be wetted and packaged in double 10-mil ACM bags and shipped in intermodals without soil for bulk disposal.

b. Asbestos insulated pipe:
   1. Shall be less than 2 inches interior diameter and less than or equal to 8 ft. in length;
   2. Shall be wetted and packaged and shipped as follows:
      - For intermodal containers: Individual pipes or bundles of 10 or less pipes strapped firmly together shall be wrapped with double layer of 10-mil plastic and shipped in lined intermodal containers for bulk placement unless a liner variance has been approved.
      - Multiple pipes shall be banded together, wrapped with double layer of 10-mil plastic or packaged in supersacks and strapped to pallets and transported via flatbed truck for offloading.
   3. Packages shall be capable of being placed in a nominal 18 inch lift and being sufficiently compacted following placement.

   Conduit containing asbestos insulated wire:
   1. Shall be cut in lengths not to exceed 8 feet;
   2. Shall have ends of conduit double wrapped with 10-mil plastic or have ends sealed with caulk and wrapped with one of layer or 10-mil plastic;
   3. Shall be banded securely together, strapped to pallets and transported via flatbed truck for offloading;
   4. Packages shall be capable of being placed in a nominal 18 inch lift and being sufficiently compacted following placement
   5. Miscellaneous pieces of conduit shall conform to 3.a above.

d. Packaged ACM items shall meet the void space WAC requirements.

e. Appropriate labels for ACM shall be visible on all containers and packages and shipping papers accompanying an ACM load shall have the term "asbestos" listed in accordance with applicable regulatory requirements.

4. Application of Blanket Variance:

a. Certification of full compliance with the conditions of this blanket variance, as stated herein, by the waste generator of a specific, approved waste lot fulfills the requirements of a variance to the physical waste acceptance criterion in accordance with *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1909&D3).

b. Generator to reference Blanket Variance EMWMF-BV-08-02 in required sections of the Waste Profile and attach a hard copy when submitting the waste profile to the Waste Acceptance Criteria (WAC) Attainment Team.

c. Generator to attach a hard copy of this blanket variance to Section II of the Readiness to Ship Checklist.

5. Revocation of Blanket Variance:

Upon discovery of waste from a specific waste lot that is not in full compliance with the conditions stated herein, this blanket variance may be revoked by written communications to the generator's BJC responsible contact and the waste declared to be anomalous waste.

Request for Approval of Variance from Physical Waste Acceptance Criteria (WAC) for the Environmental Management Waste Management Facility (EMWMF)

Instructions: The Waste Generator shall:

(1) Communicate with the EMWMF Waste Generator Services Lead to discuss the proposed variance request prior to the submittal of this form.
(2) Complete Section 1 and prepare any necessary support information.
(3) Electronically transmit the completed form and support information to the EMWMF WAC Manager.

BJC EMWMF Operations will coordinate the review of the variance request and transmit the results of the review to the Waste Generator.

Section 1---To be Completed by Waste Generator	
1. Waste Lot No.: 4.12	2. Date: December 29, 2008
3. Waste Lot Name: K-770 Scrap Yard Soils	
4. Name of Project: ETTP D&D/RA	
5. Name of Requestor: Marshall Davenport	6. Telephone No.: 576-8049
7. Alternate contact: Doug Hanahan	8. Telephone No.: 241-9573
9. Company Affiliation: BJC	10. Fax No.: 241-5178
11. Describe the physical WAC parameter(s) for which a variance is being requested: The EMWMF physical WAC states that rebar shall be cut to a maximum 4-ft length and shall be in rolls or bundles that can be placed and graded in an 18-in lift.	
12. Describe the proposed variance The Project is expecting to encounter rebar in the concrete foundation slabs that will be demolished at the K-770 Scrap Yard. It is requesting that a variance be granted to allow rebar to be sheared to lengths of 4-ft or less and comingled with the remainder of the waste lot in dump trucks for bulk disposal at the EMWMF. Rebar will be removed from concrete by crushing the concrete. Most rebar is expected to be free of concrete. However, some may contain incidental, small pieces of concrete. The Project will attempt to distribute the rebar evenly between the loads of waste and commingle with significant amounts of soil.	
13. Describe why the physical WAC parameter(s) cannot be met and provide justification for the proposed variance: Based on the expected configuration of the rebar present in this waste lot (from past experience), it would be difficult (and unsafe) to cut into 4-ft lengths and reconfigure into rolls or bundles. By removing rebar from the concrete, further size-reducing the rebar to 4-ft lengths or less, and commingling with soil in the dump truck; the debris should be suitable for placement and grading into an 18-in lift.	
14. Describe and identify if the variance is requested for the entire waste lot or for a specific portion of the waste lot: This variance request is for the entire waste lot. However, it is estimated that the rebar will comprise less than 1% of the waste lot. An attempt will be made to evenly distribute it in loads of waste (primarily soil) at the time it is generated.	
15. Describe the potential impacts of implementing the variance request and the suggested mitigation actions by the waste generator and EMWMF Operations: None.	

Request for Approval of Variance from Physical Waste Acceptance Criteria (WAC) for the Environmental Management Waste Management Facility (EMWMF)

16. Other support information:
Similar variances for the ETTP D&D/RA Project have been previously approved (see approved variance EMWMF-VR-128)

Section 2---To be Completed by EMWMF Operations

17. Was a field walkdown performed to review the waste? Yes ☐ No ☒
If so, state notes from the field walkdown that are pertinent to the variance review:

18. Provide brief justification for concurring with or rejecting the variance request:

Rebar commingled with other waste has been received at EMWMF without incident.

19. Will the requested variance impact the design basis for EMWMF? Yes ☐ No ☒
If so, describe the potential impact and mitigation measures.

20. Are other reviews (i.e., Procurement, Engineering, RADCON) required?

Yes ☒ No ☐

21. If other reviews are required, do the reviews support approval of the requested variance?

Yes ☒ No ☐

22. State variance request approval conditions:

1. Rebar shall be cut to less than or equal to 4 feet in length.
2. Bent rebar shall be cut at the bends in order to eliminate long pieces of angled lengths of rebar.
3. Rebar protruding from concrete shall be cut as closely to the concrete surface as practicable.
4. Waste shall be transported in dump trucks only.
5. Generator shall contact EMWMF Operations prior to shipping waste with commingled rebar, indicating truck number containing rebar.

Approval / Disapproval by BJC EMWMF Operations

23. Approved ☐ Approved with conditions ☒ Disapproved ☐

Printed Name:	Signature:	Date:
Steve Kucera	[signature]	2/19/09

APPENDIX J
CERCLA DOCUMENTATION

I-10513-0005

DOE/OR/01-1997&D2

Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee

This document has received the appropriate reviews for release to the public.

PREFACE

This *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1977&D2), was prepared in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986, to present the public with the selected remedy for environmental remediation of contaminated areas within Zone 1. This Record of Decision (ROD) documents the selected remedy agreed on by the U.S. Department of Energy, the Tennessee Department of Environment and Conservation, and the U.S. Environmental Protection Agency. The remedy addresses the inactive units, contaminated soil, and other contaminated material to the extent practicable while minimizing disruption of the continuing mission (environmental cleanup of the former Oak Ridge Gaseous Diffusion Plant) of the East Tennessee Technology Park. This decision is based on the Administrative Record file for this project. Following are the principal documents supporting this ROD:

- (draft) *Remedial Investigation Report for the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 1999a); and

- *Proposed Plan for Interim Remedial Actions for Selected Contaminated Soil, Material, and Blair Quarry within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2001a).

These documents and other information supporting the selected remedial action can be found at the Information Center, 475 Oak Ridge Turnpike, Oak Ridge, TN 37830; (865) 241-4780.

1.1 SITE NAME AND LOCATION

Zone 1 at East Tennessee Technology Park
Oak Ridge Reservation
Oak Ridge, Tennessee
CERCLA Information System ID TN #1890090003

1.2 STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) for interim actions presents the selected remedy for environmental remediation of contaminated areas within Zone 1 of East Tennessee Technology Park (ETTP), formerly the K-25 Site and the Oak Ridge Gaseous Diffusion Plant (ORGDP), on the U.S. Department of Energy's (DOE's) Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee. The remedy specifically addresses known areas of contaminated soil, Blair Quarry, and surface features (scrap material and debris in the K-770 Area and the K-710 sludge beds and Imhoff tanks). The scope of the decision also establishes remediation levels for soil and burial areas and a methodology for making action/no-action determinations, based on the reasonably anticipated end use for the surface of Zone 1. Finally, this ROD includes a decision to remediate other Zone 1 contaminated soil or buried waste if the Dynamic Verification Strategy (DVS), discussed later in this section and in Sect. 2.4, shows remediation is required and the selected remedy is cost effective. The scope does not include contaminated groundwater, surface water, or sediment. However, expected activities will address underlying contaminated soils that present a continuing source of groundwater contamination. Because this remedy does not include contaminated groundwater, surface water, sediment, or final land use controls (LUCs), it is an interim remedy.

Environmental remediation occurs primarily through removal of contamination. Land use controls are also selected for the residual contamination. Because this is an interim remedy, interim LUCs are specified as appropriate; however, final LUCs are not within the scope of this decision. This interim decision applies to the 1400-acre area designated as Zone 1 at ETTP. This area includes waste disposal areas, open undeveloped areas, and a previously industrialized area with facilities and scrap remaining.

DOE is currently developing for approval under the Federal Facility Agreement (FFA) for the ORR (DOE 1992) the DVS for conducting final status assessments and associated data gap sampling efforts for the remaining areas of soil in Zone 1. Final status assessments consist of the collection, analysis, and evaluation of medium-specific and screening measurement data for the purpose of determining whether additional remediation is required. The DVS generally follows the guidance outlined in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) [DOE et al. 2000] and follows the U.S. Environmental Protection Agency's (EPA's) "Triad" approach (EPA 2001). MARSSIM provides prescriptive, yet flexible guidance for collecting defensible data as part of the site closeout process. The Triad approach incorporates systematic planning, dynamic techniques, and real-time measurement technologies to streamline sampling, analysis, and data management activities.

This set of remedial actions for Zone 1 was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) [42 *United States Code* Sect. 9601 et seq.], and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 *Code of Federal Regulations (CFR)* 300]. The FFA was developed to provide a legal framework for remediation activities at the ORR and to coordinate remedial activities under CERCLA and the Resource Conservation and Recovery Act of 1976 (RCRA). The FFA's integrated approach extends to preparation of decision documents under CERCLA and RCRA. In addition, National Environmental Policy Act of 1969 (NEPA) values are incorporated in the documents prepared for this project in accordance with the *Secretarial Policy Statement on the National Environmental Policy Act of 1969* (DOE 1994a). This policy states that DOE will rely on the CERCLA process for review of actions taken under CERCLA and will address and incorporate NEPA values to the extent practicable in CERCLA evaluations.

Remediation measures presented in this ROD are intended to protect human receptors from exposure to hazardous substances in Zone 1. The primary receptor is the industrial worker. Through remediation of known areas of contamination and the application of LUCs for unknown areas and areas where subsurface residual contamination remains, the industrial worker will be protected throughout this action and until the final decision.

The interim LUCs selected in this ROD will continue in effect and remain enforceable as part of the selected CERCLA remedy until such time as they may be changed by a future CERCLA decision. DOE has developed a Land Use Control Assurance Plan (LUCAP) for the ORR to help ensure that land use restrictions are maintained and periodically verified. DOE will develop a specific Land Use Control Implementation Plan (LUCIP) that will further detail the specific measures required for land use restrictions as part of this action. DOE is committed to implementing and maintaining LUCs, including institutional controls, to ensure that the selected remedy remains protective of human health. The implementation and funding of these activities will take place in accordance with the ORR FFA. The public will be informed and involved in a timely manner in the CERCLA decision-making process consistent with requirements of CERCLA, the NCP, the ORR FFA, and the ORR CERCLA public involvement plan. Documents pertaining to the implementation and performance of the remedial actions, including 5-year reviews, will be placed in a post-ROD file, which will be available to the public.

This decision is based on documents contained in the Administrative Record file for Zone 1 of ETTP. Normally, a final remedial investigation (RI) and feasibility study (FS) will exist prior to completing a ROD. However, in this case, only a draft RI (DOE/OR/01-1778/V1-V5&D1) exists. Based on the information contained in the draft RI, contaminated areas warranting remediation were identified. In an effort to expedite remediation of these areas, a proposed plan was developed documenting some of the information normally found in a final RI and FS. This type of streamlining is encouraged by the NCP to allow cleanup to proceed as soon as sufficient information exists to make a decision on an interim remedy. DOE has considered all comments received on the proposed plan in preparing this ROD. DOE, U.S. Environmental Protection Agency (EPA), and Tennessee Department of Environment and Conservation (TDEC) [parties to the FFA] concur with the selected remedy.

1.3 ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health or welfare from actual or threatened releases of hazardous substances into the environment. The potential for an unacceptable risk to an industrial worker exists from soils in Zone 1, from soils and buried material in Blair Quarry, and from surface features (scrap, debris, tanks, and sludge beds).

1.4 DESCRIPTION OF THE SELECTED REMEDY

This remedy addresses Blair Quarry, miscellaneous contaminated soil (including the K-895 Cylinder Destruct Facility Area and the Powerhouse Area), scrap metal and debris in the K-770 Area, and the K-710 sludge beds and Imhoff tanks. Principal actions include (1) soil removal, (2) burial area removal, (3) scrap metal and debris removal, (4) demolition of certain above-ground structures, and (5) imposition of land use controls limiting use of the entire Zone 1 area, including groundwater. This decision also establishes remediation levels based on reasonably anticipated future land use for Zone 1. Known areas of contamination in Zone 1 will be remediated to meet an unrestricted industrial land use. Industrial uses will be allowed without controls to a maximum depth of 10 ft below ground surface (bgs). Use of the subsurface below 10 ft will be restricted. Until sufficient information is collected about the areas not known to be contaminated, use of these areas will also be restricted. The remedial action objective (RAO) for Zone 1 is to "Protect human health under an unrestricted industrial land use to a risk level not to exceed 10^{-4}." In addition, expected activities may control selected releases from contaminated soil to help minimize further impacts to groundwater.

Following are the major components of the selected remedy:

- Excavation of the Blair Quarry burial area and associated contaminated soil, with subsequent disposal at the Environmental Management Waste Management Facility (EMWMF) or an off-site permitted facility. Unless excavation of contaminated soil is determined to be necessary for groundwater protection, excavation will not go beyond 10 ft bgs. [Note: The EMWMF is the on-site disposal facility selected for the comprehensive management of waste generated from environmental restoration activities on the ORR. The ROD for disposal of ORR CERCLA waste documents the selection of the EMWMF (DOE 1999b)].

- Excavation of miscellaneous contaminated soil in the K-895 Cylinder Destruct Facility area and in the Powerhouse Area (includes K-725 Beryllium Building Slab), with subsequent disposal at the EMWMF or an off-site permitted facility. Unless excavation of contaminated soil is determined to be necessary for groundwater protection, excavation will not go beyond 10 ft bgs.

- Removal of scrap-metal and debris from the K-770 Area and disposal at the EMWMF or an off-site permitted facility.

- Removal of sludge and demolition of the K-710 sludge beds and Imhoff tanks with disposal at the EMWMF or an off-site permitted facility.

- Implementation of LUCs to prevent exposures to contamination known to exist in Zone 1 surface and subsurface areas, including groundwater, and to contamination which may be present in those Zone 1 areas where characterization is incomplete.

Interim LUCs are a necessary part of the selected remedy to ensure its protectiveness. The types and objectives of LUCs being imposed under this remedy include 1) property record restrictions to restrict uses of the property by imposing limitations on its use and to prohibit uses of groundwater; 2) property record notices to provide notice to anyone searching records about the existence and location of contaminated areas and limitations on their use; 3) zoning notices to provide notice to the city about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes, 4) an excavation/penetration permit program to provide notice to permit requestors of the extent of contamination and prohibiting or limiting excavation/penetration activity; 5) access controls to control and restrict access to workers and the public in order to prevent unauthorized uses; and 7) surveillance

2.1 SITE NAME, LOCATION, AND DESCRIPTION

Zone 1 at East Tennessee Technology Park
Oak Ridge Reservation
Oak Ridge, Tennessee
CERCLA Information System ID #TN1890090003

The 34,516-acre DOE ORR is located within and adjacent to the corporate limits of the city of Oak Ridge, Tennessee, in Roane and Anderson counties. The ORR is bounded to the east, south, and west by the Clinch River and on the north by the developed portion of the city of Oak Ridge. The ORR hosts three major industrial research and production facilities originally constructed as part of the World War II-era Manhattan Project: ETTP, formerly the K-25 Site and ORGDP; Oak Ridge National Laboratory (ORNL), formerly X-10; and the Y-12 National Security Complex (hereafter Y-12 Complex) [Fig. 2.1].

ETTP is located near the northwest corner of the ORR with more than 5000 acres considered part of ETTP. Potentially impacted areas account for roughly 2200 acres of the 5000 acres. A decision was made by the FFA parties to divide the site into smaller OUs for decision-making. The potentially impacted area of ETTP currently is divided into two areas: outside the main fence (Zone 1 - 1400 acres) and inside the main fence (Zone 2 - 800 acres) [Fig. 2.2]. Historically, Zone 1 was used for light industrial purposes and has some open areas with waste disposal. Zone 2 is the main plant area and has historically had a heavy industrial use.

Zone 1 has been divided into four project areas based on geography and previous land use: the K-901 Area, the Powerhouse Area, the Duct Island Area, and the K-1007 Ponds Area (Fig. 2.3).

The K-901 Area is located in the northwest portion of ETTP and extends around the site to the north. The area had very little industrial activity and tended to be used as a disposal area for construction debris and related materials associated with the construction and operation of the facility. The majority of this area has no evidence of disturbance. Waste disposal areas remain the primary problem today in the K-901 Area.

The Powerhouse Area is located on the Powerhouse Peninsula in the southwestern portion of ETTP. It is bounded by the Clinch River to the north, south, and west, and by Poplar Creek to the east. In the past, the Powerhouse Area has been divided into an industrialized area devoted to power production, storage, and plant infrastructure, and an unindustrialized area that has remained wooded and grassy. Today, the industrialized area is largely shut down, and a number of buildings have been decommissioned and demolished. Scrap material (e.g., 40,000 tons of scrap metal), building rubble and debris, concrete slabs from previously demolished buildings, an inactive sewage treatment facility, a capped fly ash pile, other surface features, contaminated soil, and burial areas remain in the Powerhouse Area.

The Duct Island Area constitutes the land area in the western–central portion of ETTP. Duct Island is bounded on the east, south, and west by Poplar Creek and on the north by the K-901 Area. Currently, Duct Island is covered by grass and woods, and there are no industrial activities occurring. This area was not frequently used in the past, although limited waste disposal occurred.

The K-1007 Ponds Area makes up the southeast portion of ETTP. It is bounded to the north by the main plant, State Highway 58 to the south and east, and Poplar Creek to the west. Today, the area contains large grassy areas, ponds, parking lots, and office buildings. In the past, the area was the site of several vehicle maintenance facilities and gas stations. They have been demolished.

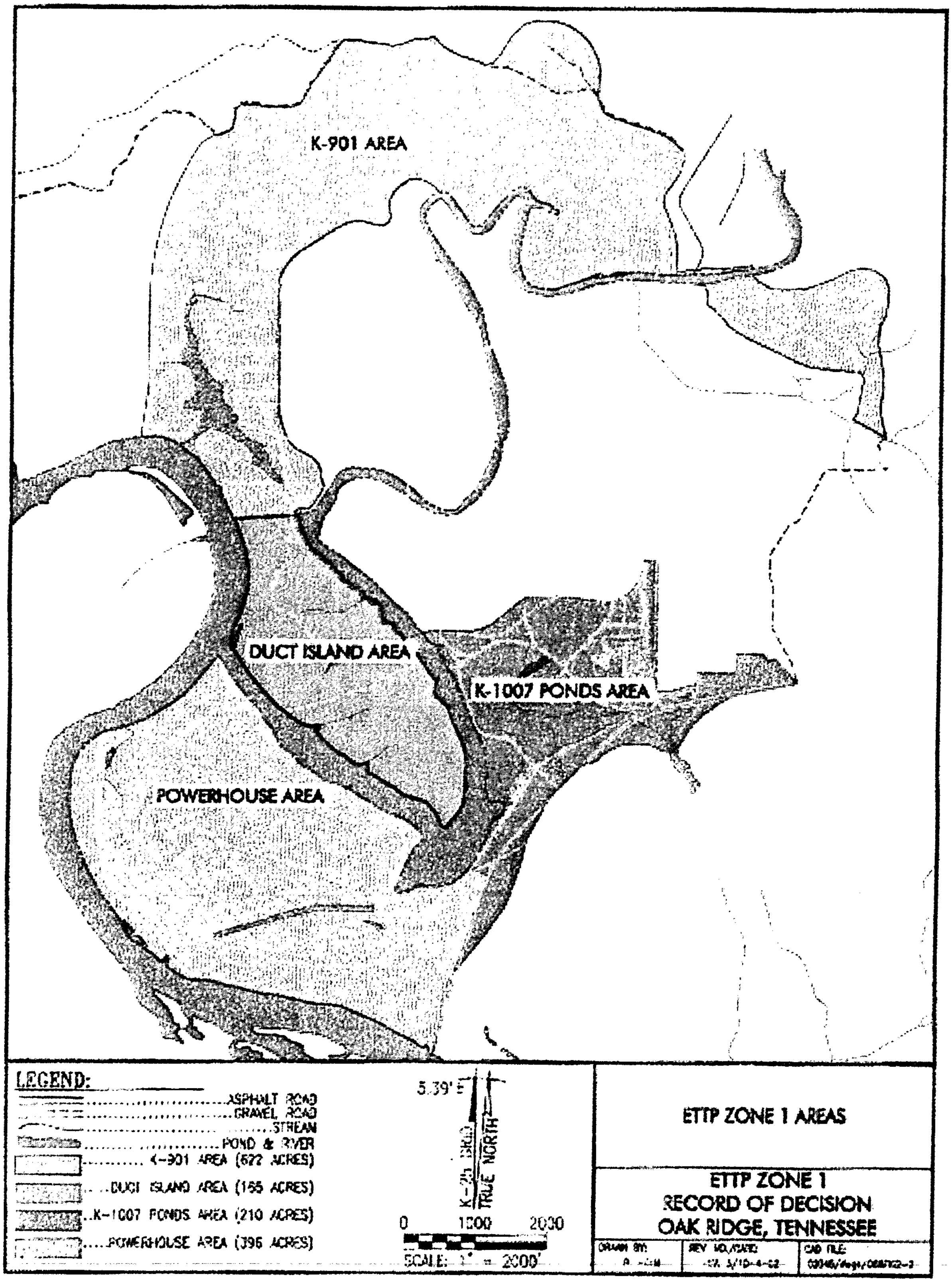

Fig. 2.3. ETTP Zone 1 project areas.

2.2.1 PREVIOUS INVESTIGATIONS AND DATA SOURCES

A comprehensive field investigation of the entire ETTP site was conducted from 1997 through 1998. This investigation resulted in a draft site-wide RI report in 1999 (DOE 1999a). This report summarized historical information as well as the results of an additional sampling effort across the site. Key historical sampling events in Zone 1 included a site-wide radiological walkover in 1994 and 1995 (also included surface soil sampling for radionuclides), sampling to support the footprint reduction program at Blair Quarry, and sampling for environmental compliance monitoring (surface water and groundwater). The RI activities included sampling for groundwater, surface soil, subsurface soil, surface water, and sediment. Other sampling summarized in the draft RI report included that associated with early actions. Since the draft RI was prepared, the Reindustrialization Program has sampled approximately 80 locations in the Powerhouse Area, 25 locations in the K-1007 Ponds Area under the Reindustrialization Parcel 3 Project, and 34 locations along the railroad tracks in the K-1007 Area. These soil samples were collected from the surface soil interval (i.e., 0 to 2 ft. bgs).

2.2.2 PREVIOUS CLEANUP DECISIONS

Previous cleanup decisions under CERCLA and other authorities have addressed, or are now addressing, some of the contamination in Zone 1, as follows:

- fish kill and cylinder removal from the K-901-A Holding Pond under an action memorandum (DOE 1997);
- excavation of the K-1070-A Burial Ground under a ROD (DOE 2000);
- demolition of two buildings in the Powerhouse Area under an action memorandum (DOE 1997);
- demolition of the Powerhouse, cooling towers, and associated buildings under categorical exclusions (DOE 1994b, 1994c, and 1994d); and
- removal of drums from the K-1085 area under an action memorandum (DOE 2001b).

2.2.3 LAND USE CONTROLS

By separate Memorandum of Understanding (MOU), EPA, TDEC, and DOE have agreed to implement facility-wide periodic site inspection, certification, and notification procedures set forth in a LUCAP (DOE, EPA, and TDEC 1999). These procedures are designed to ensure DOE maintenance of any waste-unit-specific LUCs set forth in this ROD and deemed necessary for future protection of human health and the environment. A fundamental premise underlying execution of the MOU is that, through DOE's substantial good-faith compliance with the procedures called for in the LUCAP, reasonable assurances would be provided to EPA and TDEC as to the permanency of those remedies that include the use of waste-unit-specific LUCs at the ORR.

The terms and conditions of the LUCAP, or MOU, are not specifically incorporated or made enforceable herein by reference. However, DOE, EPA, and TDEC understand and agree that the contemplated permanence of the remedy reflected herein is dependent in part on DOE's substantial good-faith compliance with the specific LUC maintenance commitments reflected in the LUCAP. Should such compliance not occur, or should the MOU be terminated, it is understood that the protectiveness of the remedy may be reconsidered; consequently, additional measures may be needed to ensure adequate and necessary future protection of human health and the environment.

2.4 SCOPE AND ROLE OF THE ACTION

The scope of the remedial actions in this interim decision is focused on the 1400-acre area designated as Zone 1 in ETTP (Fig. 2.2). This area includes waste disposal areas, open undeveloped areas, and a previously industrialized area with facilities and scrap remaining. As a result of the activities in Zone 1, surrounding media have been contaminated. This action focuses on those known sources of releases and on known areas of soil contamination.

The scope of the selected remedy also includes areas with insufficient data to determine if a release occurred or if the potential for a release is present. DOE is currently developing for approval under the FFA for the ORR (DOE 1992) the DVS for conducting final status assessments and associated data gap sampling efforts for the remaining areas of soil in Zone 1. Final status assessments consist of the collection, analysis, and evaluation of medium-specific and screening measurement data for the purpose of determining whether additional remediation is required. The DVS generally follows the guidance outlined in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) [DOE et al. 2000] and follows the U.S. Environmental Protection Agency's (EPA's) "Triad" approach (EPA 2001). MARSSIM provides prescriptive, yet flexible guidance for collecting defensible data as part of the site closeout process. The Triad approach incorporates systematic planning, dynamic techniques, and real-time measurement technologies to streamline sampling, analysis, and data management activities.

DOE and other parties involved in the final status assessments and data gap sampling activities will use the DVS to identify and eliminate data gaps and to interpret and present data ultimately leading to a remedial or No Further Action (NFA) designation (i.e., no further action for industrial use in the top 10 ft of site soils. Additional action may be required for the protection of groundwater, but groundwater-related actions are beyond the scope of this ROD). As a result of this approach, one of three recommendations will be made for each Zone 1 land area: (1) NFA, (2) remediation, or (3) data gap sampling. In all cases the ultimate goal is to release the unit for unrestricted industrial use (i.e., achieve NFA status). These decisions will be made using a combination of historical data and information, flyover maps, gamma walkover survey data, data collected as part of this ongoing effort, and other information compiled from Zone 1 studies.

The final status assessment will determine the levels and extent of residual contamination, if any, in site soils and will describe how to compare contaminant conditions with the Zone 1 soil remediation levels (RLs) presented in this ROD. The guidance found in the MARSSIM and the data quality objective (DQO) process (EPA 1994) will be used to demonstrate compliance with Zone 1 soil remediation RLs. The DVS will include a method for evaluating soil contamination levels for both radiological and non-radiological contaminants of concern (COCs). Also, the DVS will describe the data quality assessment process to be used in the Zone 1 areas. In the event the DVS approach produces recommendations that require additional remedial actions, an Explanation of Significant Differences (ESD) or ROD Amendment will be prepared. Remedial action differences, such as excavated material volume or cost increases, will be documented after implementation with an ESD. Additional remedial actions that require evaluation of alternative remedies or a no further action determination will require a ROD amendment prior to implementation.

The DVS is designed to provide flexibility to make field decisions based on real-time experience or when encountering unanticipated obstacles. Thus, conditions encountered during implementation of the DVS and findings as the survey progresses may trigger modifications to the plan. Modifications to the DVS will be justified and documented, including appropriate project approvals.

A full ecological risk assessment has not been performed for Zone 1. An ecological screening risk assessment to identify at-risk habitats, species, communities, and populations in the areas of remediation will be conducted during remedial design. A full ecological risk assessment will be completed and any necessary remedial objectives for ecological risk and remedial actions will be included in a future decision document.

The selected remedy includes contamination removal and imposition of LUCs as the overall cleanup strategy for Zone 1. Contaminant sources and contaminated soil will be removed, and LUCs will be imposed over the entire Zone 1 area, including deep soils and groundwater below the surface of Zone 1, in order to protect human health. Although the protection of ecological receptors is not an objective of this interim action, incremental improvements will occur as a result of this action.

In the event that an area of contamination presenting a significant threat to groundwater quality is discovered during soil excavation activity, DOE will take additional response actions to remove or otherwise control such contamination. Where practicable and cost-effective, such contamination will be addressed by excavation of the discovered material. Decisions on how and when to address any newly discovered groundwater contamination sources will be made on a case-by-case basis, in consultation with all parties to the FFA for this site. Groundwater use restrictions will be implemented as part of this decision to protect human health.

In addition to this ROD for interim actions in Zone 1 at the ETTP, two associated RODs are planned. One, the Zone 2 ROD, is planned to address environmental releases at the more central and industrialized portion of the ETTP. A third ROD will be developed and implemented to address site-wide groundwater contamination issues not addressed by the Zone 1 and 2 RODs.

The selected remedy will leave hazardous substances in place above risk-based levels for unrestricted use, which require land use restrictions until a final decision is made. Any future measures, including final long-term LUCs, will be addressed in a future decision document. However, the interim LUCs selected in this ROD will continue in effect and remain enforceable as part of the selected CERCLA remedy until such time as they may be changed by a future CERCLA decision.

Some of the waste areas addressed in this ROD are SWMUs [Blair Quarry-R019; K-725 Beryllium Building Soils-C004; K-770 Scrap Metal Yard-R008; K-710 Sludge Beds and Imhoff Tanks-R076; K-770 Wood Pile – C136] as defined in the RCRA Hazardous and Solid Waste Amendments of 1984 (HSWA) Permit for the ORR (#TN 001). In accordance with FFA Sect. IV (RCRA/CERCLA Coordination), the parties have agreed that for the inactive SWMUs listed in Appendix A-1 (a) of the HSWA Permit, RCRA corrective action that would otherwise be required under that permit will be deferred to the CERCLA response action process as implemented under the focused feasibility study. FFA-listed sites in Zone 1 are presented in Appendix C of this ROD, along with the ways in which that site is being addressed under this remedy.

2.5 SITE CHARACTERISTICS

Data used in characterizing Zone 1 are presented in the draft RI report (DOE 1999a) and are supplemented by Reindustrialization Program data summarized in the proposed plan (DOE 2001a). This section summarizes the data to broadly depict the primary contamination in Zone 1. Additional detailed information is provided in Appendix A.

2.5.1 AREAS OF CONCERN

Based on the data collected to date in Zone 1, only four areas of concern have been identified: Blair Quarry, miscellaneous contaminated soil (including the K-895 Cylinder Destruct Facility Area and the Powerhouse Area), scrap metal and debris in the K-770 Area, and the K-710 sludge beds and Imhoff tanks. The locations of these areas are identified on Fig. 2.4.

Blair Quarry. A remedial site evaluation sampling effort was conducted at the Blair Quarry in 1998. The quarry is a 2-acre site where historical burning and burial of miscellaneous material occurred. The site evaluation effort included constructing trenches in the area and taking 18 samples at varying depths from the content of the trenches. The deepest sample was 12 ft bgs. In addition, three surface soil samples were taken during the radiological survey activities. Samples during the remedial site evaluation were analyzed for radionuclides, polychlorinated biphenyls (PCBs), and dioxin/furans. PCBs were found up to 22 mg/kg (over 20 mg/kg in two locations from 2.5 to 3.5 ft deep) with some dioxins/furans detected in four of the samples. The radionuclides were generally present at levels below site-specific remediation levels. The exceptions were a sample that contained ^{238}U at 94 picocuries per gram (pCi/g) and two samples that contained ^{235}U at 8 to 9 pCi/g. All of these concentrations are above the average remediation levels selected by this remedy, but less than the maximum remediation levels (maximum remediation level is defined in Sect. 2.12.6 of this ROD).

Miscellaneous Soil. This area of concern includes soils from the K-770 Area scrap yard and northern portion of the Powerhouse Area (including the K-725 Beryllium Building Soils) and the soil associated with the formerly demolished K-895 Cylinder Destruct Facility in the K-901 Area.

The draft site-wide RI collected information from five borings drilled to the water table in the scrap yard/northern portion of the Powerhouse Area and analyzed for metals and radionuclides. An additional five surface soil samples were taken for the same analysis. These sample results were added to 63 surface soil samples taken during the earlier radiological walkover studies. Fifteen metals were detected above background levels, as were most radionuclides. The most prevalent radionuclides (detected in over 50% of the locations) were ^{240}Pu, ^{99}Tc, and the uranium isotopes; however, all radionuclides were only detected above background levels in the surface sampling interval. Cesium-137 was detected at a maximum of 193 pCi/g; ^{234}U at 15,200 pCi/g; ^{235}U at 1180 pCi/g; ^{238}U at 14,600 pCi/g; and ^{237}Np at 670 pCi/g. All of these radionuclide activities are considerably higher than the maximum remediation levels selected by this remedy.

During the K-901 Pond removal action, 21 soil samples were collected from around the K-895 Cylinder Destruct Facility area. Twelve of the samples were collected from different depths and analyzed for inorganic elements, radionuclides, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and PCBs. Nine surface soil samples were analyzed for radionuclides. No new samples were collected during the RI due to the extensive coverage provided by these historical samples.

No significant organic contamination was present in the samples around the K-895 Cylinder Destruct Facility area (only toluene detected at low concentrations). Likewise, the inorganic elements were usually present below background levels, and none was present above the selected remediation levels. However, the soil is contaminated with radionuclides in a few locations. Uranium-238 was as high as 7100 pCi/g; ^{235}U was as high as 171 pCi/g; ^{226}Ra was as high as 131 pCi/g; and ^{232}Th was as high as 147 pCi/g. Of the 21 samples taken, only 2 samples had concentrations above the maximum remediation levels, and they were both surfaoe soil samples. However, subsurface soils samples did exceed average remediation levels (4 out of 12 samples taken), indicating unacceptable contamination with depth is likely.

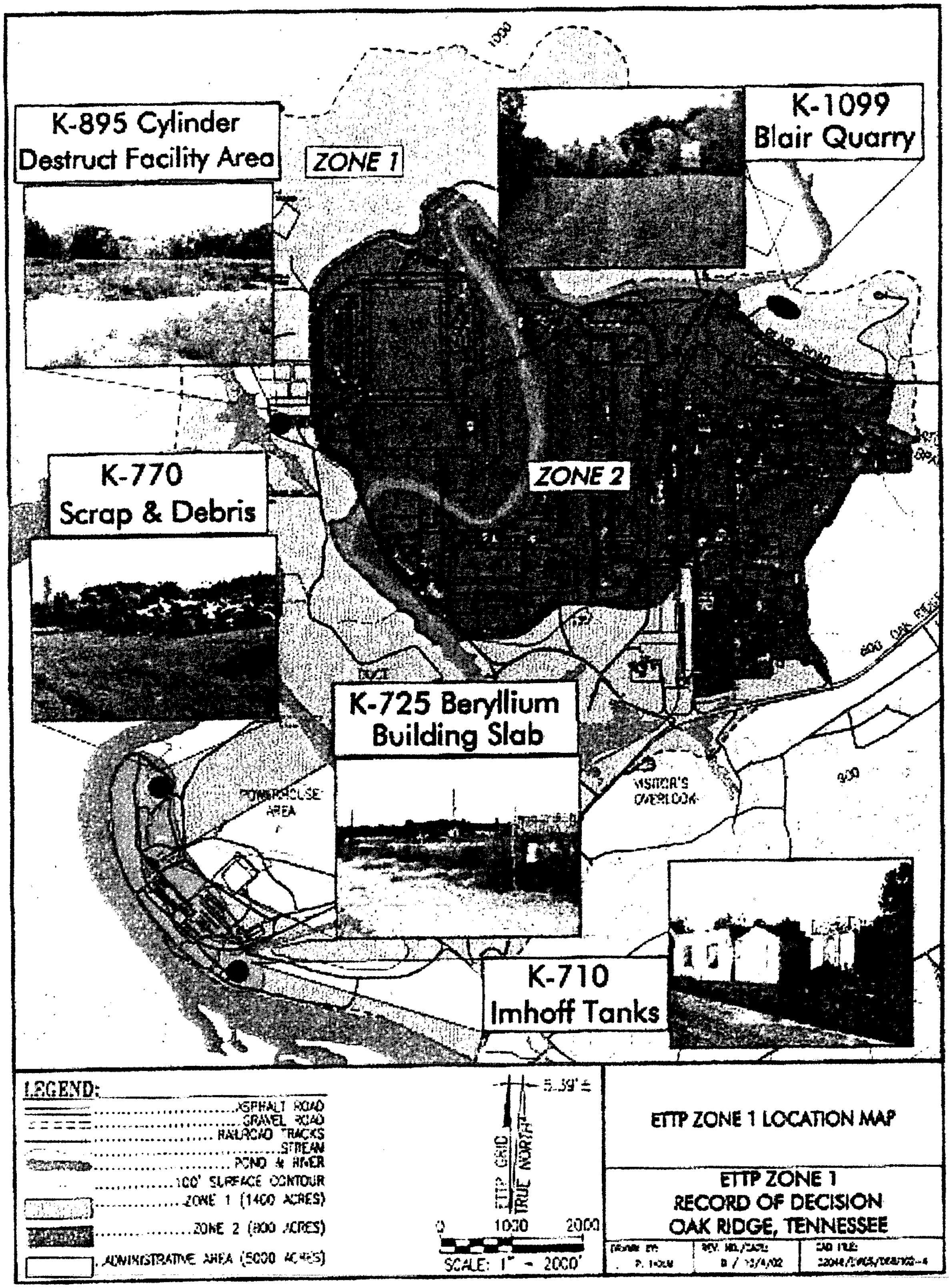

Fig. 2.4. Zone 1 areas of concern.

Scrap Metal and Debris. Early investigations in the K-770 scrap yard indicated that this area may be a source of metals and radionuclides into the environment. Associated storm drain sediment sampling during the RI indicated slightly elevated levels of radionuclides. Most of the metals were near their background levels. The maximum ^{99}Tc activity found was 42 pCi/g, and the maximum ^{234}U activity was 5 pCi/g. Neither of these radionuclide levels is sufficiently elevated to warrant remediation, but they indicate that low levels of radionuclides may be migrating from the scrap yard areas.

Soil immediately under the scrap metal and debris has not been sampled. However, the scrap metal has been scanned in the past and does have elevated levels of radioactivity. RCRA material was separated out of the scrap metal earlier, and remaining scrap metal is assumed to need to be managed as low-level waste (LLW). However, some of the debris may be a RCRA characteristic waste. Soils presently inaccessible for sampling/excavation due to the presence of the scrap metal and debris will be addressed under this ROD. DOE has assumed that these soils will require remediation. The DVS described in this ROD will be used to identify data needs and sampling requirements. Remediation of the soils will be postponed until the scrap metal and debris have been removed. Once the soil becomes accessible, remediation of the postponed contaminated soils will follow the same remedial strategy described for all other contaminated soil addressed under this ROD.

K-710 Sludge Beds and Imhoff Tanks. Based on process knowledge and known compositions of influent wastewater streams from the Powerhouse Area, the residual sludge beds and tanks were thought to be contaminated with metals, radionuclides, and PCBs. Therefore, the sludge was sampled in each bed and one of the tanks during the site-wide RI and analyzed for inorganic elements, radionuclides, and PCBs. The sample from the tank contained elevated levels of radionuclides; maximums of 39 pCi/g of ^{99}Tc and 5 pCi/g of ^{238}U. PCBs have been detected at concentrations of 120 mg/kg in the sediment in the Imhoff tanks.

Conceptual Site Model. The data compiled for the ETTP site-wide draft RI (DOE 1999a) provides information to construct a conceptual site model for the four areas of concern. The data suggest soil contamination is present at all four areas of concern that could provide a direct threat to human health. There is also limited information to suggest that contamination is migrating from the soil to groundwater. However, there is insufficient information to determine the extent of the impact and whether this migration is cause for concern. The current information suggests that impacts to groundwater are limited.

Figure 2.5 (a through c) summarizes the conceptual site models for these areas. The major pathways of concern at the K-901 Area are direct exposure to buried waste and soils. These pathways also exist at the Powerhouse Area in addition to direct exposure to scrap and surface soil under the scrap.

2.6 CURRENT AND POTENTIAL FUTURE LAND USES

In order to focus remedial planning, DOE evaluated and determined current and reasonably anticipated future land use. This allowed DOE to propose and select remedial actions protective of receptors consistent with exposure under these land use scenarios. Because this action does not address surface water or groundwater, resource uses were not evaluated.

Following the shutdown of the ETTP facility, a vision for the future use of the facility and all associated land has been developed. This vision is that ETTP becomes a commercial/industrial park with very limited DOE obligations. To facilitate the transition from a DOE-controlled uranium enrichment facility to a commercial/industrial park, significant activities need to occur. These activities include site remediation under CERCLA to bring the site to a state of protectiveness consistent with its future

I-10038-0284

DOE/OR/01-2148&D2

Waste Handling Plan, Part II for the K-770 Soils Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee

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DOE/OR/01-2162&D2

Waste Handling Plan, Part II for the ETTP Scrap Removal Project, East Tennessee Technology Park, Oak Ridge, Tennessee

This document has been approved for public release per review by:

BJC ETTP Classification & Information Control Office Date

I-10038-0175

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DOE/OR/01-2263&D1

Waste Handling Plan, Part II for the K-710 Facilities and the K-725 Concrete Slab Within Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee

APPENDIX K
EMWMF NUCLEAR CRITICALITY COMPLIANCE DOCUMENTATION

BECHTEL JACOBS
Bechtel Jacobs Company LLC

EMWMF Material Screen Calculation Worksheet

Click here to view the EMWMF Material Screen Calculation Worksheet, Rev. 0.

Title: WL 4.12 K-770 Soils and Misc. Debris		Revision No: ☒ 0 ☐ 1 ☐ 2 ☐ ___
Date: 4/14/2009	Contact: Marshall Davenport	Phone No: 576-8049

WASTE DESCRIPTION

DESCRIPTION OF THE WASTE MATERIAL: (include origin of waste, mass of waste, form and composition of waste, quantity of fissionable nuclides, types of containers, FEM calculations, etc. If information is attached, list attachments here.)

Waste Lot 4.12 consists of a total of approximately 17,500 yd^3 of primarily soil, miscellaneous debris such as embedded residual metal debris, lumber, etc. (less than 5% of waste lot), concrete (approximately 8% of waste lot), and secondary waste such as PPE, signage, plastic, hale bales, etc. ftom the K-770 Scrap Yard Soils Removal Action Project. Waste will be transported in dump trucks with an estimated 40,000 lbs per conveyance.

Radiological summary data attached (Attachment 1)? ☒ YES ☐ NO

^{235}U FEM calculation attached (Attachment 2) and signed by preparer and reviewer? ☒ YES ☐ NO

If the shipment does not meet one of the three Exemption Criteria listed below, then an NCS evaluation shall be performed to determine acceptability of the waste at EMWMF.

NOTE: This form is not required if approved NCSD addresses the waste shipment.

Enrichment Exemption Criteria

1.	Is the uranium enrichment in the shipment less than 0.90 wt% ^{235}U?	☐ YES ☐ NO
2.	Is the total activity of fissionable transuranic nuclides less than 1400 pCi/g waste?	☐ YES ☐ NO

If the answers to questions 1 and 2 are **BOTH YES**, then the shipment meets the requirements of Enrichment Exempt material and may be shipped to EMWMF with NCS concurrence noted below. Answers to questions 3 - 7 are not required.

Mass/Volume Exemption Criteria

3.	Does each waste package* contain less than 15 g ^{235}U FEM?	☐ YES ☐ NO

If the answer to question 3 is **YES**, then the material meets the requirements of Mass/Volume Exempt materials and may be shipped to EMWMF with NCS concurrence noted below. Answers to question 1, 2 and 4 through 7 are not required.

Concentration Exemption Criteria

4.	Is the fissile material concentration less than 2 g ^{235}U FEM / kg-waste? The concentration calculation shall use the highest sample value for fissile concentration and shall not include the mass of the waste container.	☒ YES ☐ NO
5.	Does the waste primarily consist of soil and/or building debris?	☒ YES ☐ NO
6.	Is the fissile material uniformly dispersed within the waste with NO concentrated deposits of fissile material?	☒ YES ☐ NO
7.	Are there NO quantities of beryllium or reactor grade graphite in excess of 1% of the mass of waste?	☒ YES ☐ NO

If the answers to questions 4 through 7 are **ALL YES**, then the shipment meets the requirements of Concentration Exempt material and may be shipped to EMWMF with NCS concurrence noted below. Answers to questions 1, 2 and 3 are not required.

I certify all information on this form is accurate and correct to the best of my knowledge.

Responsible Waste Management Lead:	[signature]	MARSHALL DAVENPORT	4/14/2009
	Signature	Print	Date

Concurrence that the information on this form meets the specified NCS exemption criterion.

NCS Engineer:	[signature]	Clyde Magin	4-14-09
	Signature	Print	Date

Concurrence that the Waste Lot specified on this form meets the EMWMF administrative WAC for NCS.

EMWMF Waste Generator Services Lead:	[signature]	Steve Kucera	4/20/09
	Signature	Print	Date

Concurrence that the Waste Lot specified on this form is acceptable for receipt at the EMWMF.

EMWMF Facility Manager:	[signature]	JEFFREY W. GRINDSTAFF	4/20/09
	Signature	Print	Date

Bechtel Jacobs Company LLC

EMWMF Material Screen Calculation Worksheet

*A waste package is defined as a container together with its contents of waste in its final form for disposal, one or more of which may constitute a shipment. Examples are (1) a single box; (2) a single drum; (3) the entire contents of a single bulk shipment. For this form, a waste package may not be smaller than 30 gallons in volume.

Click here to view *Technical Information for Delivery of Waste to the Environmental Management Waste Management Facility.*

WL 4.12 K-770 Scrap Yard Soils
EMWMF SRC Summary Statistics

SRC	Units	N	Detects	Minimum	Median	Maximum	Arithmetic Mean	PDF	LN Mean	Standard Deviation	E(X)	UCL95	HI SOF	CA SOF
Cs-137	pCi/g	57	33	0.030	0.190	28.600	0.79	B			4.90	13.07		
Co-60	pCi/g	57	5	0.030	0.080	1.870	0.13	LN	-2.426	0.748	0.12	0.14		
K-40	pCi/g	57	57	1.380	10.200	16.800	9.77	B			9.83	14.45		
Tc-99	pCi/g	57	37	1.290	4.310	629.000	20.26	B			107.92	287.20		0.627
Th-228	pCi/g	57	57	0.240	1.090	3.530	1.09	N		0.666	1.09	1.24		
Th-232	pCi/g	57	57	0.200	0.990	3.330	1.00	N		0.574	1.00	1.13		
U-233/234	pCi/g	57	56	0.110	10.200	1360.000	39.45	LN	2.061	1.626	29.50	54.43	0.000	0.017
U-235	pCi/g	57	44	0.050	1.080	185.000	5.07	LN	-0.120	1.647	3.44	6.45	0.000	0.002
U-238	pCi/g	57	57	0.430	7.650	1150.000	33.45	LN	1.841	1.659	25.00	47.09	0.017	0.021
Aluminum	mg/kg	57	57	4400.000	12300.000	21400.000	12261.05	B			12500.00	17857.28		
Antimony	mg/kg	57	35	0.115	0.500	65.100	2.01	B			11.20	29.79	0.070	
Arsenic	mg/kg	57	57	2.900	6.600	18.400	7.27	LN	1.889	0.437	7.28	8.10		
Barium	mg/kg	57	57	31.300	71.500	395.000	80.37	B			118.72	231.67	0.001	
Barium	mg/L	43	43	0.223	0.531	1.770	0.64	LN	-0.597	0.548	0.64	0.75		
Beryllium	mg/kg	57	57	0.140	0.400	1.800	0.43	B			0.59	1.12		
Boron	mg/kg	57	57	1.900	5.900	39.100	7.43	LN	1.798	0.625	7.34	8.64	0.000	
Cadmium	mg/kg	57	54	0.020	0.750	14.200	1.52	LN	-0.525	1.562	2.01	3.56		
Cadmium	mg/L	43	25	0.002	0.008	0.096	0.015	B			0.020	0.05		
Calcium	mg/kg	57	57	1860	58200	254000	79296	B			81443.33	162846.39		
Chromium	mg/kg	57	57	9.700	26.000	2880.000	102.74	B			498.95	1319.51	0.004	
Chromium	mg/L	43	7	0.002	0.006	0.030	0.01	B			0.01	0.02		
Cobalt	mg/kg	57	57	1.500	9.000	41.900	9.04	B			13.23	26.16		
Copper	mg/kg	57	57	3.500	83.000	4780.000	284.53	LN	4.226	1.722	301.00	592.50		
Iron	mg/kg	57	57	4630.000	24700.000	155000.000	27793.51	B			43071.87	90299.55		
Lead	mg/kg	57	57	2.900	36.600	733.000	60.60	LN	3.380	1.279	66.50	97.11	0.044	
Lead	mg/L	43	11	0.009	0.017	0.599	0.04	B			0.11	0.28		
Lithium	mg/kg	57	57	5.300	12.300	68.000	14.69	B			20.42	39.90		
Magnesium	mg/kg	57	57	1060.000	6350.000	73800.000	14335.61	LN	8.918	1.160	14600.00	38631.00		
Manganese	mg/kg	57	57	59.200	496.000	2210.000	618.75	LN	6.192	0.734	640.00	781.20	0.002	
Mercury	mg/kg	57	46	0.0050	0.360	4.400	0.88	LN	-1.628	2.468	4.13	7.80		
Mercury	mg/L	43	6	3.000E-05	3.000E-05	1.500E-04	4.000E-05	B			5.000E-05	8.410E-05		
Molybdenum	mg/kg	57	57	0.690	2.700	69.200	5.56	B			13.45	33.51	0.003	
Nickel	mg/kg	57	57	4.200	48.900	1700.000	127.18	LN	3.814	1.478	135.00	220.10		
Potassium	mg/kg	57	57	482.000	838.000	1940.000	880.44	B			962.330	1434.51		
Selenium	mg/kg	57	12	0.230	0.275	25.700	0.82	B			4.51	11.75	0.003	
Silver	mg/kg	57	25	0.040	0.050	1.400	0.24	B			0.27	0.66		
Sodium	mg/kg	57	50	0.750	75.400	481.000	124.410	LN	3.933	1.960	349.000	418.700		
Tin	mg/kg	42	14	15.500	23.200	232.000	37.400	B			56.700	120.000	0.026	
Vanadium	mg/kg	57	57	8.000	21.800	52.900	22.29	N		9.428	22.29	24.38	0.001	
Zinc	mg/kg	57	57	9.300	110.000	1040.000	186.21	LN	4.667	1.139	203.00	571.60		
PCB-1248	mg/kg	57	6	0.008	0.110	13.000	1.77	B			2.24	5.96		

WL 4.12 K-770 Scrap Yard Soils
EMWMF SRC Summary Statistics

SRC	Units	N	Detects	Minimum	Median	Maximum	Arithmetic Mean	PDF	LN Mean	Standard Deviation	E(X)	UCL95	HI SOF	CA SOF
PCB-1254	mg/kg	57	46	0.008	0.39	7.30	1.35	B			1.48	3.66		
PCB-1260	mg/kg	57	43	0.006	0.20	2.80	0.49	B			0.60	1.45		
Total PCBs	mg/kg	57	46	0.024	0.590	23.000	3.58	B			4.23	10.90		
2-Butanone	mg/kg	42	14	0.000	0.005	0.045	0.01	B			0.01	0.02		
2-Methylnaphthalene	mg/kg	43	30	0.020	0.071	0.300	0.10	B			0.10	0.19	0.000	
3 & 4 Methylphenol	mg/kg	43	4	0.019	0.190	0.580	0.19	B			0.23	0.41	0.001	
Acenaphthene	mg/kg	43	14	0.019	0.185	1.200	0.17	B			0.33	0.70	0.000	
Acenaphthylene	mg/kg	43	5	0.019	0.190	0.205	0.17	B			0.16	0.20	0.000	
Acetone	mg/kg	42	31	0.004	0.026	0.260	0.06	B			0.06	0.14	0.000	
Anthracene	mg/kg	43	25	0.019	0.110	3.200	0.19	B			0.61	1.54		
Benz(a)anthracene	mg/kg	43	37	0.024	0.160	10.000	0.37	B			1.78	4.65		
Benzo(a)pyrene	mg/kg	43	39	0.021	0.150	8.200	0.33	B			1.47	3.83		
Benzo(b)fluoranthene	mg/kg	43	39	0.024	0.140	7.400	0.31	B			1.33	3.46		
Benzo(ghi)perylene	mg/kg	43	39	0.035	0.140	5.500	0.26	B			1.02	2.60		
Benzo(k)fluoranthene	mg/kg	43	38	0.025	0.150	8.000	0.32	B			1.44	3.74		
Benzoic Acid	mg/kg	43	17	0.022	0.185	0.290	0.15	B			0.18	0.25	0.000	
Bis(2-ethylhexyl)phthalate	mg/kg	43	11	0.180	0.200	140.000	3.85	B			23.50	63.20		
Butyl benzyl phthalate	mg/kg	43	5	0.026	0.190	14.000	0.50	B			2.46	6.49		
Carbazole	mg/kg	43	16	0.021	0.190	1.100	0.16	B			0.31	0.66		0.000
Chrysene	mg/kg	43	39	0.020	0.160	9.700	0.38	B			1.73	4.52		
Dibenz(a,h)anthracene	mg/kg	43	27	0.019	0.080	2.200	0.16	B			0.42	1.06		
Dibenzofuran	mg/kg	43	17	0.021	0.185	0.520	0.14	B			0.21	0.38		
Di-n-octylphthalate	mg/kg	43	3	0.027	0.190	0.590	0.19	B			0.23	0.41		
Fluoranthene	mg/kg	43	39	0.025	0.180	26.000	0.83	B			4.46	11.90		
Fluorene	mg/kg	43	10	0.021	0.190	1.200	0.19	B			0.33	0.70		
Indeno(1,2,3-cd)pyrene	mg/kg	43	38	0.024	0.120	5.000	0.23	B			0.92	2.36		
Naphthalene	mg/kg	43	21	0.019	0.180	0.205	0.12	B			0.16	0.20	0.000	
Phenanthrene	mg/kg	43	38	0.029	0.170	11.000	0.45	B			1.95	5.11		
Phenol	mg/kg	43	7	0.023	0.190	1.100	0.19	B			0.31	0.66	0.000	
Pyrene	mg/kg	43	39	0.021	0.195	16.000	0.61	B			2.80	7.39		
													0.172	0.668

Notes:
SRC = Site Related Contaminant
PDF = Probability Density Function
LN = Lognormal, N = Normal, B = PERT Beta
N = Number of Samples
pCi/g = picoCurie/gram
mg/kg = milligram/kilogram
E(X) = Expected Concentration in Waste Lot
UCL95 = 95% Upper Confidence Limit on the Mean
Standard Deviation = Standard deviation from arithmetic mean for Normal distributions and standard deviation from log transformed mean for Lognormal distributions.

Waste Lot 4.12 EMWMF Material Screen

Radionuclide	Max Detect (pCi/g)	Rad Error (pCi/g)	2X Rad Error (pCi/g)	Total (pCi/g)
U-234	1360	283	566	1926
U-235	185	117	234	419
U-238	1150	246	492	1642

Waste Lot	WL 4.12	see profile
Container Mass	40,000	Pounds
	18160000	Grams

Enrichment Exemption Criteria (Questions 1 & 2)

Uranium enrichment	3.32	wt% ^{235}U
Fissionable Transuranics	0.00E+00	pCi/g

FGE/FEM Calculations for Mass/Volume Exemption Criteria (Question 3)

Nuclide	Maximum Activity (pCi/g)	$T_{1/2}$[1,2] (years)	Atomic Weight	Specific Activity[3] (ci/g)	Total grams per container (g)	Curies (Ci)	Mass (g)	^{235}U FEM Mass Factor	^{235}U FEM (g)
^{233}U		1.592E+05	233	9.642E-03	1.816E+07	0.000E+00	0.000E+00	1.4	0.000E+00
^{234}U	1926	2.460E+05	234	6.230E-03	1.816E+07	3.50E-02	5.61E+00	N/A	N/A
^{235}U	418	7.038E+08	235	2.160E-06	1.816E+07	7.61E-03	3.519E+03	1	3.52E+03
^{238}U	1642	4.460E+09	238	3.370E-07	1.816E+07	2.98E-02	8.85E+04	N/A	N/A
^{236}Np		1.550E+05	236	5.778E-03	1.816E+07	0.00E+00	0.000E+00	140	0.00E+00
^{237}Np		2.140E+06	237	7.052E-04	1.816E+07	0.00E+00	0.000E+00	0.035	0.00E+00
^{238}Pu		8.774E+01	238	1.712E+01	1.816E+07	0.00E+00	0.000E+00	0.23	0.00E+00
^{239}Pu		2.440E+04	239	6.130E-02	1.816E+07	0.00E+00	0.000E+00	1.56	0.00E+00
^{240}Pu		6.570E+03	240	2.280E-01	1.816E+07	0.00E+00	0.000E+00	0.047	0.00E+00
^{241}Pu		1.440E+01	241	1.031E+02	1.816E+07	0.00E+00	0.000E+00	3.5	0.00E+00
^{242}Pu		3.760E+05	242	3.931E-03	1.816E+07	0.00E+00	0.000E+00	0.018	0.00E+00
^{241}Am		4.330E+02	241	3.430E+00	1.816E+07	0.00E+00	0.000E+00	0.044	0.00E+00
^{242m}Am		1.520E+02	242	9.724E+00	1.816E+07	0.00E+00	0.000E+00	84.0	0.00E+00
^{243}Am		7.370E+03	243	1.997E-01	1.816E+07	0.00E+00	0.000E+00	0.028	0.00E+00
^{243}Cm		2.910E+01	243	5.058E+01	1.816E+07	0.00E+00	0.000E+00	7.8	0.00E+00
^{244}Cm		1.810E+01	244	8.098E+01	1.816E+07	0.00E+00	0.000E+00	0.23	0.00E+00
^{245}Cm		8.500E+03	245	1.718E-01	1.816E+07	0.00E+00	0.000E+00	23.0	0.00E+00
^{247}Cm		1.560E+07	247	9.282E-05	1.816E+07	0.00E+00	0.000E+00	0.78	0.00E+00
^{249}Cf		3.510E+02	249	4.092E+00	1.816E+07	0.00E+00	0.000E+00	70.0	0.00E+00
^{251}Cf		9.000E+02	251	1.583E+00	1.816E+07	0.00E+00	0.000E+00	140.0	0.00E+00
									3.52E+03 g Total ^{235}U FEM

Concentration Exemption Criteria (Questions 4-7)

Nuclide	Maximum Activity (pCi/g)	Convert Ci/g	NA	Specific Activity[3] (ci/g)	g U/g-waste	^{235}U FEM Mass Factor	^{235}U FEM (g)	g ^{235}U FEM/ kg-waste
^{233}U	0	0	NA	9.64E-03	0.00E+00	1.4	0.00E+00	0.00E+00
^{235}U	418	4.18E-10	NA	2.16E-06	1.94E-04	1.0	1.94E-04	1.94E-01
^{236}Np	0	0	NA	5.78E-03	0.00E+00	140.0	0.00E+00	0.00E+00
^{237}Np	0	0	NA	7.05E-04	0.00E+00	0.035	0.00E+00	0.00E+00
^{238}Pu	0	0	NA	1.71E+01	0.00E+00	0.23	0.00E+00	0.00E+00
^{239}Pu	0	0	NA	6.13E-02	0.00E+00	1.56	0.00E+00	0.00E+00
^{240}Pu	0	0	NA	2.27E-01	0.00E+00	0.047	0.00E+00	0.00E+00
^{241}Pu	0	0	NA	1.03E+02	0.00E+00	3.5	0.00E+00	0.00E+00
^{242}Pu	0	0	NA	3.93E-03	0.00E+00	0.018	0.00E+00	0.00E+00
^{241}Am	0	0	NA	3.43E+00	0.00E+00	0.044	0.00E+00	0.00E+00
^{242m}Am	0	0	NA	9.72E+00	0.00E+00	84.0	0.00E+00	0.00E+00
^{243}Am	0	0	NA	2.00E-01	0.00E+00	0.028	0.00E+00	0.00E+00
^{243}Cm	0	0	NA	5.06E+01	0.00E+00	7.8	0.00E+00	0.00E+00
^{244}Cm	0	0	NA	8.10E+01	0.00E+00	0.23	0.00E+00	0.00E+00
^{245}Cm	0	0	NA	1.72E-01	0.00E+00	23.0	0.00E+00	0.00E+00
^{247}Cm	0	0	NA	9.28E-05	0.00E+00	0.78	0.00E+00	0.00E+00
^{249}Cf	0	0	NA	4.09E+00	0.00E+00	70.0	0.00E+00	0.00E+00
^{251}Cf	0	0	NA	1.58E+00	0.00E+00	140.0	0.00E+00	0.00E+00
								1.94E-01 Total g ^{235}U FEM/kg-waste

[1] Isotope half-lives taken from LA-12846-MS except for ^{236}Np, ^{243}Cm, ^{244}Cm, ^{247}Cm, ^{249}Cf, and ^{251}Cf

[2] ^{236}Np, ^{243}Cm, ^{244}Cm, ^{247}Cm, ^{249}Cf, and ^{251}Cf half-lives taken from "Nuclides and Isotopes. Fourteenth Edition", GE Nuclear Energy

[3] Formula for specific activity taken from LA-12846-MS

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Date: 12/30/08

Reviewed By:

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