MUNITIONS AND EXPLOSIVES OF CONCERN
RISK ASSESSMENT AND ALTERNATIVES ANALYSIS

FOR

OPEN DETONATION GROUNDS

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C.1 BACKGROUND

C.1.1 A qualitative risk assessment was conducted to evaluate explosive hazards to human receptors. A risk from explosive hazards exists at an MRS if there is a complete MEC exposure pathway, consisting of a receptor that can come near or into contact with MEC and interact with the item in a manner that might result in its detonation. For this reason, the risk depends upon the presence of three critical elements, all of which must be present for a risk to exist from explosive hazards (i.e., there is no risk if any one of these three elements is absent). These three critical elements are:

(1) A *source* of MEC (i.e., an explosively hazardous item);

(2) A *receptor* (i.e., a person); and

(3) The *potential for harmful outcome resulting from interaction between the MEC source and the receptor* (i.e., the possibility a receptor encounters the MEC item and causes energy to be imparted on it resulting in an unintentional detonation).

C.1.2 The qualitative risk assessment technique presented here follows the "*Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop RAOs for MRSs*" (USACE, 2017), hereafter referred to as the "Decision Logic to Assess Risks." The Decision Logic to Assess Risks provides an assessment of the explosive hazards associated with MEC at an MRS by analyzing MRS-specific conditions and human issues that affect the likelihood that a MEC accident will occur. The Decision Logic to Assess Risks focuses on risks to human receptors and does not directly address environmental or ecological concerns that might be associated with MEC. The Decision Logic to Assess Risks is described in a final study paper that was established as interim guidance by USACE on January 3, 2017 for a two-year trial period. The method uses input data based on historical documentation, field observations, and results of previous studies and removal actions. Most importantly, the Decision Logic to Assess Risks provides a means to evaluate site-specific factors with regard to explosive hazards at an MRS and differentiate acceptable versus unacceptable conditions.

C.1.3 The risk assessment presented below was conducted to evaluate the baseline conditions for the MRS regarding risks associated with explosive hazards and to evaluate the changes to the risks that would result from implementation of the response alternatives presented in the FS Report. This baseline risk assessment provides the basis for the evaluation and implementation of effective management response alternatives for mitigating unacceptable risks. The risk assessment also supports hazard communication among stakeholders by organizing MRS information in a consistent manner for the hazard management decision-making process.

C.2 ADDRESSING MULTIPLE RISK SCENARIOS

C.2.1 The Decision Logic to Assess Risks is applied to all portions of an MRS. However, the MEC-related characteristics of discrete areas within an MRS may differ regarding the munitions types and quantities, land uses, receptors, and other factors. If these factors differ significantly, the qualitative risks associated with explosive hazards in the discrete areas are also likely to vary. For example, the characteristics of a range impact area and its safety fan are likely to differ regarding the amount of MEC potentially present or different land use activities may exist that create differing potentials for MEC interaction with human receptors within a large maneuver area. Additionally, the current and future land uses at an MRS or part of an MRS may differ, which

might also affect the qualitative risks associated with explosive hazards. Finally, different levels of risk may also result in different response alternatives being appropriate for these discrete areas.

C.2.2 For these reasons, there may be multiple possible risk scenarios within the MRS and it may be appropriate to evaluate them separately. In such cases, two or more distinct risk scenarios may be identified, each of which will be the subject of a separate application of the Decision Logic to Assess Risks. However, if a project site is likely to be the subject of only one response alternative (e.g., the MRS is small), it may be evaluated using a single risk scenario despite the potential for differing risk-related characteristics. In this event, the most conservative input factors (see below) should be selected for purposes of the Decision Logic to Assess Risks. A determination regarding risk scenarios is made for each MRS subject to the risk assessment.

C.3 OVERVIEW OF INPUT FACTORS FOR DECISION LOGIC TO ASSESS RISKS FROM EXPLOSIVE HAZARDS

C.3.1 The Decision Logic to Assess Risks (USACE, 2017) uses three matrices (Matrices 1 through 3) to support the risk evaluation for each risk scenario. To complete the baseline risk assessment for the explosive hazards under each risk scenario, input factors for the three matrices are reviewed and suitable categories are selected based on historical documentation and data results. These matrices are related to the three critical elements noted previously and are:

- **Likelihood of Encounter (Matrix 1)**, which is based on the input factors:
  - *Amount of MEC* (i.e., how much MEC is there at the site?).
  - *Accessibility* (i.e., how likely are human receptors to contact MEC at the site based on access conditions and frequency of use?).
- **Severity of Incident (Matrix 2)**, which is based on the input factors:
  - *Likelihood of encounter* (see first bullet above).
  - *Severity Associated with Detonation of Specific Munitions* (i.e., if someone encounters MEC and it detonates, how many people might be injured and how seriously?).
- **Likelihood of Detonation (Matrix 3)**, which is based on the input factors:
  - *Sensitivity/Susceptibility to Detonation* (i.e., how sensitive is the fuzing of the MEC?).
  - *Likelihood to Impart Energy on an Item* (i.e., what are the activities involved that might result in human receptors encountering MEC at the site?).

C.3.2 A fourth matrix (Matrix 4) combines the results of the other matrices to differentiate acceptable versus unacceptable conditions regarding risk from explosive hazards.

- **Matrix 4: Acceptable and Unacceptable Site Conditions**, which is based on the:
  - *Severity of Incident* (i.e., output of Matrix 2).
  - *Likelihood of Detonation* (i.e., output of Matrix 3).

C.3.3 The four risk matrices and the input factors required to complete the risk assessment are described below, though more complete details and explanations are provided in the Decision Logic to Assess Risks (USACE, 2017).

C.3.4 *Matrix 1, Likelihood of Encounter*: This is dependent on two input factors, the *amount of MEC* items known or suspected to exist, and *access conditions* (e.g., accessibility and

frequency of use). "Amount of MEC" is determined using site specific characterization data or anticipated or completed results of a remedial action. Although the scale emphasizes the results of distribution, the selection may also include consideration of available historical information, such as former uses. "Access Conditions" are selected based on considerations of the access and frequency of use for the MRS. The selection considers "Accessibility" (i.e., how easily human receptors can gain access to the area), but also considers other relevant conditions, such as topography, terrain, specific land use, and specific potential receptors via defined pathways to establish access conditions as a frequency of use. Matrix 1 is shown in **Table C.1**.

Table C.1
Decision Logic to Assess Risks, Matrix 1: Likelihood of Encounter

Likelihood of Encounter (Amount of MEC versus Access Conditions)			Access Conditions (frequency of use)			
			Regular (e.g., daily use, open access)	**Often** (e.g., less regular or periodic use, some access)	**Intermittent** (e.g., some irregular use, or limited access)	**Rare** (e.g., very limited use, access prevented)
Amount of MEC	I	MEC are visible on surface and detected in subsurface	Frequent	Frequent	Likely	Occasional
	II	MEC are known (i.e., *confirmed*) or suspected (e.g., *MD indicative of MEC is identified*) to be present on surface and in subsurface	Frequent	Likely	Occasional	Seldom
	III	• There is physical evidence of MEC, or • MEC concentration (e.g., MEC/acre) is below a project-specific threshold that supports this selection	Likely	Occasional	Seldom	Unlikely
	IV	• MEC presence is based on isolated historical discoveries (e.g., Explosive Ordnance Disposal report) prior to investigation, or • A DERP response action has been conducted to physically remove MEC and known or suspected MEC remains to support this selection (e.g., surface MEC removal where subsurface MEC has not been addressed), or • MEC concentration (e.g., MEC/acre) is below a project-specific threshold that supports this selection	Occasional	Seldom	Unlikely	Unlikely
	V	• MEC presence is suspected based on historical evidence of munitions use only, or • A DERP response action has been conducted to physically remove surface and subsurface MEC (evidence some residual hazard remains to support this selection), or • MEC concentration (e.g., MEC/acre) is below a project-specific threshold that supports this selection	Seldom	Seldom	Unlikely	Unlikely
	VI	• Investigation of the area did not identify evidence of MEC presence, or • A DERP response action has been conducted that will achieve unrestricted use/unlimited exposure (UU/UE)	Unlikely	Unlikely	Unlikely	Unlikely

C.3.5 *Matrix 2, Severity of Incident*: This factor relates "Likelihood of Encounter" from Matrix 1 (see above) to the severity of an unintentional detonation. Unlike the two factors affecting the likelihood of encounter in Matrix 1, the "Severity" factor in Matrix 2 is a static characteristic of each of the munitions known or suspected to exist at the site. Matrix 2 is shown in **Table C.2**.

Table C.2
Decision Logic to Assess Risks, Matrix 2: Severity of Incident

Severity of Explosive Incident (Severity versus Likelihood of Encounter)		Likelihood of Encounter (from Matrix 1)				
		Frequent	Likely	Occasional	Seldom	Unlikely
Severity Associated with Specific Munitions Items	**Catastrophic/Critical**: May result in one or more deaths, permanent total or partial disability, or hospitalization	A	A	B	B	D
	Modest: May result in one or more injuries requiring emergency medical treatment, without hospitalization	B	B	B	C	D
	Minor: May result in one or more injuries requiring first aid or medical treatment, without hospitalization	B	C	C	C	D
	Improbable: No injury anticipated	D	D	D	D	D

C.3.6 *Matrix 3, Likelihood of Detonation*: This factor relates the sensitivity of site specific munitions items to the likelihood of energy being imparted on an item, such that the interaction results in detonation (i.e., a MEC incident). MEC sensitivity and the likelihood for energy imparted during an encounter are both specific to the CSM. The "sensitivity" of a munitions item is inherent to the known or suspected munitions present at the site. The "likelihood to impart energy" is selected based on the known activities at the site that may cause an interaction that results in energy being imparted on a munitions item by human activity. Matrix 3 is shown in **Table C.3**.

Table C.3
Decision Logic to Assess Risks, Matrix 3: Likelihood of Detonation

Likelihood of Detonation (Munitions Sensitivity versus Likelihood of Energy to be Imparted)		Likelihood to Impart Energy on an Item		
		High (e.g., areas planned for development, or seasonally tilled)	**Modest** (e.g., undeveloped wildlife refuge, parks)	**Inconsequential** (e.g., not anticipated, prevented, mitigated)
Sensitivity: Susceptibility to Detonation	**High** (e.g., classified as sensitive)	1	1	3
	Moderate (e.g., HE or pyrotechnics)	1	2	3
	Low (e.g., propellant or bulk secondary explosives)	1	3	3
	Not Sensitive	2	3	3

C.3.7 *Matrix 4, Acceptable and Unacceptable Site Conditions*: The final matrix represents the overall risk for the site and differentiates "acceptable" from "unacceptable" conditions. This is determined based on the likelihood of an encounter (Matrix 1), with consideration given to the severity of the incident (Matrix 2), combined with the likelihood of an interaction that results in detonation (Matrix 3). For example, a result of "A" from Matrix 2 and "3" from Matrix 3 indicates "Unacceptable" site conditions for risks when cross-referenced on Matrix 4. The overall risk for this selection is driven by a "frequent" or "likely" encounter (Matrix 1) with a potentially catastrophic munitions item (Matrix 2), even though the likelihood of a detonation (Matrix 3) is low ("3") based on sensitivity and likelihood to impart energy on the item. Matrix 4 is shown in **Table C.4**.

Table C.4
Decision Logic to Assess Risks, Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result from Matrix 2			
		A	B	C	D
Result from Matrix 3	1	**Unacceptable**	**Unacceptable**	**Unacceptable**	Acceptable
	2	**Unacceptable**	**Unacceptable**	Acceptable	Acceptable
	3	**Unacceptable**	Acceptable	Acceptable	Acceptable

C.3.8 At the end of characterization, the result from Matrix 4 is used to differentiate unacceptable from acceptable risk conditions. If an acceptable risk scenario is identified and concurred by the project team and stakeholders, then it may be possible to recommend no further action to address explosive hazards at the site. Where an unacceptable risk scenario is identified as the baseline condition, a remedial response is required to address risks from explosive hazards. In these situations, the matrices is used as part of the FS to identify remedial responses that will ultimately achieve acceptable conditions. A summary of this process is depicted in **Figure C.1**.

C.4 BASELINE RISK SCENARIOS

C.4.1 Description of Risk Scenarios – OD Ground MRS

C.4.1.1 *Overview*: A qualitative baseline risk assessment of hazards posed by MEC was developed for OD Hill by reviewing each of the input factors for the Decision Logic to Assess Risks described in Subchapter C.3 above. Historical data available from prior studies were used to determine the appropriate categories for each input factor. Selection of these categories for the OD Hill is discussed in the following paragraphs.

C.4.1.2 *Risk Scenarios*: The CSM for the OD Grounds MRS identifies two separate areas related to MEC contamination and planned future remediation: "OD Hill," and the "Kickout Area." Potential contamination related to UXO and DMM was identified in both the OD Hill and Kickout Area of the OD Grounds MRS. However, the amount of contamination related to UXO and DMM is higher for the OD Hill than the Kickout Area of the OD Grounds MRS and this is likely to influence the relative explosives hazards in both areas. For this reason, separate baseline risk scenarios will be evaluated for the OD Hill and Kickout Area.

C.4.1.3 Additionally, it is the ultimate goal of the Army to transfer the property containing the OD Grounds MRS out of DOD control; therefore, it is also anticipated that the land uses and associated receptors will change between the current use conditions at the property (i.e., under DOD control), and the planned future property use (as a Conservation/Recreation Area). For this reason, baseline risk scenarios will be evaluated for both current and future conditions at both the OD Hill and Kickout Area.

C.4.2 Baseline Decision Logic to Assess Risks from Explosive Hazards – OD Hill Area

C.4.2.1 *Matrix 1, Likelihood of Encounter*: Based on the CSM, MEC in the form of UXO and DMM are almost certain to exist subsurface and can be suspected to be present on the surface at the OD Hill. Therefore, the "**Amount of MEC**" for the OD Hill is determined to be "*Category II*". A "*Category I*" rating is not considered appropriate for this area because the surface of the OD Hill has been cleared during previous investigations; therefore, no MEC is anticipated to be visible on the surface. The OD Grounds MRS is located on a closed installation and Army operations at the site have ceased. A fence is present around the property containing the MRS, however, the fence is not monitored. Hunting is performed in the area. The deer hunting season begins in mid-November and ends during the second week of December. Based on these land uses, the "**Access Conditions**" for the OD Hill is determined to be "*Intermittent*" (i.e., some irregular use, or limited access) under current conditions with a possible change to "*Often*" (i.e., less regular or periodic use, some access) in the future during planned use as a conservation/recreation area. Evaluating these input factors on Matrix 1 results in a "**Likelihood of Encounter**" of "*Occasional*" for current and "*Likely*" for future conditions at the OD Hill.

C.4.2.2 *Matrix 2, Severity of Incident*: Evidence of UXO/DMM presence at the OD Hill included 2.36" High Explosive Anti-Tank (HEAT) Rocket Warhead (UXO), 75mm, 57mm, and 40mm projectiles (UXO), and M72 LAW Rocket Warheads (UXO). A MEC incident involving any of these munitions may result in one or more deaths, permanent total or partial disability, or hospitalization, and so the "**Severity Associated with Specific Munitions Items**" is determined to be "*Catastrophic/Critical*" for the OD Hill. The "**Likelihood of Encounter**" from Matrix 1 (see above) was determined to be "*Occasional*" for current use, and "*Likely*" for future use. Evaluating these input factors on Matrix 2 results in a "**Severity of Incident**" of "*B*" for current use, and a "**Severity of Incident**" of "*A*" for future use.

C.4.2.3 *Matrix 3, Likelihood of Detonation*: As described above, evidence of UXO/DMM presence at the OD Hill included 2.36" HEAT Rocket Warhead (UXO). The "**Sensitivity: Susceptibility to Detonation**" for the OD Hill is determined to be "*High*" based on the presence of HEAT munitions. The "**Likelihood to Impart Energy on an Item**" for the OD Hill is determined to be "*Inconsequential*" under current site conditions for three reasons: (1) intrusive activities are currently restricted to those following appropriate safety protocols; (2) the only allowed activity that could impart energy to UXO or DMM is walking over the site, but the previously completed surface clearance has removed all UXO and DMM that might have been susceptible to detonation via walking activities; and (3) current site access procedures include UXO safety education which stress the 3Rs. If the land is transferred without use restrictions in place, future land use could include plowing/tilling of food plots as part of the habitat development at the conservation/recreation area; therefore, the "**Likelihood to Impart Energy on an Item**" for the OD Hill must be conservatively assumed to be "*High*" under future site conditions. Based on the categories described above, the "**Likelihood of Detonation**" for the OD Hill is determined to be "*3*" under current conditions and "*1*" under future conditions.

C.4.2.4 *Matrix 4, Acceptable and Unacceptable Site Conditions*: As described above, the "**Severity of Incident**" (Matrix 2) for OD Hill was determined to be "*B*" for current use, and a "*A*" for future use while the "**Likelihood of Detonation**" (Matrix 3) was determined to be "*3*" under current conditions and "*1*" under future conditions. Evaluating the inputs of "*B-3*" and "*A-1*" on Matrix 4 indicates the overall risk from explosive hazards is "*Acceptable*" at the OD Hill under current conditions but is "Unacceptable" under future conditions. **Exhibits C.1 and C.2** summarize the matrix inputs and outputs for the OD Hill current and future conditions risk scenario, respectively.

C.4.3 Baseline Decision Logic to Assess Risks from Explosive Hazards – Kickout Area

C.4.3.1 *Matrix 1, Likelihood of Encounter*: Based on the CSM, MEC in the form of UXO and DMM have been confirmed on the surface and subsurface at the Kickout Area. Therefore, the "**Amount of MEC**" for the Kickout Area is determined to be "*Category I*". A "*Category I*" rating is appropriate for this area because the surface has not been completely cleared; and UXO/DMM have been confirmed on the surface during prior actions. The OD Grounds MRS is located on a closed installation and Army operations at the site have ceased. A fence is present around the property containing the MRS, however, the fence is not monitored. Hunting is performed in the area. The deer hunting season begins in mid-November and ends during the second week of December. Based on these land uses, the "**Access Conditions**" for the Kickout Area is determined to be "*Intermittent*" (i.e., some irregular use, or limited access) under current conditions with a change to "*Often*" (i.e., less regular or periodic use, some access) in the future during planned use as a conservation/recreation area. Evaluating these input factors on Matrix 1 results in a "**Likelihood of Encounter**" of "*Likely*" for current and "*Frequent*" for future conditions at the Kickout Area.

C.4.3.2 *Matrix 2, Severity of Incident*: Many different types of UXO/DMM items have been identified at the Kickout Area including a 75mm HE projectile, 2.75-inch rockets, 106mm HEAT projectiles along with MD from munitions types including bombs, grenades, mines, mortars, rockets, projectiles, and fuzes. A MEC incident involving many of these munitions may result in one or more deaths, permanent total or partial disability, or hospitalization, and so the "**Severity Associated with Specific Munitions Items**" is determined to be "*Catastrophic/Critical*" for the Kickout Area. The "**Likelihood of Encounter**" from Matrix 1 (see above) was determined to be "*Likely*" for current use, and "*Frequent*" for future use. Evaluating these input factors on Matrix 2 results in a "**Severity of Incident**" of "*A*" for current use and for future use.

C.4.3.3 *Matrix 3, Likelihood of Detonation*: As described above, evidence of UXO/DMM presence at the Kickout Area included 106mm HEAT projectiles. The "**Sensitivity: Susceptibility to Detonation**" for the Kickout Area is determined to be "*High*" based on the presence of HEAT munitions. The "**Likelihood to Impart Energy on an Item**" for the Kickout Area is determined to be "*Modest*" under current site conditions, because while intrusive or high energy activities are restricted to those following appropriate safety protocols, items may remain on the surface where receptors may impart energy on the item. A rating of "*Modest*" is typically selected for undeveloped wildlife refuges and parks. Future land use would include plowing/tilling of food plots as part of the habitat development at the conservation/recreation area; therefore, the "**Likelihood to Impart Energy on an Item**" for the Kickout Area is determined to be "*High*" under future site conditions. Based on the categories described above, the "**Likelihood of Detonation**" for the OD Hill is determined to be "*3*" under current conditions and "*1*" under future conditions.

C.4.3.4 *Matrix 4, Acceptable and Unacceptable Site Conditions*: As described above, the "**Severity of Incident**" (Matrix 2) for Kickout Area was determined to be "*A*" for both current and future use while the "**Likelihood of Detonation**" (Matrix 3) was determined to be "*3*" under current conditions and "*1*" under future conditions. Evaluating the inputs of "*A-3*" and "*A-1*" on Matrix 4 indicates the overall risk from explosive hazards is "*Unacceptable*" at the Kickout Area under current and future conditions. **Exhibits C.3 and C.4** summarize the matrix inputs and outputs for the Kickout Area under current and future conditions risk scenario, respectively.

C.4.4 Summary of Results for OD Ground MRS

C.4.4.1 A summary of the results for the subareas and use scenarios at the OD Grounds MRS are presented in **Table C.5**. As described in the previous subchapters, the evaluation conducted using the Decision Logic to Assess Risks indicates the overall risk from explosive hazards is "*Acceptable*" at the OD Hill and "*Unacceptable*" in the kickout area under current conditions. The main difference between the OD Hill area and the Kickout Area is that in the OD Hill Area no MEC are expected on the surface while MEC are expected on the surface in the Kickout Area. The indicated overall risk from explosive hazards is "*unacceptable*" in both the OD Hill and the Kickout Area under the anticipated future land use conditions.

Table C.5
Decision Logic to Assess Risks, Summary of Results for OD Grounds Current and Future Conditions

MRS/Area	Risk Scenario	UXO and DMM	Receptors	Exposure Pathways	Baseline Risk Condition (Matrix 4)	Risks from Explosive Hazards
OD Hill	Current conditions	UXO and DMM likely To many munitions types to list.	*Current*: Site workers	Potentially Complete	B-3	Acceptable
	Future conditions	UXO and DMM likely To many munitions types to list.	*Future*: Site workers, site visitors, and possible plowing of feed plots by site workers	Potentially Complete	A-1	**Unacceptable**
Kickout Area	Current conditions	UXO and DMM likely To many munitions types to list.	*Current*: Site workers	Potentially Complete	A-3	**Unacceptable**
	Future conditions	UXO and DMM likely To many munitions types to list.	*Future*: Site workers, site visitors, and possible plowing of feed plots by site workers	Potentially Complete	A-1	**Unacceptable**

Exhibit C.1
Summary of Decision Logic Evaluation Results for the OD Hill Area
Current Use Conditions Risk Scenario
Seneca Army Depot Activity, Open Detonation Grounds

Matrix 1: Likelihood of Encounter

Likelihood of Encounter *(Amount of MEC versus Access Conditions)*		Access Conditions (frequency of use)			
		Regular	**Often**	**Intermittent**	**Rare**
Amount of MEC	**Category I (Most)**	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	Occasional	Seldom
	Category III	Likely	Occasional	Seldom	Unlikely
	Category IV	Occasional	Seldom	Unlikely	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2: Severity of Incident

Severity of Explosive Incident *(Severity vs. Likelihood of Encounter)*		Likelihood of Encounter (from Matrix 1)				
		Frequent	**Likely**	**Occasional**	**Seldom**	**Unlikely**
Severity	**Catastrophic/Critical**	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Matrix 3: Likelihood of Detonation

Likelihood of Detonation *(Sensitivity vs. Likelihood to Impart Energy)*		Likelihood to Impart Energy on an Item		
		High	**Modest**	**Inconsequential**
Sensitivity	**High**	1	1	3
	Moderate	1	2	3
	Low	1	3	3
	Not Sensitive	2	3	3

Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result from Matrix 2			
		A	**B**	**C**	**D**
Result from Matrix 3	**1**	**Unacceptable**	**Unacceptable**	**Unacceptable**	Acceptable
	2	**Unacceptable**	**Unacceptable**	Acceptable	Acceptable
	3	**Unacceptable**	Acceptable	Acceptable	Acceptable

Exhibit C.2
Summary of Decision Logic Evaluation Results for the OD Hill Area
Future Use Conditions Risk Scenario
Seneca Army Depot Activity, Open Detonation Grounds

Matrix 1: Likelihood of Encounter

Likelihood of Encounter *(Amount of MEC versus Access Conditions)*		Access Conditions (frequency of use)			
		Regular	Often	Intermittent	Rare
Amount of MEC	Category I (Most)	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	Occasional	Seldom
	Category III	Likely	Occasional	Seldom	Unlikely
	Category IV	Occasional	Seldom	Unlikely	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2: Severity of Incident

Severity of Explosive Incident *(Severity vs. Likelihood of Encounter)*		Likelihood of Encounter (from Matrix 1)				
		Frequent	Likely	Occasional	Seldom	Unlikely
Severity	Catastrophic/Critical	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Matrix 3: Likelihood of Detonation

Likelihood of Detonation *(Sensitivity vs. Likelihood to Impart Energy)*		Likelihood to Impart Energy on an Item		
		High	Modest	Inconsequential
Sensitivity	High	1	1	3
	Moderate	1	2	3
	Low	1	3	3
	Not Sensitive	2		3

Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result from Matrix 2			
		A	B	C	D
Result from Matrix 3	1	Unacceptable	Unacceptable	Unacceptable	Acceptable
	2	Unacceptable	Unacceptable	Acceptable	Acceptable
	3	Unacceptable	Acceptable	Acceptable	Acceptable

Exhibit C.3
Summary of Decision Logic Evaluation Results for the Kickout Area
Current Use Conditions Risk Scenario
Seneca Army Depot Activity, Open Detonation Grounds

Matrix 1: Likelihood of Encounter

Likelihood of Encounter *(Amount of MEC versus Access Conditions)*		Access Conditions (frequency of use)			
		Regular	Often	Intermittent	Rare
Amount of MEC	Category I (Most)	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	Occasional	Seldom
	Category III	Likely	Occasional	Seldom	Unlikely
	Category IV	Occasional	Seldom	Unlikely	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2: Severity of Incident

Severity of Explosive Incident *(Severity vs. Likelihood of Encounter)*		Likelihood of Encounter (from Matrix 1)				
		Frequent	Likely	Occasional	Seldom	Unlikely
Severity	Catastrophic/Critical	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Matrix 3: Likelihood of Detonation

Likelihood of Detonation *(Sensitivity vs. Likelihood to Impart Energy)*		Likelihood to Impart Energy on an Item		
		High	Modest	Inconsequential
Sensitivity	High	1	1	3
	Moderate	1	2	3
	Low	1	3	3
	Not Sensitive	2	3	3

Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result from Matrix 2			
		A	B	C	D
Result from Matrix 3	1	Unacceptable	Unacceptable	Unacceptable	Acceptable
	2	Unacceptable	Unacceptable	Acceptable	Acceptable
	3	Unacceptable	Acceptable	Acceptable	Acceptable

Exhibit C.4
Summary of Decision Logic Evaluation Results for the Kickout Area
Future Use Conditions Risk Scenario
Seneca Army Depot Activity, Open Detonation Grounds

Matrix 1: Likelihood of Encounter

Likelihood of Encounter *(Amount of MEC versus Access Conditions)*		Access Conditions (frequency of use)			
		Regular	**Often**	**Intermittent**	**Rare**
Amount of MEC	**Category I (Most)**	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	Occasional	Seldom
	Category III	Likely	Occasional	Seldom	Unlikely
	Category IV	Occasional	Seldom	Unlikely	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2: Severity of Incident

Severity of Explosive Incident *(Severity vs. Likelihood of Encounter)*		Likelihood of Encounter (from Matrix 1)				
		Frequent	**Likely**	**Occasional**	**Seldom**	**Unlikely**
Severity	**Catastrophic/Critical**	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Matrix 3: Likelihood of Detonation

Likelihood of Detonation *(Sensitivity vs. Likelihood to Impart Energy)*		Likelihood to Impart Energy on an Item		
		High	**Modest**	**Inconsequential**
Sensitivity	**High**	1	1	3
	Moderate	1	2	3
	Low	1	3	3
	Not Sensitive	2		3

Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result from Matrix 2			
		A	**B**	**C**	**D**
Result from Matrix 3	**1**	**Unacceptable**	**Unacceptable**	**Unacceptable**	Acceptable
	2	**Unacceptable**	**Unacceptable**	Acceptable	Acceptable
	3	**Unacceptable**	Acceptable	Acceptable	Acceptable

C.5 ALTERNATIVE RISK SCENARIOS FOR THE OD GROUND MRS

C.5.1 Description of Alternatives – OD Grounds MRS

In addition to providing a technique to evaluate baseline MEC risks, the Decision Logic to Assess Risks (USACE, 2017) matrices may be used to evaluate the anticipated MEC risk conditions that would remain following implementation of a remedial action. This is done by evaluating how the assumptions made regarding the future conditions at the site would change from the baseline conditions using the three matrices (Matrices 1 through 3) to support the risk evaluation for each hypothetical future risk scenario.

The land use at the OD Grounds MRS is anticipated to change with a land transfer out of DOD control following implementation of an appropriate remedial action alternative. Therefore, the comparison of the anticipated risk scenario of each potential remedial action alternative will use the future land use risk scenario as the baseline condition. This analysis will evaluate each potential remedial action alternative to determine if implementation would achieve acceptable MEC risk conditions base on the planned future land use.

The remedial action alternates considered at the OD Ground MRS are described in detail in the FS Report. The following alternatives were retained for analysis in the FS Report and were therefore evaluated as part of this Risk Assessment.

- Alternative 1: No Action
- Alternative 3: Consolidate and cap with surface and subsurface clearance to 2 feet bgs outside the cap and LUCs
- Alternative 4: Excavate OD Hill to grade and perform surface/subsurface clearance to 2 feet bgs over site, and LUCs; and
- Alternative 5: Excavate entire site to 1 foot below grade and perform surface/subsurface clearance to 2 feet bgs

This Risk Assessment will focus on describing the specific aspect of each alternative that will change the assumptions presented in the Decision Logic to Assess Risks (USACE, 2017) categories. **Figure C.1** shows a diagram summarizing the structure of the MEC Risk Evaluation. Within the Decision Logic to Assess Risks the following five risk factors are evaluated base on site conditions (note that only three will change based on implementation of a remedial action):

- *Amount of MEC* (i.e., how much MEC is there at the site?).
  - This element may change due to physical removal of MEC during a remedial action.
- *Access Conditions* (i.e., how likely are human receptors to contact MEC at the site based on accessibility and frequency of use?).

- This element may change through the implementation of LUCs or barriers that alter future use of the site.

- *Severity Associated with Detonation of Specific Munitions* (i.e., if someone encounters MEC and it detonates, how many people might be injured and how seriously?).
  - This element does not change based on implementation of any of the alternatives because all may leave deep-buried UXO or DMM that, if unintentionally detonated by an uninformed future user, could result in severe or catastrophic harm.
- *Sensitivity/Susceptibility to Detonation* (i.e., how sensitive is the fuzing of the MEC?).
  - This element does not change based on implementation of any of the alternatives because all may leave deep-buried UXO or DMM that might have sensitive fuzing.
- *Likelihood to Impart Energy on an Item* (i.e., what are the activities involved that might result in human receptors encountering MEC at the site?).
  - This element may change if remedial actions are implemented that affect behavioral modifications or changes that will affect the likelihood or ability of imparting energy on a munitions item.

Table C.6 presents a summary of the appropriate input factors selected to complete the Decision Logic to Assess MEC Risk for each of the five alternatives evaluated in the FS. As noted above, only three input factors are influenced by implementation of a remedial action (*Amount of MEC*, *Access Conditions*, and *Likelihood to Impart Energy on an Item*). Alternative 1, the no action alternative, assumes no remedial action element are implemented, therefore this alternative would not change any input factors from the baseline future risk conditions. Alternative 2 is implementation of LUCs only. This alternative would not change the amount of MEC or access conditions (LUCs under Alternative 2 do not restrict access or activities). The Likelihood to impart energy would be changed from high to modest due to the influence of educational awareness which would change behavior to reduce the likelihood that a person would impart energy on an MEC item. Evaluation of Alternative 2 shows the following implementation of Remedial Action Alternative 2 would not achieve acceptable MEC risk conditions.

For each of Alternatives 3, 4 and 5. the *Amount of MEC* rating will change to Category V in both the OD Hill and the Kickout Area following implementation of the remedial action. The Category V rating applies to sites where "A DERP response action has been conducted to physically remote surface and subsurface MEC". If Alternative 3 were implemented MEC would not be physically removed from the subsurface at the OD Hill; however, the MEC remaining on site would be secured under a cap. Because the cap will include 18 inches of clean soil over the top of any remaining MEC, this alternative is considered equivalent to a surface and subsurface MEC removal. And has been scored as if surface and subsurface response action were complete.

A surface and subsurface MEC removal would be conducted within the Kickout Area under Alternative 3 so this area is also scored as Category V. Both the Kickout Area and the OD Hill under Alternatives 4 and 5 would include a surface and subsurface MEC removal; therefore, Category V for *Amount of MEC* is appropriate for both the OD Hill and Kickout Area under each of these alternatives.

At the OD Ground MRS the future site use conditions are well known. As such the remedial alternatives evaluated in the FS were developed to achieve acceptable use conditions based on planned future use. Access Conditions used in the Future Risk Use Conditions are consistent with the future use under all of the alternative scenarios. The access conditions in all cases is "Often (e.g., less regular or periodic use, some access)". The intended future land use is for conservation/recreation; while driving tours may visit the site daily, persons accessing the site on foot where access with MEC could occur would be only periodic.

Under the future use risk conditions, the *Likelihood to Impart Energy on an Item* was rated as "High (e.g., areas planned for development, or seasonally tilled)." This category was selected because future land use would include plowing/tilling of food plots as part of the habitat development at the conservation/recreation area and MEC are anticipated to be present at the depths that would be impacted by tilling and intrusive activity. Under Alternatives 4 and 5 surface and subsurface MEC removal will be conducted to depths appropriate to meet the RAOs in both the Kickout Area and OD Hill. In both areas after remedial action implementation under Alternatives 4 and 5 it would no longer be expected that seasonal tilling or other allowed intrusive activities would result in interaction with subsurface MEC. In these cases, the *Likelihood to Impart Energy on an Item* has been rated as Inconsequential because interaction is no longer anticipated as the intrusive depth no longer overlaps with the depth interval where MEC might exist. LUCs will further mitigate any unforeseen interactions with MEC by teaching land users to obey the 3Rs of explosive safety in the unlikely event they discover UXO or DMM. Under Alternative 3 the Kickout area has the same remedial action as under Alternative 4 and in the OD Hill intrusive activity restrictions in the cap would prevent interaction with MEC that may remain below the cap. Therefore, Alternative 3 is also scored as Inconsequential (e.g., not anticipated, prevented, mitigated) for the same reasons described above for Alternatives 4 and 5.

Exhibits C.5 and C.6 summarize the matrix inputs and outputs for Alternative 2 within the OD Hill and Kickout Area, respectively. **Exhibit C.7** summarizes the matrix inputs and outputs for the Kickout Area and OD Hill for post remedial action conditions following implementation of Alternatives 3, 4 or 5.

Figure C.1
Summary of Decision Logic to Assess MEC Risk Evaluation Factors and Structure
Seneca Army Depot Activity, Open Detonation Grounds

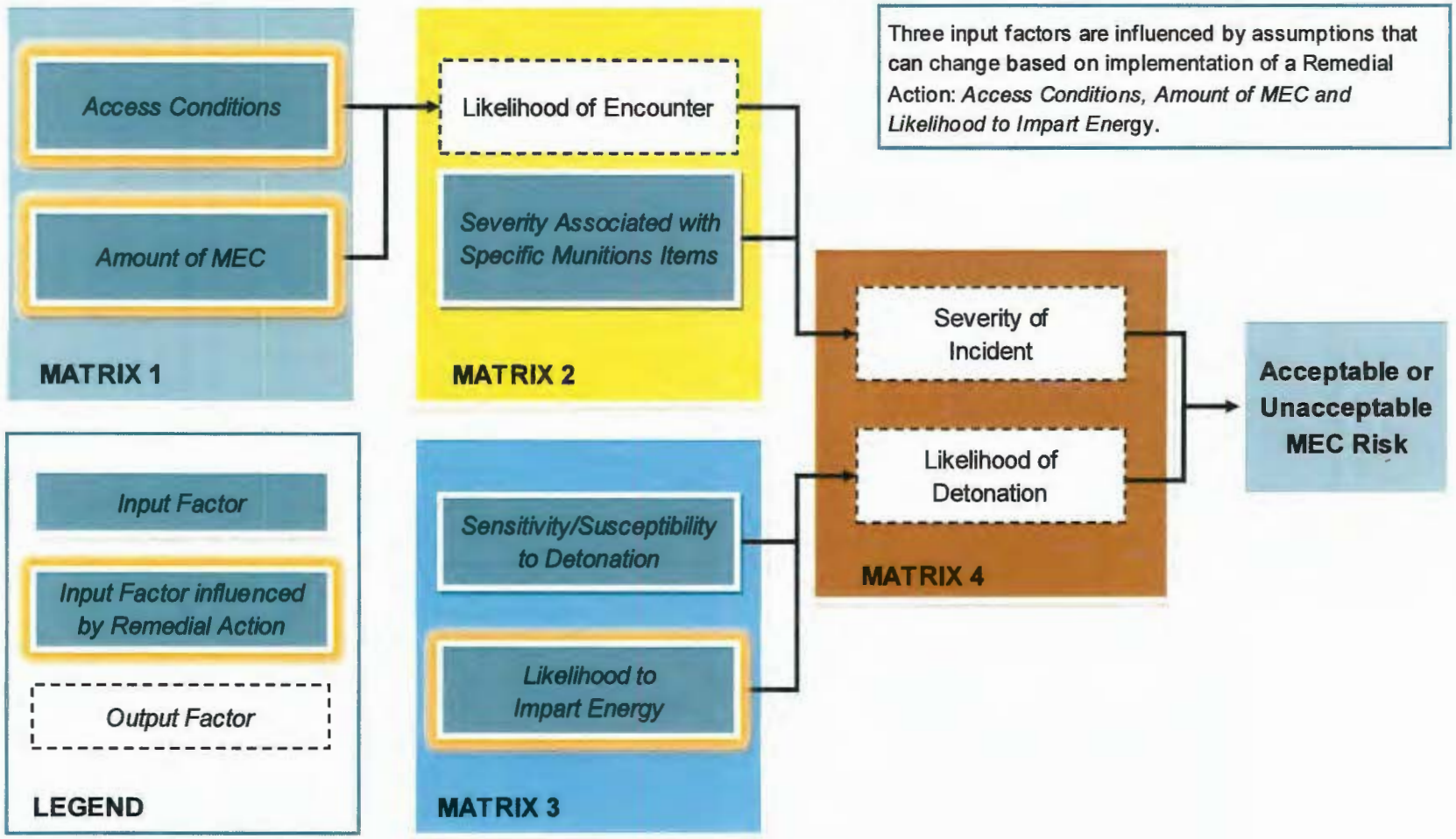

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Table C.6
Analysis of Alternatives using the Decision Logic to Assess MEC Risk
Seneca Army Depot Activity, Open Detonation Grounds

	Matrix 1		Matrix 2		Matrix 3		Matrix 4		
Risk Scenario	**Access Conditions**	**Amount of MEC**	**Likelihood of Encounter**	**Severity Associated with Specific Munitions Items**	**Sensitivity Susceptibility to Detonation**	**Likelihood to Impart Energy**	**Likelihood of Detonation**	**Severity of Incident**	**Rating**
Future Baseline - OD Hill	Often	Category II	Likely	Catastrophic/Critical	High	High	1	A	Unacceptable
Future Baseline - Kickout	Often	Category I (Most)	Frequent	Catastrophic/Critical	High	High	1	A	Unacceptable
Alternative 1 No Action									
Alternative 1 would results in no change from the Future Baseline Conditions Risk Scenario									
Alternative 2 LUCs only									
Alternative 2 - OD Hill	Often	Category II	Likely	Catastrophic/Critical	High	Modest	2	A	Unacceptable
Alternative 2 - Kickout	Often	Category I (Most)	Frequent	Catastrophic/Critical	High	Modest	2	A	Unacceptable
Rationale	LUCs would not prevent access	This alternative does not remove MEC.	--	--	--	Educational Awareness will reduce the likelihood that people will impart energy on an item	--	--	--
Alternative 3									
Alternative 3 - OD Hill	Often	Category V	Seldom	Catastrophic/Critical	High	Inconsequential	3	B	Acceptable
Alternative 3 - Kickout	Often	Category V	Seldom	Catastrophic/Critical	High	Inconsequential	3	B	Acceptable
Rationale	LUCs would not prevent access	The cap at the OD Hill would be equivalent to a surface and subsurface MEC removal. Surface and subsurface MEC removal would be conducted in the kickout area.	--	--	--	Removal depth below anticipated intrusive depth.	--	--	--
Alternative 4									
Alternative 4 - OD Hill	Often	Category V	Seldom	Catastrophic/Critical	High	Inconsequential	3	B	Acceptable
Alternative 4 - Kickout	Often	Category V	Seldom	Catastrophic/Critical	High	Inconsequential	3	B	Acceptable
Rationale	LUCs would not prevent access	Surface and subsurface MEC removal would be conducted in the OD Hill and kickout area.	--	--	--	Removal depth below anticipated intrusive depth.	--	--	--

Alternative 5

Alternative 5 - OD Hill	Often	Category V	Seldom	Catastrophic/Critical	High	Inconsequential	3	B	Acceptable
Alternative 5 - Kickout	Often	Category V	Seldom	Catastrophic/Critical	High	Inconsequential	3	B	Acceptable
Rationale	LUCs would not prevent access	Surface and subsurface MEC removal would be conducted in the OD Hill and kickout area.	--	--	--	Removal depth below anticipated intrusive depth.	--	--	--

Exhibit C.5
Summary of Decision Logic Evaluation Results for the OD Hill Area
Alternative 2 Use Conditions Risk Scenario
Seneca Army Depot Activity, Open Detonation Grounds

Matrix 1: Likelihood of Encounter

Likelihood of Encounter (Amount of MEC versus Access Conditions)		Access Conditions (frequency of use)			
		Regular	Often	Intermittent	Rare
Amount of MEC	Category I (Most)	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	Occasional	Seldom
	Category III	Likely	Occasional	Seldom	Unlikely
	Category IV	Occasional	Seldom	Unlikely	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2: Severity of Incident

Severity of Explosive Incident (Severity vs. Likelihood of Encounter)		Likelihood of Encounter (from Matrix 1)				
		Frequent	Likely	Occasional	Seldom	Unlikely
Severity	Catastrophic/Critical	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Matrix 3: Likelihood of Detonation

Likelihood of Detonation (Sensitivity vs. Likelihood to Impart Energy)		Likelihood to Impart Energy on an Item		
		High	Modest	Inconsequential
Sensitivity	High	1	1	3
	Moderate	1	2	3
	Low	1	3	3
	Not Sensitive	2		3

Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result from Matrix 2			
		A	B	C	D
Result from Matrix 3	1	Unacceptable	Unacceptable	Unacceptable	Acceptable
	2	Unacceptable	Unacceptable	Acceptable	Acceptable
	3	Unacceptable	Acceptable	Acceptable	Acceptable

Exhibit C.6
Summary of Decision Logic Evaluation Results for the Kickout Area
Alternative 2 Use Conditions Risk Scenario
Seneca Army Depot Activity, Open Detonation Grounds

Matrix 1: Likelihood of Encounter

Likelihood of Encounter *(Amount of MEC versus Access Conditions)*		Access Conditions (frequency of use)			
		Regular	Often	Intermittent	Rare
Amount of MEC	Category I (Most)	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	Occasional	Seldom
	Category III	Likely	Occasional	Seldom	Unlikely
	Category IV	Occasional	Seldom	Unlikely	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2: Severity of Incident

Severity of Explosive Incident *(Severity vs. Likelihood of Encounter)*		Likelihood of Encounter (from Matrix 1)				
		Frequent	Likely	Occasional	Seldom	Unlikely
Severity	Catastrophic/Critical	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Matrix 3: Likelihood of Detonation

Likelihood of Detonation *(Sensitivity vs. Likelihood to Impart Energy)*		Likelihood to Impart Energy on an Item		
		High	Modest	Inconsequential
Sensitivity	High	1	1	3
	Moderate	1	2	3
	Low	1	3	3
	Not Sensitive	2		3

Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result from Matrix 2			
		A	B	C	D
Result from Matrix 3	1	Unacceptable	Unacceptable	Unacceptable	Acceptable
	2	Unacceptable	Unacceptable	Acceptable	Acceptable
	3	Unacceptable	Acceptable	Acceptable	Acceptable

Exhibit C.7
Summary of Decision Logic Evaluation Results for the OD Hill and Kickout Area
Alternative 3, 4 and 5 Use Conditions Risk Scenario
Seneca Army Depot Activity, Open Detonation Grounds

Matrix 1: Likelihood of Encounter

Likelihood of Encounter (Amount of MEC versus Access Conditions)		Access Conditions (frequency of use)			
		Regular	Often	Intermittent	Rare
Amount of MEC	Category I (Most)	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	Occasional	Seldom
	Category III	Likely	Occasional	Seldom	Unlikely
	Category IV	Occasional	Seldom	Unlikely	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2: Severity of Incident

Severity of Explosive Incident (Severity vs. Likelihood of Encounter)		Likelihood of Encounter (from Matrix 1)				
		Frequent	Likely	Occasional	Seldom	Unlikely
Severity	Catastrophic/Critical	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Matrix 3: Likelihood of Detonation

Likelihood of Detonation (Sensitivity vs. Likelihood to Impart Energy)		Likelihood to Impart Energy on an Item		
		High	Modest	Inconsequential
Sensitivity	High	1	1	3
	Moderate	1	2	3
	Low	1	3	3
	Not Sensitive	2	3	3

Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result from Matrix 2			
		A	B	C	D
Result from Matrix 3	1	Unacceptable	Unacceptable	Unacceptable	Acceptable
	2	Unacceptable	Unacceptable	Acceptable	Acceptable
	3	Unacceptable	Acceptable	Acceptable	Acceptable

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APPENDIX D

DETAILED COST ESTIMATE

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		Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
	Title:	**No Action**	**LUCs Only**	**Cap with MPPEH Removal**	**Partial Excavation with MPPEH Removal**	**Full Excavation with MPPEH Removal**
	Description:	No Action	LUCs Only	Consolidate and Cap with Surface and Subsurface Clearance to 2 feet bgs outside the cap and LUCs	Excavate OD Hill to grade and perform surface/subsurface clearance to 2 feet bgs over site, and LUCs	Excavate entire site to 1 foot below grade and perform surface/subsurface clearance to 2 feet bgs (total of 3 feet removal)
	Total Cost:	**$0**	**$271,680**	**$18,494,249**	**$13,546,296**	**$69,120,588**
	Estimated Field Durration:	0 Days	10 Days	42 Months	40 Months	115 Months
	No Action	$0	--	--	--	--
Controls	LUCs	--	$ 271,680	$ 271,680	$ 271,680	$ 271,680
Support Tasks	Grubbing and Vegetation Clearance with UXO Technician Support	--	--	$ 1,081,240	$ 1,081,240	$ 1,081,240
	Site Re-grading and Re-vegetation	--	--	$ 1,041,267	$ 1,041,267	$ 2,597,402
LTM	Annual Groundwater Sampling at Landfill Inspection and Reporting			$ 4,500,000		
	Land Fill Maintenance			$ 900,000		
	Post RA Groundwater Confirmation Sampling				$ 400,000	$ 400,000
MEC Detection/Removal	Consolidate High Metal Content Soil at OD Hill and Cover with Engineered Cap. Remove Visible MPPEH During Earthwork.	--	--	$ 3,278,595	--	--
	Install Slurry Wall around Cap	--	--	$ 353,378	--	--
	Backfill with clean soil	--	--	$ 1,239,206	--	--
	Excavate, Clear soil of MPPEH, and Return as Fill or Haz waste off-site disposal after Surface/Subsurface Clearance	--	--	--	$ 4,757,118	$ 61,137,485
	Surface/Subsurface Clearance	--	--	$ 5,603,882	$ 5,819,991	$ 3,457,780
Reporing	Work Planning	--	--	$ 150,000	$ 100,000	$ 100,000
	Final Reporting	--	--	$ 75,000	$ 75,000	$ 75,000

Alt 2	LUCs Only					
Year	Capital Cost ($)	Annual O&M Costs ($)	Periodic Costs ($)	Total Cost + 0% Tax($)	Discount Factor at 0.6%	Present Value at 3%
0	$42,468.00	$4,000		$46,468.00	1.00	$46,468.00
1	$0.00	$4,000		$4,000.00	0.99	$3,976.14
2	$0.00	$4,000		$4,000.00	0.99	$3,952.43
3	$0.00	$4,000		$4,000.00	0.98	$3,928.86
4	$0.00	$4,000	$18,202	$22,202.06	0.98	$21,677.11
5	$0.00	$4,000		$4,000.00	0.97	$3,882.13
6	$0.00	$4,000		$4,000.00	0.96	$3,858.98
7	$0.00	$4,000		$4,000.00	0.96	$3,835.96
8	$0.00	$4,000		$4,000.00	0.95	$3,813.08
9	$0.00	$4,000	$18,202	$22,202.06	0.95	$21,038.34
10	$0.00	$4,000		$4,000.00	0.94	$3,767.73
11	$0.00	$4,000		$4,000.00	0.94	$3,745.26
12	$0.00	$4,000		$4,000.00	0.93	$3,722.92
13	$0.00	$4,000		$4,000.00	0.93	$3,700.72
14	$0.00	$4,000	$18,202	$22,202.06	0.92	$20,418.39
15	$0.00	$4,000		$4,000.00	0.91	$3,656.71
16	$0.00	$4,000		$4,000.00	0.91	$3,634.90
17	$0.00	$4,000		$4,000.00	0.90	$3,613.22
18	$0.00	$4,000		$4,000.00	0.90	$3,591.67
19	$0.00	$4,000	$18,202	$22,202.06	0.89	$19,816.71
20	$0.00	$4,000		$4,000.00	0.89	$3,548.95
21	$0.00	$4,000		$4,000.00	0.88	$3,527.79
22	$0.00	$4,000		$4,000.00	0.88	$3,506.75
23	$0.00	$4,000		$4,000.00	0.87	$3,485.83
24	$0.00	$4,000	$18,202	$22,202.06	0.87	$19,232.77
25	$0.00	$4,000		$4,000.00	0.86	$3,444.38
26	$0.00	$4,000		$4,000.00	0.86	$3,423.83
27	$0.00	$4,000		$4,000.00	0.85	$3,403.41
28	$0.00	$4,000		$4,000.00	0.85	$3,383.11
29	$0.00	$4,000	$18,202	$22,202.06	0.84	$18,666.02
Total	$42,468	$120,000	$109,213	$271,680		$251,722
				Total Cost + 0% Tax($)		**$271,680**
				Lower end of TPV Range		**$163,619**
				Upper end of TPV Range		**$377,583**

Alt 3	Cap with MPPEH Removal					
Year	Capital Cost ($)	Annual O&M Costs ($)	Periodic Costs ($)	Total Cost + 0% Tax($)	Discount Factor at 0.6%	Present Value at 3%
0	$3,675,724.76	$154,000		$3,829,724.76	1.00	$3,829,724.76
1	$3,675,724.76	$154,000.00		$3,829,724.76	0.99	$3,806,883.46
2	$3,675,724.76	$154,000.00		$3,829,724.76	0.99	$3,784,178.39
3	$1,837,862.38	$154,000.00		$1,991,862.38	0.98	$1,956,434.84
4	$0.00	$154,000.00	$18,202	$172,202.06	0.98	$168,130.47
5	$0.00	$154,000.00		$154,000.00	0.97	$149,462.01
6	$0.00	$154,000.00		$154,000.00	0.96	$148,570.59
7	$0.00	$154,000.00		$154,000.00	0.96	$147,684.48
8	$0.00	$154,000.00		$154,000.00	0.95	$146,803.66
9	$0.00	$154,000.00	$318,202	$472,202.06	0.95	$447,451.59
10	$0.00	$154,000.00		$154,000.00	0.94	$145,057.74
11	$0.00	$154,000.00		$154,000.00	0.94	$144,192.59
12	$0.00	$154,000.00		$154,000.00	0.93	$143,332.59
13	$0.00	$154,000.00		$154,000.00	0.93	$142,477.72
14	$0.00	$154,000.00	$18,202	$172,202.06	0.92	$158,367.70
15	$0.00	$154,000.00		$154,000.00	0.91	$140,783.26
16	$0.00	$154,000.00		$154,000.00	0.91	$139,943.60
17	$0.00	$154,000.00		$154,000.00	0.90	$139,108.94
18	$0.00	$154,000.00		$154,000.00	0.90	$138,279.27
19	$0.00	$154,000.00	$318,202	$472,202.06	0.89	$421,469.59
20	$0.00	$154,000.00		$154,000.00	0.89	$136,634.73
21	$0.00	$154,000.00		$154,000.00	0.88	$135,819.81
22	$0.00	$154,000.00		$154,000.00	0.88	$135,009.75
23	$0.00	$154,000.00		$154,000.00	0.87	$134,204.53
24	$0.00	$154,000.00	$18,202	$172,202.06	0.87	$149,171.83
25	$0.00	$154,000.00		$154,000.00	0.86	$132,608.45
26	$0.00	$154,000.00		$154,000.00	0.86	$131,817.55
27	$0.00	$154,000.00		$154,000.00	0.85	$131,031.36
28	$0.00	$154,000.00		$154,000.00	0.85	$130,249.86
29	$0.00	$154,000.00	$318,202	$472,202.06	0.84	$396,996.28
Total	$12,865,037	$4,620,000	$1,009,213	$18,494,249		$17,911,881
				Total Cost + 0% Tax($)		**$18,494,249**
				Lower end of TPV Range		**$11,642,723**
				Upper end of TPV Range		**$26,867,822**

Alt 4	Partial Excavation with MPPEH Removal					
Year	Capital Cost ($)	Annual O&M Costs ($)	Periodic Costs ($)	Total Cost + 0% Tax($)	Discount Factor at 0.6%	Present Value at 3%
0	$3,995,125.20	$4,000		$3,999,125.20	1.00	$3,999,125.20
1	$3,995,125.20	$4,000.00		$3,999,125.20	0.99	$3,975,273.56
2	$3,995,125.20	$4,000.00		$3,999,125.20	0.99	$3,951,564.17
3	$1,331,708.40	$4,000.00		$1,335,708.40	0.98	$1,311,951.30
4	$0.00	$4,000.00	$18,202	$22,202.06	0.98	$21,677.11
5	$0.00	$4,000.00		$4,000.00	0.97	$3,882.13
6	$0.00	$4,000.00		$4,000.00	0.96	$3,858.98
7	$0.00	$4,000.00		$4,000.00	0.96	$3,835.96
8	$0.00	$4,000.00		$4,000.00	0.95	$3,813.08
9	$0.00	$4,000.00	$18,202	$22,202.06	0.95	$21,038.34
10	$0.00	$4,000.00		$4,000.00	0.94	$3,767.73
11	$0.00	$4,000.00		$4,000.00	0.94	$3,745.26
12	$0.00	$4,000.00		$4,000.00	0.93	$3,722.92
13	$0.00	$4,000.00		$4,000.00	0.93	$3,700.72
14	$0.00	$4,000.00	$18,202	$22,202.06	0.92	$20,418.39
15	$0.00	$4,000.00		$4,000.00	0.91	$3,656.71
16	$0.00	$4,000.00		$4,000.00	0.91	$3,634.90
17	$0.00	$4,000.00		$4,000.00	0.90	$3,613.22
18	$0.00	$4,000.00		$4,000.00	0.90	$3,591.67
19	$0.00	$4,000.00	$18,202	$22,202.06	0.89	$19,816.71
20	$0.00	$4,000.00		$4,000.00	0.89	$3,548.95
21	$0.00	$4,000.00		$4,000.00	0.88	$3,527.79
22	$0.00	$4,000.00		$4,000.00	0.88	$3,506.75
23	$0.00	$4,000.00		$4,000.00	0.87	$3,485.83
24	$0.00	$4,000.00	$18,202	$22,202.06	0.87	$19,232.77
25	$0.00	$4,000.00		$4,000.00	0.86	$3,444.38
26	$0.00	$4,000.00		$4,000.00	0.86	$3,423.83
27	$0.00	$4,000.00		$4,000.00	0.85	$3,403.41
28	$0.00	$4,000.00		$4,000.00	0.85	$3,383.11
29	$0.00	$4,000.00	$18,202	$22,202.06	0.84	$18,666.02
Total	$13,317,084	$120,000	$109,213	$13,546,296		$13,431,311
				Total Cost + 0% Tax($)		**$13,546,296**
				Lower end of TPV Range		**$8,730,352**
				Upper end of TPV Range		**$20,146,966**

Alt 5	Full Excavation with MPPEH Removal					
Year	Capital Cost ($)	Annual O&M Costs ($)	Periodic Costs ($)	Total Cost + 0% Tax($)	Discount Factor at 0.6%	Present Value at 3%
0	$7,188,665.23	$4,000.00		$7,192,665.23	1.00	$7,192,665.23
1	$7,188,665.23	$4,000.00		$7,192,665.23	0.99	$7,149,766.63
2	$7,188,665.23	$4,000.00		$7,192,665.23	0.99	$7,107,123.89
3	$7,188,665.23	$4,000.00		$7,192,665.23	0.98	$7,064,735.48
4	$7,188,665.23	$4,000.00	$18,202	$7,210,867.29	0.98	$7,040,371.56
5	$7,188,665.23	$4,000.00		$7,192,665.23	0.97	$6,980,715.58
6	$7,188,665.23	$4,000.00		$7,192,665.23	0.96	$6,939,081.10
7	$7,188,665.23	$4,000.00		$7,192,665.23	0.96	$6,897,694.93
8	$7,188,665.23	$4,000.00		$7,192,665.23	0.95	$6,856,555.60
9	$4,193,388.05	$4,000.00	$18,202	$4,215,590.11	0.95	$3,994,629.92
10	$0.00	$4,000.00		$4,000.00	0.94	$3,767.73
11	$0.00	$4,000.00		$4,000.00	0.94	$3,745.26
12	$0.00	$4,000.00		$4,000.00	0.93	$3,722.92
13	$0.00	$4,000.00		$4,000.00	0.93	$3,700.72
14	$0.00	$4,000.00	$18,202	$22,202.06	0.92	$20,418.39
15	$0.00	$4,000.00		$4,000.00	0.91	$3,656.71
16	$0.00	$4,000.00		$4,000.00	0.91	$3,634.90
17	$0.00	$4,000.00		$4,000.00	0.90	$3,613.22
18	$0.00	$4,000.00		$4,000.00	0.90	$3,591.67
19	$0.00	$4,000.00	$18,202	$22,202.06	0.89	$19,816.71
20	$0.00	$4,000.00		$4,000.00	0.89	$3,548.95
21	$0.00	$4,000.00		$4,000.00	0.88	$3,527.79
22	$0.00	$4,000.00		$4,000.00	0.88	$3,506.75
23	$0.00	$4,000.00		$4,000.00	0.87	$3,485.83
24	$0.00	$4,000.00	$18,202	$22,202.06	0.87	$19,232.77
25	$0.00	$4,000.00		$4,000.00	0.86	$3,444.38
26	$0.00	$4,000.00		$4,000.00	0.86	$3,423.83
27	$0.00	$4,000.00		$4,000.00	0.85	$3,403.41
28	$0.00	$4,000.00		$4,000.00	0.85	$3,383.11
29	$0.00	$4,000.00	$18,202	$22,202.06	0.84	$18,666.02
Total	$68,891,375	$120,000	$109,213	$69,120,588		$67,358,631
				Total Cost + 0% Tax($)		**$69,120,588**
				Lower end of TPV Range		**$43,783,110**
				Upper end of TPV Range		**$101,037,947**

Table: 1.1_LUCs and 4K per year annual inspections
Element: LUCs
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

Assumptions

Implementation elements include:

1 LUCs RD Plan
2 Environmental Easement
3 5-year Reviews
4 Educational Awareness

		Unit	Unit Cost				
1 LUCs RD Plan							
Project Manager	hour	24	$ 146.00				
Engineer II	hour	40	$ 97.00				
Scientist I	hour	100	$ 72.00				
Administrative (Home Office)	hour	16	$ 62.00				
			$ 19,896.00				
2 Environmental Easement							
Project Manager	hour	16	$ 146.00				
Engineer II	hour	80	$ 97.00				
Scientist I	hour	30	$ 72.00				
Administrative (Home Office)	hour	16	$ 62.00				
			$ 10,936.00				
3 5-year Reviews				Hrs per Review	Total Reviews	Total Hours	
Project Manager	hour	48	$ 146.00	8	6	48	
Engineer II	hour	384	$ 97.00	64	6	384	include planning time (16), site visit (16), and reporting (24) for each review
Scientist I	hour	384	$ 72.00	64	6	384	include planning time (16), site visit (16), and reporting (24) for each review
Administrative (Home Office)	hour	96	$ 62.00	16	6	96	planning and reporting
Newspaper ad	each	6	$ 100.00	1	6	6	one per review
Airfare: HSV-SYR plus webfee (1 week notice)	RT	12	$ 848.75	2	6	12	2 per review (2 people)
Truck Rental (week)	weekly	6	$ 400.00	1	6	6	one per review
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	6	$ 2,268.00	1	6	6	half per review
M&IE Travel Day (75%)	day	24	$ 44.25	4	6	24	4 per review (2 people 2 travel days)
M&IE Full Day	day	12	$ 59.00	2	6	12	2 per review (2 people)
Lodging + 13% SYR Tax	night	24	$ 116.39	4	6	24	4 per review (2 people 2 nights)
			$ 109,212.36				
4 Educational Awareness							
Project Manager	hour	12	$ 146.00	Manage task			
Engineer II	hour	20	$ 97.00	Review prepared material			
Scientist I	hour	60	$ 72.00	Develop materials and assist distribution			
Administrative (Home Office)	hour	32	$ 62.00	12 for general prep assistance, 20 for finding addresses and mailing			
Printing (color on gloss white per sheet)	each	500	$ 0.40	500 pamphlets			
			$ 11,636.00				

Table: 2.1_Veg_Clear
Element: Grubbing and Vegetation Clearance with UXO Technician Support
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

Assumptions

Implementation elements include:

1 Vegetation Removal Subcontractor
2 UXO Escort

							production - 1 acre/day for light and medium and .5 for heavy	544.1 crew days
1	**Vegetation Removal Subcontractor**		Unit	Unit Cost			Production = 0.5 acres/crew/day for heavy (141.05) and 1 acre/crew/day medium and light over (201.5+60.45) = 806 crew days. Assume 4 crews and 137 work day	137 days
	Project Manager	hour	70	$ 146.00			2 hrs per week duration of 203 work days or 51 weeks	35 weeks
	Scientist I	hour	105	$ 72.00			3 hrs per week duration of 203 work days or 51 weeks	4 crews
	Brush Clearing - Heavy	acre	141.05	$ 3,500.00	35%	141.05	Percentage of total site acres and acres	
	Brush Clearing - Medium	acre	60.45	$ 2,400.00	15%	60.45	Percentage of total site acres and acres	
	Brush Clearing - Light	acre	201.5	$ 500.00	50%	201.5	Percentage of total site acres and acres	
	Brush Contractor Mob/Demob (Personnel and Equipment)	each	16	$ 750.00			2 Mobs and 2 Demobs per crew due to duration	
				$ 769,285.00				
2	**UXO Escort**							137 days
	Project Manager	hour	17.5	$ 146.00			Staff Management 0.5 hr per week.	35 weeks
	Scientist I	hour	35	$ 72.00			Coordination 1 hr per week	4 crews
	UXO Tech II w/8% HPD	hour	5480	$ 56.00			Production = 0.5 acres/crew/day for 403 acres = 806 crew days. Assume 4 crews and 203 work days	
				$ 311,955.00				

Table: 2.2_Site_Restoration
Element: Site Re-grading and Re-vegetation
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

Assumptions

Implementation elements include:

1 Regrading
2 Reseeding/Restoration

	UOM	Units	Unit Cost			
1 Regrading						
Project Manager	hour	4	$	146.00	2 hrs per week duration	2 weeks
Scientist I	hour	6	$	72.00	3 hrs per week duration	2 crews
Grading	acre	18.03026087	$	4,000.00	100% 403 Percentage of total site acres and acres	
Brush Contractor Mob/Demob (Personnel and Equipment)	each	4	$	750.00	1 Mob and 1 Demob due to duration per crew	
			$	76,137.04		
2 Reseeding/Restoration						
Project Manager	hour	17	$	146.00	Staff Management 0.5 hr per week.	34 weeks
Scientist I	hour	34	$	72.00	Coordination 1 hr per week	2 crews
UXO Tech II w/8% HPD	hour	2700	$	56.00		
Brush Contractor Mob/Demob (Personnel and Equipment)	each	4	$	750.00	1 Mob and 1 Demob due to duration per crew	
Seeding	acre	403	$	2,000.00	100% 403 Percentage of total site acres and acres	
			$	965,130.00		

Production = 1.5 acres/crew/day for 403 acres = 267 crew days. Assume 2 crews and 134 work days — 7 days

Production = 1.5 acres/crew/day for 403 acres = 267 crew days. Assume 2 crews and 134 work days — 135 days

Production = 0.5 acres/crew/day for 403 acres = 806 crew days. Assume 4 crews and 203 work days

Table: 2.2_Site_Restoration
Element: Site Re-grading and Re-vegetation
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

Assumptions

Implementation elements include:

1 Regrading
2 Reseeding/Restoration

		UOM	Units		Unit Cost		
1	**Regrading**					Production = 1.5 acres/crew/day for 403 acres = 267 crew days. Assume 2 crews and 134 work days	135 days
	Project Manager	hour	68	$	146.00	2 hrs per week duration	34 weeks
	Scientist I	hour	102	$	72.00	3 hrs per week duration	2 crews
	Grading	acre	403	$	4,000.00	100% 403 Percentage of total site acres and acres	
	Brush Contractor Mob/Demob (Personnel and Equipment)	each	4	$	750.00	1 Mob and 1 De mob due to duration per crew	
				$	1,632,272.00		
2	**Reseeding/Restoration**					Production = 1.5 acres/crew/day for 403 acres = 267 crew days. Assume 2 crews and 134 work days	135 days
	Project Manager	hour	17	$	146.00	Staff Management 0.5 hr per week.	34 weeks
	Scientist I	hour	34	$	72.00	Coordination 1 hr per week	2 crews
	UXO Tech II w/8% HPD	hour	2700	$	56.00	Production = 0.5 acres/crew/day for 403 acres = 806 crew days. Assume 4 crews and 203 work days	
	Brush Contractor Mob/Demob (Personnel and Equipment)	each	4	$	750.00	1 Mob and 1 De mob due to duration per crew	
	Seeding	acre	403	$	2,000.00	100% 403 Percentage of total site acres and acres	
				$	965,130.00		

Table: 3.1_Cap
Element: Consolidate High Metal Content Soil at OD Hill and Cover with Engineered Cap. Remove Visible MPPEH During Earthwork.
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

Implementation elements include:

1 Mob/Demob
2 Earthworks
3 Confirmation and Borrow Area Sampling
4 Cap Construction
5 Borrow Earthwork

Assumptions

Task	Counts	Units	Production	Units	Teams	Work Days	Work Weeks (4 day)	Per Diem Days/person	Persons	Total Staff
Alt 3										
Mob/Demob	1	persons	0.5	round trips per day	1	2	0.5	3.5	7	SUXOS, Safety, UXO QC, Excavation Sub, Tech II Escort, Engineer III
Earthworks	34907	CY	200	CY/day/team	2	88	22	154	6	SUXOS, Safety, UXO QC, Excavation Sub, Tech II Escort, Engineer III
Confirmation and Borrow Area Sampling	12	Samples	1	day/day/team	1	12	3	21	1	1 Geo
Cap Construction	9154	CY	300	CY/day/team	2	16	4	28	6	SUXOS, Safety, UXO QC, Excavation Sub, Tech II Escort, Engineer III
Borrow Earthwork	9154	CY	300	CY/day/team	2	16	4	28	6	SUXOS, Safety, UXO QC, Excavation Sub, Tech II Escort, Engineer III

1 Mob/Demob

		Unit	Unit Cost	
Senior UXO Supervisor	hour	16	$	82.00
UXO Quality Control Specialist	hour	16	$	73.00
UXO Safety Officer	hour	16	$	78.00
UXO Tech II	hour	32	$	52.00
Engineer III	hour	16	$	125.00
Project Manager	hour	16	$	146.00
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	4	$	2,268.00
Conex Delivery and Pickup	each	4	$	1,392.00
Office Trailer Mob/Demob	each	1	$	2,162.00
Airfare: HSV-SYR plus webfee (1 week notice)	RT	7	$	848.75
M&IE Travel Day (75%)	day	14	$	44.25
Lodging + 13% SYR Tax	night	14	$	116.39
			$	34,720.21

2 Earthworks

Senior UXO Supervisor	hour	880	$	82.00
UXO Quality Control Specialist	hour	880	$	73.00
UXO Safety Officer	hour	880	$	78.00
UXO Tech II	hour	1760	$	52.00
Engineer III	hour	880	$	125.00
Project Manager	hour	88	$	146.00
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	2	$	2,268.00
Armor an Excavator	each	2	$	16,000.00
Armor a Dozer	each	2	$	24,000.00
Armor a Haul Truck	each	2	$	6,000.00
PC-200 Excavator	day	176	$	1,360.00
Dozer	day	176	$	900.00
Haul Truck	day	176	$	800.00
Operator	day	176	$	1,145.00
Perdiem	day	176	$	146.00
Pickup Truck Rental	/week	110	$	300.00
Radio - 2 way (set of 10)	/month	5.5	$	725.30
Sanitation	/month	5.5	$	78.70
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	924	$	175.39
			$	1,481,202.36

Table: 3.1_Cap
Element: Consolidate High Metal Content Soil at OD Hill and Cover with Engineered Cap. Remove Visible MPPEH During Earthwork.
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

		Unit		Unit Cost	
3 Confirmation and Borrow Area Sampling					
Scientist II	hour	120	$	85.00
GPS Handheld	/week	3	$	300.00
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	2	$	2,268.00
Pickup Truck Rental	/week	3	$	300.00
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	21	$	175.39
FED Exp Package (50 lbs)	each	6	$	309.78
Soil Sample Set	each	12	$	170.00
			$	24,117.87
4 Cap Construction				
Senior UXO Supervisor	hour	160	$	82.00
UXO Quality Control Specialist	hour	160	$	73.00
UXO Safety Officer	hour	160	$	78.00
UXO Tech II	hour	320	$	52.00
Project Manager	hour	16	$	146.00
Engineer III	hour	160	$	125.00
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	2	$	2,268.00
Armor an Excavator	each	2	$	16,000.00
Armor a Dozer	each	2	$	24,000.00
Armor a Haul Truck	each	2	$	6,000.00
Pickup Truck Rental	/week	24	$	300.00
Radio - 2 way (set of 10)	/month	1	$	725.30
Sanitation	/month	1	$	78.70
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	168	$	175.39
Solid Waste Landfill Cap with HDPE	acre	4	$	300,000.00
			$	1,410,261.52
5 Borrow Earthwork				
Senior UXO Supervisor	hour	160	$	82.00
UXO Quality Control Specialist	hour	160	$	73.00
UXO Safety Officer	hour	160	$	78.00
UXO Tech II	hour	320	$	52.00
Project Manager	hour	16	$	146.00
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	2	$	2,268.00
Armor an Excavator	each	2	$	16,000.00
Armor a Dozer	each	2	$	24,000.00
Armor a Haul Truck	each	2	$	6,000.00
PC-200 Excavator	day	32	$	1,360.00
Dozer	day	32	$	900.00
Haul Truck	day	32	$	800.00
Operator	day	32	$	1,145.00
Perdiem	day	32	$	146.00
Pickup Truck Rental	/week	20	$	300.00
Radio - 2 way (set of 10)	/month	1	$	725.30
Sanitation	/month	1	$	78.70
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	168	$	175.39
			$	328,293.52

Table: 3.2_Slurry
Element: Install Slurry Wall around Cap
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

Implementation elements include:

1 Mob/Demob
2 Earthworks
3 Slurry Wall Installation
4 Well Installation
5 Design

Assumptions

Task	Counts	Units	Production	Units	Teams	Work Days	Work Weeks (4 day)	Per Diem Days/person	Persons	Total Staff
Alt 3										
Mob/Demob	1	persons	0.5	round trips per	1	2	0.5	3.5	3	Excavation Sub, Tech II Escort, Engineer III, Scientist II
Earthworks	671	CY	300	CY/day/team	1	3	0.75	5.25	6	SUXOS, Safety, UXO QC, Excavation Sub, Tech II Escort, Engineer III, Scientist II
Slurry Wall Installation	1812	square feet	100	ft2/day/team	1	19	4.75	33.25	6	SUXOS, Safety, UXO QC, Excavation Sub, Tech II Escort, Engineer III, Scientist II
Well Installation	10	wells	1	well/day/team	1	10	2.5	17.5	5	SUXOS, Safety, UXO QC, Excavation Sub, Tech II Escort, Scientist II

1 Mob/Demob

		Unit	Unit Cost	
UXO Tech II	hour	16	$	52.00
Engineer III	hour	16	$	125.00
Scientist II	hour	16	$	85.00
Project Manager	hour	16	$	146.00
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	1	$	2,268.00
Airfare: HSV-SYR plus webfee (1 week notice)	RT	4	$	848.75
M&IE Travel Day (75%)	day	8	$	44.25
Lodging + 13% SYR Tax	night	8	$	116.39
			$	13,476.12

2 Earthworks

Senior UXO Supervisor	hour	30	$	82.00
UXO Quality Control Specialist	hour	30	$	73.00
UXO Safety Officer	hour	30	$	78.00
UXO Tech II	hour	30	$	52.00
Engineer III	hour	30	$	125.00
Scientist II	hour	30	$	85.00
Project Manager	hour	3	$	146.00
Armor an Excavator	each	1	$	16,000.00
PC-200 Excavator	day	3	$	1,360.00
Operator	day	3	$	1,145.00
Perdiem	day	3	$	146.00
Pickup Truck Rental	/week	3	$	300.00
Radio - 2 way (set of 10)	/month	0.1875	$	725.30
Sanitation	/month	0.1875	$	78.70
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	31.5	$	175.39
			$	45,816.54

Senior UXO Supervisor	hour	190	$	82.00
UXO Quality Control Specialist	hour	190	$	73.00
UXO Safety Officer	hour	190	$	78.00
UXO Tech II	hour	190	$	52.00
Engineer III	hour	190	$	125.00
Scientist II	hour	190	$	85.00
Project Manager	hour	19	$	146.00
GPS Handheld	/week	4.75	$	300.00
Pickup Truck Rental	/week	4.75	$	300.00
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	199.5	$	175.39
Slurry Wall Install	square foot	1812	$	20.00
			$	170,904.31

Table: 3.2_Slurry
Element: Install Slurry Wall around Cap
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

		Unit	Unit Cost	
Senior UXO Supervisor	hour	100	$ 82.00	
UXO Quality Control Specialist	hour	100	$ 73.00	
UXO Safety Officer	hour	100	$ 78.00	
UXO Tech II	hour	100	$ 52.00	
Project Manager	hour	10	$ 146.00	
Scientist II	hour	100	$ 85.00	
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	4	$ 2,268.00	
PC-200 Excavator	day	12.5	$ 1,360.00	used as replacement for drilling rig cost.
Radio - 2 way (set of 10)	/month	0.625	$ 725.30	
Sanitation	/month	0.625	$ 78.70	
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	87.5	$ 175.39	
Drums for MD storage	each	10	$ 111.11	as cost for IDW drums
FED Exp Package (50 lbs)	each	5	$ 309.78	
Soil Sample Set	each	14	$ 170.00	
			$ 85,421.13	
Project Manager	hour	20	$ 146.00	
Engineer III	hour	160	$ 125.00	
Scientist II	hour	160	$ 85.00	
Administrative (Home Office)	hour	20	$ 62.00	
			$ 37,760.00	

Table: 3.3_Backfill
Element: Backfill with clean soil
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

Assumptions

Implementation elements include:

1 Regrading
2 Fill Material

	UOM	Units	Unit Cost			
1 Regrading						
Project Manager	hour	8	$	146.00	2 hrs per week duration	4 weeks
Scientist I	hour	12	$	72.00	3 hrs per week duration	1 crews
Grading	acre	18.03026087	$	4,000.00	The Area outside the OD Hill that is contaminated.	
Brush Contractor Mob/Demob (Personnel and Equipment)	each	2	$	750.00	1 Mob and 1 Demob due to duration per crew	
			$	75,653.04	Production = 1.5 acres/crew/day for 18 acres = 13 crew days.	13 days
2 Fill Material						
Clean Backfill Material	CY	29089	$	40.00		
			$	1,163,552.83		

Table: 3.4_Mech_Remove
Element: LUCs
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

Assumptions

Implementation elements include:

1 Mobilization/Demobilization
2 Mechancial Excavation
3 Sorting
4 Return/Regrading
5 Waste Characterization
6 Soil Stabilization and Offsite Disposal
7 Demolition

Task		Counts	Units	Production	Units	Teams	Work Days	Work Weeks (4 day)	Per Diem Days/person	Persons	Total Staff
Alt 4											
	Mobilization/Demobilization	1	persons	0.5	roundtrips per day	1	2	0.5	3.5	22	SUXOS, Safety, UXO QC, Excavation Sub, Sorting Team with 2 Tech III, 6 Tech II,and 6 UXO Tech I, 1 Geo for sampling, Tech II Escort for Excavation (2) and Regrading (2) one per team
	Mechancial Excavation	30139	CY	300	CY/day/team	2	51	12.75	89.25	5	SUXOS, Safety, UXO QC, Excavation Sub, Tech II Escort Volume of OD Hill
	Sorting	30139	CY	300	CY/day/team	2	51	12.75	89.25	17	SUXOS, Safety, UXO QC, Two Sorting Team totallying 2 Tech III, 6 Tech II 6 UXO Tec Volume of OD Hill
	Return/Regrading	30139	CY	300	CY/day/team	2	51	12.75	89.25	5	SUXOS, Safety, UXO QC, Excavation Sub Volume of OD Hill
	Waste Characterization	21	Samples	1	day/drum/team	1	22	5.5	38.5	1	1 Geo
	Soil Stabilization	35397	CY	5000	day/drum/team	2	4	1	7	5	SUXOS, Safety, UXO QC, Excavation Sub
Alt 5											
	Mobilization/Demobilization	1	persons	0.5	roundtrips per day	1	2	0.5	3.5	40	SUXOS, Safety, UXO QC, Excavation Sub, Sorting Team with 4 Tech III, 12 Tech II, and 12 UXO Tech I, 1 Geo for sampling plus 4 tech escorts for return and 4 tech escorts for excavation
	Mechancial Excavation	757359	CY	300	CY/day/team	4	632	158	1106	7	SUXOS, Safety, UXO QC, Excavation Sub, Tech II Escort Volume of OD Hill plus site to 1 foot bgs
	Sorting	757359	CY	300	CY/day/team	4	632	158	1106	31	SUXOS, Safety, UXO QC, four Sorting Team totallying 4 Tech III, 12 Tech II 12 UXO T Volume of OD Hill plus site to 1 foot bgs
	Return/Regrading	757359	CY	300	CY/day/team	4	632	158	1106	7	SUXOS, Safety, UXO QC, Excavation Sub Volume of OD Hill plus site to 1 foot bgs
	Waste Characterization	530	Samples	1	day/drum/team	1	531	132.75	929.25	1	1 Geo
	Soil Stabilization	72170	CY	5000	day/drum/team	4	4	1	7	7	SUXOS, Safety, UXO QC, Excavation Sub

		Alt 3 Unit	Alt 3 Unit Cost	Alt 4 Unit	Alt 4 Unit Cost	Alt 5 Unit	Alt 5 Unit Cost			
1 Mobilization/Demobilization										
Senior UXO Supervisor	hour		$ 82.00	48	$ 82.00	48	$ 82.00		3	Multiple mob/demobs due to long duration for Site Management
UXO Quality Control Specialist	hour		$ 73.00	48	$ 73.00	48	$ 73.00			
UXO Safety Officer	hour		$ 78.00	48	$ 78.00	48	$ 78.00			
UXO Tech III	hour		$ 63.00	64	$ 63.00	64	$ 63.00	2	4	Sorting Team Leaders
UXO Tech II	hour		$ 52.00	160	$ 52.00	320	$ 52.00	10	20	Sorting Teams = 3 per team, Excavation = 1 per team, Regrading = 1 per team
UXO Tech I	hour		$ 44.00	96	$ 44.00	192	$ 44.00	6	12	Sorting Teams = 3 per team
Scientist II	hour		$ 85.00	16	$ 85.00	16	$ 85.00	1	1	Geos
Project Manager	hour		$ 146.00	48	$ 146.00	48	$ 146.00		1	Field Visits
Misc Field Supplies (batteries, fire extinguishers, cameras)	each		$ 2,268.00	2	$ 2,268.00	2	$ 2,268.00			
Conex Delivery and Pickup	each		$ 1,392.00	12	$ 1,392.00	24	$ 1,392.00			
Office Trailer Mob/Demob	each		$ 2,162.00	1	$ 2,162.00	1	$ 2,162.00			
Airfare: HSV-SYR plus webfee (1 week notice)	RT		$ 848.75	33	$ 848.75	49	$ 848.75			
M&IE Travel Day (75%)	day		$ 44.25	66	$ 44.25	98	$ 44.25			
Lodging + 13% SYR Tax	night		$ 116.39	66	$ 116.39	98	$ 116.39			
			$ -		$ 98,140.99		$ 146,109.47			
2 Mechancial Excavation										
Senior UXO Supervisor	hour		$ 82.00	510	$ 82.00	6320	$ 82.00		1	Person
UXO Quality Control Specialist	hour		$ 73.00	510	$ 73.00	6320	$ 73.00		1	Person
UXO Safety Officer	hour		$ 78.00	510	$ 78.00	6320	$ 78.00		1	Person
UXO Tech II	hour		$ 52.00	1020	$ 52.00	25280	$ 52.00	2	4	based on number of teams above
Project Manager	hour		$ 146.00	51	$ 146.00	632	$ 146.00		1	Field Visits
Misc Field Supplies (batteries, fire extinguishers, cameras)	each		$ 2,268.00	2	$ 2,268.00	4	$ 2,268.00			
Armor an Excavator	each		$ 16,000.00	2	$ 16,000.00	4	$ 16,000.00			
Armor a Dozer	each		$ 24,000.00	2	$ 24,000.00	4	$ 24,000.00			
Armor a Haul Truck	each		$ 6,000.00	2	$ 6,000.00	4	$ 6,000.00			
PC-200 Excavator	day		$ 1,360.00	102	$ 1,360.00	2528	$ 1,360.00			
Dozer	day		$ 900.00	102	$ 900.00	2528	$ 900.00			
Haul Truck	day		$ 800.00	102	$ 800.00	2528	$ 800.00			
Operator	day		$ 1,145.00	102	$ 1,145.00	2528	$ 1,145.00			
Perdiem	day		$ 146.00	102	$ 146.00	2528	$ 146.00			
Pickup Truck Rental	/week		$ 300.00	63.75	$ 300.00	1106	$ 300.00			1 per team plus 3 for site management
Radio - 2 way (set of 10)	/month		$ 725.30	3.1875	$ 725.30	39.5	$ 725.30			
Sanitation	/month		$ 78.70	3.1875	$ 78.70	39.5	$ 78.70			
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day		$ 175.39	446.25	$ 175.39	7742	$ 175.39			
			$ -		$ 819,609.54		$ 15,793,219.38			

Table: 3.4_Mech_Remove
Element: LUCs
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

		Alt 3 Unit	Alt 3 Unit Cost	Alt 4 Unit	Alt 4 Unit Cost	Alt 5 Unit	Alt 5 Unit Cost				
3 Sorting											
Senior UXO Supervisor	hour		$ 82.00	510	$ 82.00	6320	$ 82.00	1	1	Person	
UXO Quality Control Specialist	hour		$ 73.00	510	$ 73.00	6320	$ 73.00	1	1	Person	
UXO Safety Officer	hour		$ 78.00	510	$ 78.00	6320	$ 78.00	1	1	Person	
UXO Tech III	hour		$ 63.00	1020	$ 63.00	25280	$ 63.00	2	4	Sorting Team Leaders	
UXO Tech II	hour		$ 52.00	3060	$ 52.00	75840	$ 52.00	6	12	Sorting Teams = 3 per team	
UXO Tech I	hour		$ 44.00	3060	$ 44.00	75840	$ 44.00	6	12	Sorting Teams = 3 per team	
Scientist II	hour		$ 85.00	510	$ 85.00	6320	$ 85.00	1	1	Geos	
Project Manager	hour		$ 146.00	16	$ 146.00	16	$ 146.00	1	1	Field Visits	
Project Manager	hour		$ 146.00	51	$ 146.00	632	$ 146.00	1 hr per day		Office Time	
Misc Field Supplies (batteries, fire extinguishers, cameras)	each		$ 2,268.00	2	$ 2,268.00	4	$ 2,268.00			1 per team	
Sifting Operation Build Out	each		$ 20,000.00	2	$ 20,000.00	4	$ 20,000.00			1 per team	
Armor an Excavator	each		$ 16,000.00	2	$ 16,000.00	4	$ 16,000.00			1 per team	
PC-200 Excavator	day		$ 1,360.00	102	$ 1,360.00	2528	$ 1,360.00			1 per team	
Operator	day		$ 1,145.00	102	$ 1,145.00	2528	$ 1,145.00			1 per team	
Perdiem	day		$ 146.00	102	$ 146.00	2528	$ 146.00			1 per team	
Pickup Truck Rental	/week		$ 300.00	114.75	$ 300.00	2370	$ 300.00			3 per team plus 3 for Site Management	
Radio - 2 way (set of 10)	/month		$ 725.30	3.1875	$ 725.30	39.5	$ 725.30				
Generator	/week		$ 600.00	51	$ 600.00	158	$ 600.00			2 per team	
Generator Mob/Demob	each		$ 85.00	4	$ 85.00	8	$ 85.00			2 per team per week	
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day		$ 175.39	1517.25	$ 175.39	34286	$ 175.39				
			$ -		$ 1,210,707.37		$ 24,680,998.89				
4 Return/Regrading											
Senior UXO Supervisor	hour		$ 82.00	510	$ 82.00	6320	$ 82.00		1	Person	
UXO Quality Control Specialist	hour		$ 73.00	510	$ 73.00	6320	$ 73.00		1	Person	
UXO Safety Officer	hour		$ 78.00	510	$ 78.00	6320	$ 78.00		1	Person	
UXO Tech II	hour		$ 52.00	1020	$ 52.00	25280	$ 52.00	2	4	based on number of teams above	
Project Manager	hour		$ 146.00	51	$ 146.00	632	$ 146.00		1	Field Visits	
Misc Field Supplies (batteries, fire extinguishers, cameras)	each		$ 2,268.00	2	$ 2,268.00	4	$ 2,268.00				
Armor an Excavator	each		$ 16,000.00	2	$ 16,000.00	4	$ 16,000.00				
Armor a Dozer	each		$ 24,000.00	2	$ 24,000.00	4	$ 24,000.00				
Armor a Haul Truck	each		$ 6,000.00	2	$ 6,000.00	4	$ 6,000.00				
PC-200 Excavator	day		$ 1,360.00	102	$ 1,360.00	2528	$ 1,360.00				
Dozer	day		$ 900.00	102	$ 900.00	2528	$ 900.00				
Haul Truck	day		$ 800.00	102	$ 800.00	2528	$ 800.00				
Operator	day		$ 1,145.00	102	$ 1,145.00	2528	$ 1,145.00				
Perdiem	day		$ 146.00	102	$ 146.00	2528	$ 146.00				
Pickup Truck Rental	/week		$ 300.00	63.75	$ 300.00	1106	$ 300.00			1 per team plus 3 for site management	
Radio - 2 way (set of 10)	/month		$ 725.30	3.1875	$ 725.30	39.5	$ 725.30				
Sanitation	/month		$ 78.70	3.1875	$ 78.70	39.5	$ 78.70				
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day		$ 175.39	446.25	$ 175.39	7742	$ 175.39				
			$ -		$ 819,609.54		$ 15,793,219.38				
5 Waste Characterization											
Scientist II	hour		$ 85.00	220	$ 85.00	5310	$ 85.00				
GPS Handheld	/week		$ 300.00	5.5	$ 300.00	132.75	$ 300.00				
Misc Field Supplies (batteries, fire extinguishers, cameras)	each		$ 2,268.00	2	$ 2,268.00	2	$ 2,268.00				
Pickup Truck Rental	/week		$ 300.00	5.5	$ 300.00	132.75	$ 300.00				
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day		$ 175.39	38.5	$ 175.39	929.25	$ 175.39				
FED Exp Package (50 lbs)	each		$ 309.78	11	$ 309.78	265.5	$ 309.78				
Soil Sample Set	each		$ 170.00	21	$ 170.00	530	$ 170.00				
			$ -		$ 40,282.62		$ 870,889.52				
6 Soil Stabilization and Offsite Disposal											
Engineer II	hour		$ 97.00	40	$ 97.00	40	$ 97.00				
Scientist I	hour		$ 72.00	40	$ 72.00	40	$ 72.00			Alt 4 volume portion of OD Hill	
Senior UXO Supervisor	hour		$ 82.00	40	$ 82.00	40	$ 82.00		1	Person Alt 5 volume Portion of OD Hill and 1 foot inside 500 foot radius	
UXO Quality Control Specialist	hour		$ 73.00	40	$ 73.00	40	$ 73.00		1	Person	
UXO Safety Officer	hour		$ 78.00	40	$ 78.00	40	$ 78.00		1	Person	
UXO Tech II	hour		$ 52.00	80	$ 52.00	160	$ 52.00	2	4	based on number of teams above	
Project Manager	hour		$ 146.00	4	$ 146.00	4	$ 146.00		1	Field Visits	
Misc Field Supplies (batteries, fire extinguishers, cameras)	each		$ 2,268.00	2	$ 2,268.00	4	$ 2,268.00				
Armor an Excavator	each		$ 16,000.00	2	$ 16,000.00	4	$ 16,000.00				
Armor a Dozer	each		$ 24,000.00	2	$ 24,000.00	4	$ 24,000.00				
Armor a Haul Truck	each		$ 6,000.00	2	$ 6,000.00	4	$ 6,000.00				
PC-200 Excavator	day		$ 1,360.00	8	$ 1,360.00	16	$ 1,360.00				
Dozer	day		$ 900.00	8	$ 900.00	16	$ 900.00				
Haul Truck	day		$ 800.00	8	$ 800.00	16	$ 800.00				
Operator	day		$ 1,145.00	8	$ 1,145.00	16	$ 1,145.00				
Perdiem	day		$ 146.00	8	$ 146.00	16	$ 146.00				
Pickup Truck Rental	/week		$ 300.00	5	$ 300.00	7	$ 300.00				
Radio - 2 way (set of 10)	/month		$ 725.30	0.25	$ 725.30	0.25	$ 725.30				
Sanitation	/month		$ 78.70	0.25	$ 78.70	0.25	$ 78.70				
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day		$ 175.39	35	$ 175.39	49	$ 175.39				
Administrative (Home Office)	hour		$ 62.00	20	$ 62.00	20	$ 62.00				
Transport and Disposal to a non-hazardous class 2 landfill	Ton		$ 42.00	35396.65715	$ 42.00	72169.76	$ 42.00	CY of soil	Density g/cm3	Tons/CY	
Soil Sample Set	each		$ 170.00	[illegible]	$ 170.00	[illegible]	$ 170.00	28,000	57,089	1.5	1.26
			$ -		$ 1,651,307.25		$ 3,337,737.24				

Table: 3.4_Mech_Remove
Element: LUCs
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

		Alt 3		Alt 4		Alt 5	
7 Demolition		Unit	Unit Cost	Unit	Unit Cost	Unit	Unit Cost
Drums for MD storage	each		$ 111.11	300	$ 111.11	300	$ 111.11
Medium ISOs	each		$ 10.05	300	$ 10.05	300	$ 10.05
Small ISOs	each		$ 2.15	300	$ 2.15	300	$ 2.15
Misc Field Supplies (batteries, fire extinguishers, cameras)	each		$ 2,268.00	1	$ 2,268.00	10	$ 2,268.00
On-call Explosives (per Demo Shot)	each		$ 2,661.00	11.75	$ 2,661.00	158	$ 2,661.00
Munitions Debris Disposal	/2 tons		$ 4,400.00	8	$ 4,400.00	8	$ 4,400.00
			$ -		$ -		$ -

Table: 3.5_DGM_Intrusive
Element: LUCs
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

Implementation elements include:

1 Mobilization/Demobilization
2 Dynamic Data Collection
3 Cued Data Collection
4 Intrusive
5 IVS Setup

Assumptions

Task	Counts	Units	Production	Units	Teams	Work Days	Work Weeks (4 day)	Per Diem Days/ person	Persons	Total Staff	
Alt 3											
Mobilization/Demobilization	1	persons	0.5	round trips per day	1	2	0.5	2	25	SUXOS, Safety, UXO QC, Geo Lead, 3 Geos, 3 UXO Tech II (geo), 2 UXO Tech III, 4 UXO Tech II, and 4 UXO Tech I	
Dynamic Data Collection	353	Acres	1	acres/day/team	3	118	29.5	206.5	10	SUXOS, Safety, UXO QC, Geo Lead, 3 Geos, 3 UXO Tech II	Total number of MRS Acres minus Footprint of cap
Cued Data Collection	141,484	anomalies	275	targets/day/team	2	258	64.5	451.5	8	SUXOS, Safety, UXO QC, Geo Lead, 2 Geos, 2 UXO Tech II	See Compilation Report Calcs for rates.
Intrusive	28,297	TOI	125	TOI/day/team	8	76	19	133	19	SUXOS, Safety, UXO QC, 1 Geo, 2 UXO Tech III, 4 UXO Tech II, and 4 UXO Tech I	This is assumed at 80% reduction due to small items
IVS	3	Days	1	day/day/team	1	3	0.75	5.25	5	SUXOS, Safety, UXO QC, 2 Geo	
Alt 4											
Mobilization/Demobilization	1	persons	0.5	round trips per day	1	2	0.5	3.5	18	SUXOS, Safety, UXO QC, Geo Lead, 3 Geos, 3 UXO Tech II (geo), 2 UXO Tech III, 3 UXO Tech II, and 3 UXO Tech I	
Dynamic Data Collection	805	Acres	1	acres/day/team	3	135	33.75	236.25	10	SUXOS, Safety, UXO QC, Geo Lead, 3 Geos, 3 UXO Tech II	Full acres of site
Cued Data Collection	141,484	anomalies	275	targets/day/team	2	258	64.5	451.5	8	SUXOS, Safety, UXO QC, Geo Lead, 3 Geos, 3 UXO Tech II	Highest number, will include OD hill area without excavation of 1 foot.
Intrusive	28,297	TOI	125	TOI/day/team	3	76	19	133	19	SUXOS, Safety, UXO QC, 1 Geo	This is assumed at 80% reduction due to small items
IVS	2	Days	1	day/day/team	1	3	0.75	5.25	5	SUXOS, Safety, UXO QC, 2 Geo	
Alt 5											
Mobilization/Demobilization	1	persons	0.5	round trips per day	1	2	0.5	3.5	18	SUXOS, Safety, UXO QC, Geo Lead, 3 Geos, 3 UXO Tech II (geo), 2 UXO Tech III, 3 UXO Tech II, and 3 UXO Tech I	
Dynamic Data Collection	403	Acres	1	acres/day/team	3	135	33.75	236.25	10	SUXOS, Safety, UXO QC, Geo Lead, 3 Geos, 3 UXO Tech II	Full acres of site
Cued Data Collection	57,217	anomalies	275	targets/day/team	2	105	26.25	183.75	8	SUXOS, Safety, UXO QC, Geo Lead, 3 Geos, 3 UXO Tech II	Should assume 97% removal outside center, and 60% in center
Intrusive	11,443	TOI	125	TOI/day/team	3	31	7.75	54.25	19	SUXOS, Safety, UXO QC, 1 Geo	This is assumed at 80% reduction due to small items
IVS	3	Days	1	day/day/team	1	3	0.75	5.25	5	SUXOS, Safety, UXO QC, 2 Geo	

		Alt 3 Unit	Alt 3 Unit Cost	Alt 4 Unit	Alt 4 Unit Cost	Alt 5 Unit	Alt 5 Unit Cost	
1 Mobilization/Demobilization								
Senior UXO Supervisor	hour	48	$ 82.00	48	$ 82.00	48	$ 82.00	1 Multiple mob/demobs due to long duration
UXO Quality Control Specialist	hour	48	$ 73.00	48	$ 73.00	48	$ 73.00	
UXO Safety Officer	hour	48	$ 78.00	48	$ 78.00	48	$ 78.00	
UXO Tech III	hour	48	$ 63.00	48	$ 63.00	48	$ 63.00	3 Intrusive team leaders
UXO Tech II	hour	144	$ 52.00	144	$ 52.00	144	$ 52.00	9 3 for Geo and 4 for Intrusive, not the same due to overlap of tasks
UXO Tech I	hour	96	$ 44.00	96	$ 44.00	96	$ 44.00	6 4 for Intrusive
Scientist II	hour	48	$ 85.00	48	$ 85.00	48	$ 85.00	3 Geos
Scientist III	hour	16	$ 115.00	16	$ 115.00	16	$ 115.00	1 Geo Lead
Project Manager	hour	64	$ 146.00	64	$ 146.00	64	$ 146.00	4 Field Visits
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	2	$ 2,268.00	2	$ 2,268.00	2	$ 2,268.00	
Conex Delivery and Pickup	each	2	$ 1,392.00	2	$ 1,392.00	2	$ 1,392.00	
Office Trailer Mob/Demob	each	1	$ 2,162.00	1	$ 2,162.00	1	$ 2,162.00	
Airfare: HSV-SYR plus webfee (1 week notice)	RT	25	$ 848.75	25	$ 848.75	25	$ 848.75	
M&IE Travel Day (75%)	day	70	$ 44.25	70	$ 44.25	70	$ 44.25	
Lodging + 13% SYR Tax	night	70	$ 116.39	70	$ 116.39	70	$ 116.39	
			$ 83,129.55		$ 83,129.55		$ 83,129.55	
2 Dynamic Data Collection								
Senior UXO Supervisor	hour	1180	$ 82.00	1350	$ 82.00	1350	$ 82.00	1 Person
UXO Quality Control Specialist	hour	1180	$ 73.00	1350	$ 73.00	1350	$ 73.00	1 Person
UXO Safety Officer	hour	1180	$ 78.00	1350	$ 78.00	1350	$ 78.00	1 Person
Scientist II	hour	3540	$ 85.00	4050	$ 85.00	4050	$ 85.00	based on number of teams above
Scientist III	hour	1180	$ 115.00	1350	$ 115.00	1350	$ 115.00	1 Person
Project Manager	hour	118	$ 146.00	135	$ 146.00	135	$ 146.00	
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	2	$ 2,268.00	2	$ 2,268.00	2	$ 2,268.00	
GPS Handheld	/week	29.5	$ 300.00	33.75	$ 300.00	33.75	$ 300.00	
GPS - RTK Base Station	/week	29.5	$ 400.00	33.75	$ 400.00	33.75	$ 400.00	
GPS Network Rover Only	/week	88.5	$ 450.00	101.25	$ 450.00	101.25	$ 450.00	1 per team
Geophysical Survey Instruments	/week	88.5	$ 560.00	101.25	$ 560.00	101.25	$ 560.00	1 per team
Mobilization - Geophysical Instrumentation (80 lbs)	each	6	$ 150.00	6	$ 150.00	6	$ 150.00	2 per team
Pickup Truck Rental	/week	88.5	$ 300.00	101.25	$ 300.00	101.25	$ 300.00	1 per team
Radio - 2 way (set of 10)	/month	7.375	$ 725.30	8.4375	$ 725.30	8.4375	$ 725.30	
Computer	/week	29.5	$ 23.75	33.75	$ 23.75	33.75	$ 23.75	
Sanitation	/month	7.375	$ 78.70	8.4375	$ 78.70	8.4375	$ 78.70	
Gator	/month	7.375	$ 908.00	8.4375	$ 908.00	8.4375	$ 908.00	1 towed teams
Gator Mob/Demob	each	2	$ 80.00	2	$ 80.00	2	$ 80.00	
Generator	/week	29.5	$ 600.00	33.75	$ 600.00	33.75	$ 600.00	
Generator Mob/Demob	each	2	$ 85.00	2	$ 85.00	2	$ 85.00	
Tractor/skidsteer	/week	59	$ 953.00	67.5	$ 953.00	67.5	$ 953.00	2 AGC dynamic teams
Tractor Mob/Demob	each	2	$ 85.00	2	$ 85.00	2	$ 85.00	
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	2065	$ 175.39	2362.5	$ 175.39	2362.5	$ 175.39	
			$ 1,320,722.98		$ 1,510,141.44		$ 1,510,141.44	

Table: 3.5_DGM_Intrusive
Element: LUCs
Date: July 31, 2018
Contract: W912DY-08-D-0003 Task Order 0013
Document: FS Report for OD Grounds MRA
Site: Seneca Army Depot Activity, Romulus, New York

3 Cued Data Collection										
Senior UXO Supervisor	hour	2580	$ 82.00	2580	$ 82.00	1050	$ 82.00	1	Person
UXO Quality Control Specialist	hour	2580	$ 73.00	2580	$ 73.00	1050	$ 73.00	1	Person
UXO Safety Officer	hour	2580	$ 78.00	2580	$ 78.00	1050	$ 78.00	1	Person
UXO Tech II	hour	5160	$ 52.00	5160	$ 52.00	2100	$ 52.00		based on number of teams above
Scientist II	hour	5160	$ 85.00	5160	$ 85.00	2100	$ 85.00		based on number of teams above
Scientist III	hour	2580	$ 115.00	2580	$ 115.00	1050	$ 115.00	1	Person
Project Manager	hour	258	$ 146.00	258	$ 146.00	105	$ 146.00		
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	2	$ 2,268.00	2	$ 2,268.00	2	$ 2,268.00		
GPS Handheld	/week	64.5	$ 300.00	64.5	$ 300.00	26.25	$ 300.00		
GPS - RTK Base Station	/week	64.5	$ 400.00	64.5	$ 400.00	26.25	$ 400.00		
GPS Network Rover Only	/week	129	$ 450.00	129	$ 450.00	52.5	$ 450.00		1 per team
Geophysical Survey Instruments	/week	129	$ 560.00	129	$ 560.00	52.5	$ 560.00		1 per team
Mobilization - Geophysical Instrumentation (80 lbs)	each	4	$ 150.00	4	$ 150.00	4	$ 150.00		2 per team
Pickup Truck Rental	/week	129	$ 300.00	129	$ 300.00	52.5	$ 300.00		1 per team
Radio - 2 way (set of 10)	/month	16.125	$ 725.30	16.125	$ 725.30	6.5625	$ 725.30		
Computer	/week	64.5	$ 23.75	64.5	$ 23.75	26.25	$ 23.75		
Sanitation	/month	16.125	$ 78.70	16.125	$ 78.70	6.5625	$ 78.70		
Generator	/week	64.5	$ 600.00	64.5	$ 600.00	26.25	$ 600.00		
Generator Mob/Demob	each	2	$ 85.00	2	$ 85.00	2	$ 85.00		
Tractor/skidsteer	/week	129	$ 953.00	129	$ 953.00	52.5	$ 953.00	2	AGC cued teams
Tractor Mob/Demob	each	2	$ 85.00	2	$ 85.00	2	$ 85.00		
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	3612	$ 175.39	3612	$ 175.39	1470	$ 175.39		
			$ 2,671,686.06		$ 2,671,686.06		$ 1,090,561.49		
4 Intrusive										
Senior UXO Supervisor	hour	760	$ 82.00	760	$ 82.00	310	$ 82.00	1	Person
UXO Quality Control Specialist	hour	760	$ 73.00	760	$ 73.00	310	$ 73.00	1	Person
UXO Safety Officer	hour	760	$ 78.00	760	$ 78.00	310	$ 78.00	1	Person
UXO Tech III	hour	2280	$ 63.00	2280	$ 63.00	930	$ 63.00		1 per team
UXO Tech II	hour	4560	$ 52.00	4560	$ 52.00	1860	$ 52.00		2 per team
UXO Tech I	hour	4560	$ 44.00	4560	$ 44.00	1860	$ 44.00		2 per team
Project Manager	hour	228	$ 146.00	228	$ 146.00	93	$ 146.00		
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	2	$ 2,268.00	2	$ 2,268.00	2	$ 2,268.00		
GPS Handheld	/week	19	$ 300.00	19	$ 300.00	7.75	$ 300.00		
GPS Network Rover Only	/week	57	$ 450.00	57	$ 450.00	23.25	$ 450.00		
Geophysical Survey Instruments	/week	57	$ 560.00	57	$ 560.00	23.25	$ 560.00		
Mobilization - Geophysical Instrumentation (80 lbs)	each	6	$ 150.00	6	$ 150.00	6	$ 150.00		
Pickup Truck Rental	/week	57	$ 300.00	57	$ 300.00	23.25	$ 300.00		
Radio - 2 way (set of 10)	/month	4.75	$ 725.30	4.75	$ 725.30	1.9375	$ 725.30		
Sanitation	/month	4.75	$ 78.70	4.75	$ 78.70	1.9375	$ 78.70		
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	2527	$ 175.39	2527	$ 175.39	1030.75	$ 175.39		
			$ 1,324,603.53		$ 1,324,603.53		$ 543,517.49		
5 IVS Setup										
Senior UXO Supervisor	hour	30	$ 82.00	30	$ 82.00	30	$ 82.00	1	Person
UXO Quality Control Specialist	hour	30	$ 73.00	30	$ 73.00	30	$ 73.00	1	Person
UXO Safety Officer	hour	30	$ 78.00	30	$ 78.00	30	$ 78.00	1	Person
UXO Tech III	hour	30	$ 63.00	30	$ 63.00	30	$ 63.00		based on number of teams above
UXO Tech II	hour	30	$ 52.00	30	$ 52.00	30	$ 52.00		based on number of teams above
UXO Tech I	hour	30	$ 44.00	30	$ 44.00	30	$ 44.00	1	Person
Project Manager	hour	3	$ 146.00	3	$ 146.00	3	$ 146.00		
Misc Field Supplies (batteries, fire extinguishers, cameras)	each	2	$ 2,268.00	2	$ 2,268.00	2	$ 2,268.00		
GPS Handheld	/week	0.75	$ 300.00	0.75	$ 300.00	0.75	$ 300.00		
GPS - RTK Base Station	/week	0.75	$ 400.00	0.75	$ 400.00	0.75	$ 400.00		
GPS Network Rover Only	/week	0.75	$ 450.00	0.75	$ 450.00	0.75	$ 450.00		
Geophysical Survey Instruments	/week	0.75	$ 560.00	0.75	$ 560.00	0.75	$ 560.00		
Mobilization - Geophysical Instrumentation (80 lbs)	each	2	$ 150.00	2	$ 150.00	2	$ 150.00		
Pickup Truck Rental	/week	0.75	$ 300.00	0.75	$ 300.00	0.75	$ 300.00		
Radio - 2 way (set of 10)	/month	0.1875	$ 725.30	0.1875	$ 725.30	0.1875	$ 725.30		
Computer	/week	0.75	$ 23.75	0.75	$ 23.75	0.75	$ 23.75		
Sanitation	/month	0.1875	$ 78.70	0.1875	$ 78.70	0.1875	$ 78.70		
Gator	/month	0	$ 908.00	0.1875	$ 908.00	0.1875	$ 908.00		
Gator Mob/Demob	each	2	$ 80.00	2	$ 80.00	2	$ 80.00		
Generator	/week	0.75	$ 600.00	0.75	$ 600.00	0.75	$ 600.00		
Generator Mob/Demob	each	2	$ 85.00	2	$ 85.00	2	$ 85.00		
Tractor/skidsteer	/week	0	$ 953.00	0	$ 953.00	0	$ 953.00		
Tractor Mob/Demob	each	2	$ 85.00	2	$ 85.00	2	$ 85.00		
Full Day Per Diem (Lodging, 13% Tax + M&IE)	day	0	$ 175.39	0	$ 175.39	0	$ 175.39		
			$ 19,660.06		$ 19,830.31		$ 19,830.31		

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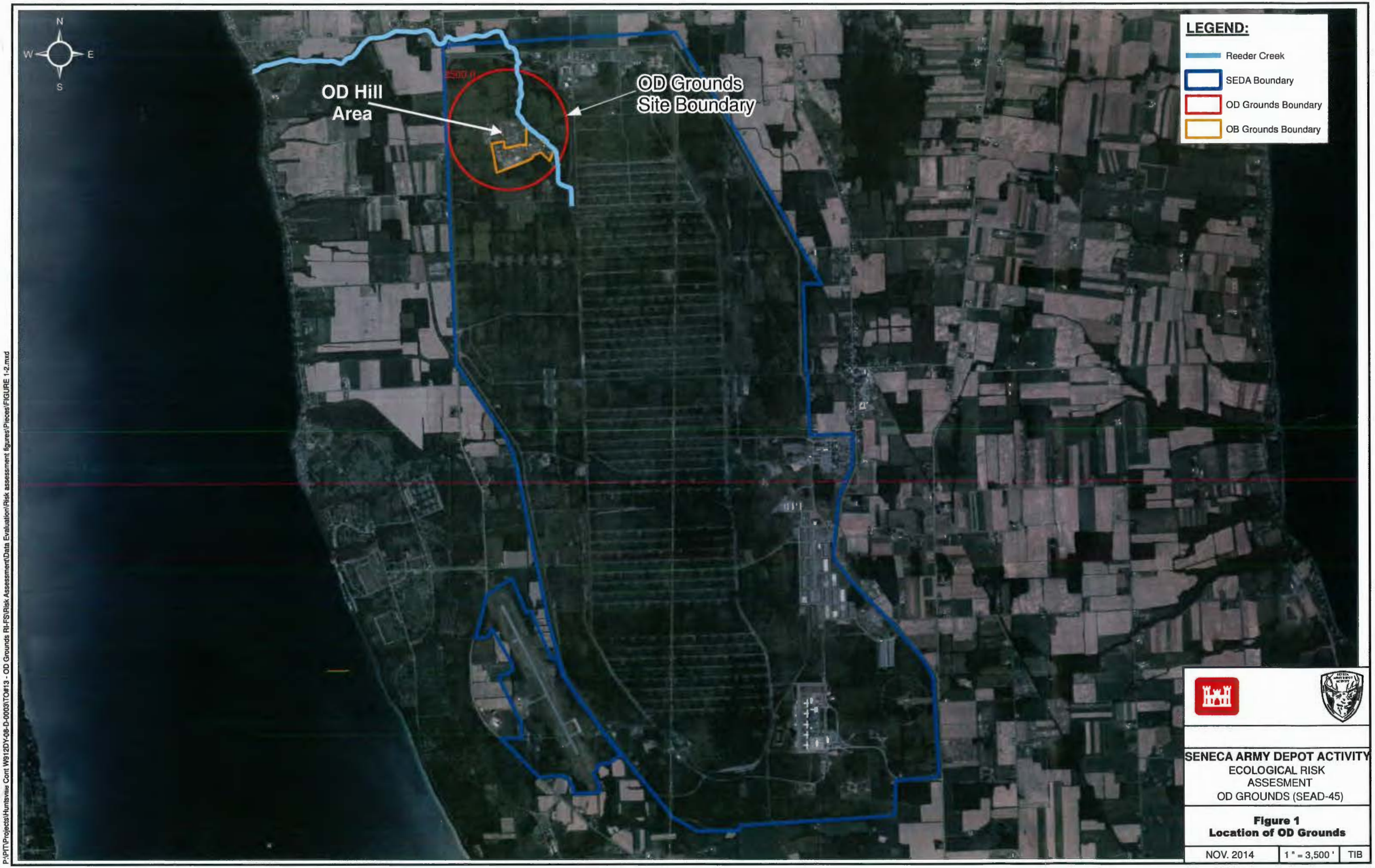
APPENDIX E
COMPILATION OF PREVIOUS INVESTIGATIONS AND STUDIES

Appendix C2
Munitions and Explosives of Concern Risk Assessment (MEC RA) and Alternatives Analysis



SENECA ARMY DEPOT ACTIVITY
ECOLOGICAL RISK ASSESMENT
OD GROUNDS (SEAD-45)

Figure 1
Location of OD Grounds

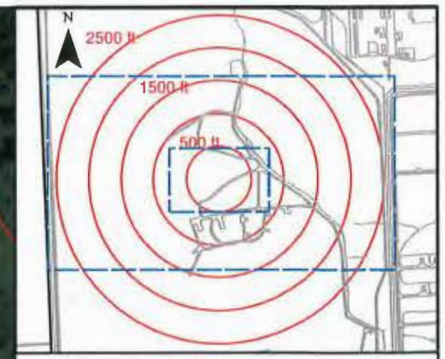
NOV. 2014	1 " = 3,500 '	TIB

P:\PIT\Projects\Huntsville Cont W912DY-08-D-0003\TO#13 - OD Grounds RI-FS\Risk Assessment\Data Evaluation\Risk assessment figures\Pieces\FIGURE 1-2.mxd

N
W
E
S

1500 ft
1000 ft
500 ft

S45-R15-01
S45-R15-02
S45-R15-06
S45-R10-01
S45-R10-02
S45-R10-06
OD Hill Area
SD45-1
SD45-4
SS45-8
SD45-2
S45-R5-07
SS45-1
SS45-9
S45-R5-06
SD45-3
S45-R10-03
S45-R15-05
S45-R10-05
SS45-2
S45-R15-03
S45-R4-01
SS45-3
S45-R5-05
S45-R5-08
S45-R5-04
S45-R10-07
S45-R10-04
S45-R15-04



OD Grounds Site

Legend

500 ft — Radius Rings from OD Hill Distance from Center

Center Point of all Radius Rings (N 1012812, E 738375)

OB Grounds Boundary

Subsurface Soil Sample Location

Surface Soil Sample Location

Drainage Ditch Sample Location

SENECA ARMY DEPOT ACTIVITY
ECOLOGICAL
RISK ASSESMENT
OD GROUNDS (SEAD-45)

Figure 2
OD Grounds Soil Sample Locations

NOV. 2014	1 " = 300 '	BBO

P:\PIT\Projects\Huntsville Cont W912DY-08-D-0003\TO#13 - OD Grounds RI-FS\Risk Assessment\Data Evaluation\Risk assessment figures\FIGURE B-1-2.mxd

N
W
E
S

LEGEND:

- Onsite Ditch Samples
- Upstream Samples
- Onsite and Downstream Reeder Creek Samples
- Reeder Creek
- OD Grounds Boundary
- OB Grounds Boundary

SW-110
SW-320
SW-120
SW45-1
SW-300
SW45-4
SW-140
SW45-2
SW-150
SW45-3
SW-196
Direction Of Flow

P:\PIT\Projects\Huntsv...ont W912DY-08-D-0003\TO#13 - OD Grounds RI-FS\Risk Assessment\Data Evaluation\Risk assessment figures\F... ...\FIGURE B-1-5.mxd

SENECA ARMY DEPOT ACTIVITY
HUMAN HEALTH
RISK ASSESMENT
OD GROUNDS (SEAD-45)

Figure 3
OD Grounds Surface Water Sample Locations

NOV. 2014	1 " = 2,000 '	TIB

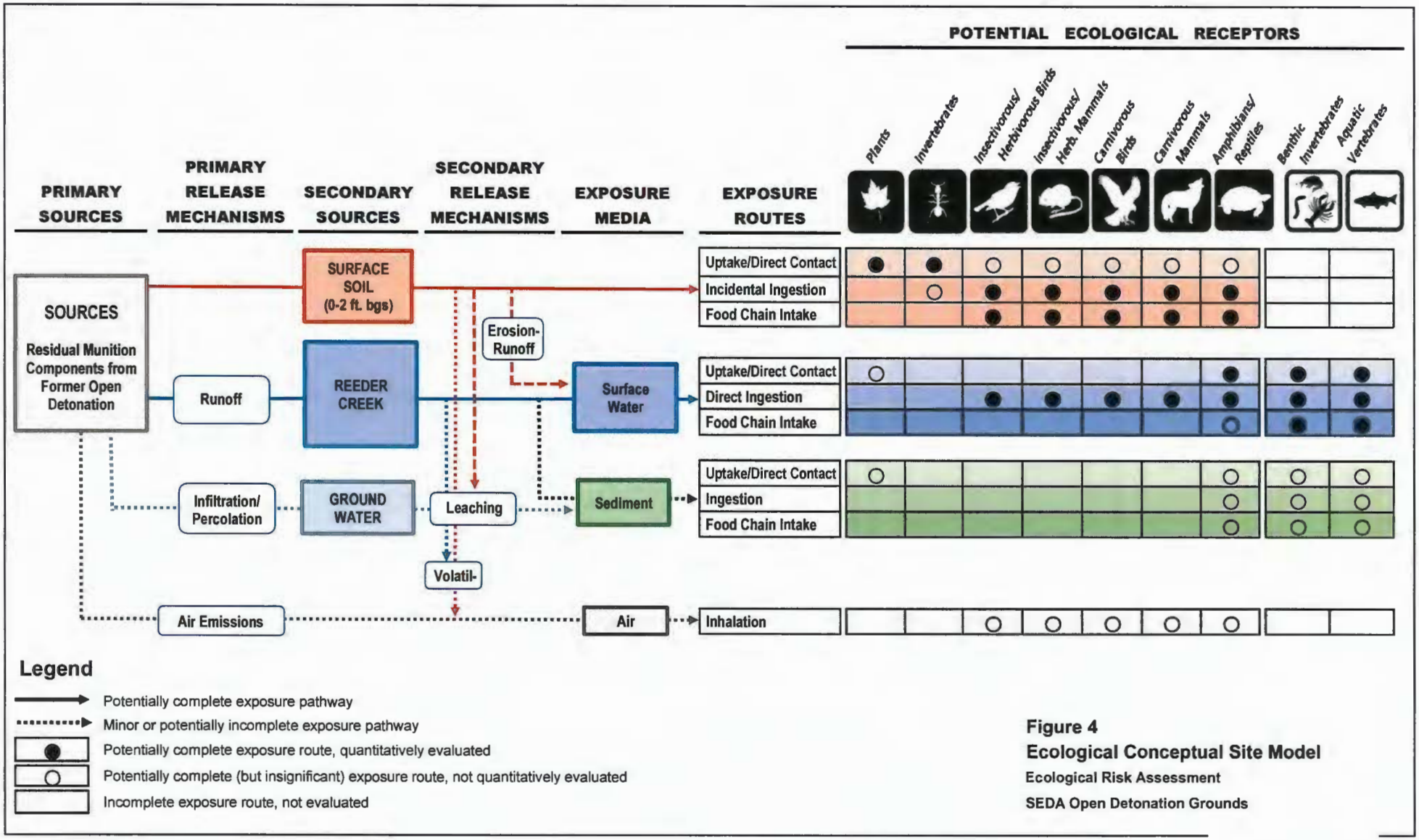


Figure 4
Ecological Conceptual Site Model
Ecological Risk Assessment
SEDA Open Detonation Grounds

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ATTACHMENT A

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Open Detonation (OD) Grounds – OD Hill
Seneca Army Depot Activity (SEDA)
Baseline Ecological Risk Assessment

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.17/25/2018 6:53:11 PM
From File	Surfsoil_ProUCL_temp.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Aluminum

General Statistics

Total Number of Observations	55	Number of Distinct Observations	37
		Number of Missing Observations	0
Minimum	5910	Mean	18346
Maximum	35000	Median	17800
SD	4206	Std. Error of Mean	567.2
Coefficient of Variation	0.229	Skewness	1.883

Normal GOF Test

Shapiro Wilk Test Statistic	0.755	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	9.842E-12	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.237	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	19295	95% Adjusted-CLT UCL (Chen-1995)	19433
		95% Modified-t UCL (Johnson-1978)	19319

Gamma GOF Test

A-D Test Statistic	4.081	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.749	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.208	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	20.42	k star (bias corrected MLE)	19.32
Theta hat (MLE)	898.3	Theta star (bias corrected MLE)	949.5
nu hat (MLE)	2246	nu star (bias corrected)	2125
MLE Mean (bias corrected)	18346	MLE Sd (bias corrected)	4174
		Approximate Chi Square Value (0.05)	2019
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	2016

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	19310	95% Adjusted Gamma UCL (use when n<50)	19336

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.773	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	6.041E-11	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.205	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	8.684	Mean of logged Data	9.792
Maximum of Logged Data	10.46	SD of logged Data	0.23

Assuming Lognormal Distribution

95% H-UCL	19398	90% Chebyshev (MVUE) UCL	20101
95% Chebyshev (MVUE) UCL	20885	97.5% Chebyshev (MVUE) UCL	21973
99% Chebyshev (MVUE) UCL	24110		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	19279	95% Jackknife UCL	19295
95% Standard Bootstrap UCL	19267	95% Bootstrap-t UCL	19584
95% Hall's Bootstrap UCL	19929	95% Percentile Bootstrap UCL	19257
95% BCA Bootstrap UCL	19489		
90% Chebyshev(Mean, Sd) UCL	20047	95% Chebyshev(Mean, Sd) UCL	20818
97.5% Chebyshev(Mean, Sd) UCL	21888	99% Chebyshev(Mean, Sd) UCL	23989

Suggested UCL to Use

95% Student's-t UCL	19295	or 95% Modified-t UCL	19319

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Antimony

General Statistics

Total Number of Observations	55	Number of Distinct Observations	41
		Number of Missing Observations	0
Minimum	0.09	Mean	1.929
Maximum	13.4	Median	0.26
SD	3.564	Std. Error of Mean	0.481
Coefficient of Variation	1.848	Skewness	2.107

Normal GOF Test

Shapiro Wilk Test Statistic	0.552	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.369	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	2.733	95% Adjusted-CLT UCL (Chen-1995)	2.865
		95% Modified-t UCL (Johnson-1978)	2.756
Gamma GOF Test			
A-D Test Statistic	5.953	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.817	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.239	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.127	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	0.491	k star (bias corrected MLE)	0.476
Theta hat (MLE)	3.928	Theta star (bias corrected MLE)	4.049
nu hat (MLE)	54.01	nu star (bias corrected)	52.4
MLE Mean (bias corrected)	1.929	MLE Sd (bias corrected)	2.795
		Approximate Chi Square Value (0.05)	36.77
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	36.42
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	2.748	95% Adjusted Gamma UCL (use when n<50)	2.775
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.829	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	2.7805E-8	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.194	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-2.408	Mean of logged Data	-0.64
Maximum of Logged Data	2.595	SD of logged Data	1.489
Assuming Lognormal Distribution			
95% H-UCL	2.938	90% Chebyshev (MVUE) UCL	2.767
95% Chebyshev (MVUE) UCL	3.326	97.5% Chebyshev (MVUE) UCL	4.101
99% Chebyshev (MVUE) UCL	5.624		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	2.719	95% Jackknife UCL	2.733
95% Standard Bootstrap UCL	2.706	95% Bootstrap-t UCL	2.904
95% Hall's Bootstrap UCL	2.79	95% Percentile Bootstrap UCL	2.693
95% BCA Bootstrap UCL	2.836		
90% Chebyshev(Mean, Sd) UCL	3.37	95% Chebyshev(Mean, Sd) UCL	4.024
97.5% Chebyshev(Mean, Sd) UCL	4.93	99% Chebyshev(Mean, Sd) UCL	6.711
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	4.024		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Arsenic			
General Statistics			
Total Number of Observations	55	Number of Distinct Observations	25
		Number of Missing Observations	0
Minimum	4	Mean	5.578
Maximum	12.4	Median	5.2
SD	1.462	Std. Error of Mean	0.197
Coefficient of Variation	0.262	Skewness	3.036
Normal GOF Test			
Shapiro Wilk Test Statistic	0.687	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	1.277E-14	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.258	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	5.908	95% Adjusted-CLT UCL (Chen-1995)	5.989
		95% Modified-t UCL (Johnson-1978)	5.921
Gamma GOF Test			
A-D Test Statistic	3.425	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.749	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.227	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	20.59	k star (bias corrected MLE)	19.48
Theta hat (MLE)	0.271	Theta star (bias corrected MLE)	0.286
nu hat (MLE)	2265	nu star (bias corrected)	2142
MLE Mean (bias corrected)	5.578	MLE Sd (bias corrected)	1.264
		Approximate Chi Square Value (0.05)	2036
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	2033
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	5.87	95% Adjusted Gamma UCL (use when n<50)	5.878
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.828	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	2.3344E-8	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.209	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			

Lognormal Statistics			
Minimum of Logged Data	1.386	Mean of logged Data	1.694
Maximum of Logged Data	2.518	SD of logged Data	0.208
Assuming Lognormal Distribution			
95% H-UCL	5.84	90% Chebyshev (MVUE) UCL	6.033
95% Chebyshev (MVUE) UCL	6.247	97.5% Chebyshev (MVUE) UCL	6.543
99% Chebyshev (MVUE) UCL	7.127		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	5.902	95% Jackknife UCL	5.908
95% Standard Bootstrap UCL	5.896	95% Bootstrap-t UCL	6.071
95% Hall's Bootstrap UCL	6.404	95% Percentile Bootstrap UCL	5.911
95% BCA Bootstrap UCL	5.993		
90% Chebyshev(Mean, Sd) UCL	6.169	95% Chebyshev(Mean, Sd) UCL	6.437
97.5% Chebyshev(Mean, Sd) UCL	6.809	99% Chebyshev(Mean, Sd) UCL	7.539
Suggested UCL to Use			
95% Student's-t UCL	5.908	or 95% Modified-t UCL	5.921
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Barium			
General Statistics			
Total Number of Observations	55	Number of Distinct Observations	45
		Number of Missing Observations	0
Minimum	27.9	Mean	178.2
Maximum	365	Median	170
SD	53.75	Std. Error of Mean	7.248
Coefficient of Variation	0.302	Skewness	0.912
Normal GOF Test			
Shapiro Wilk Test Statistic	0.911	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	3.8416E-4	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.196	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	190.4	95% Adjusted-CLT UCL (Chen-1995)	191.1
		95% Modified-t UCL (Johnson-1978)	190.5
Gamma GOF Test			
A-D Test Statistic	1.957	**Anderson-Darling Gamma GOF Test**	

5% A-D Critical Value	0.75	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.165	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	9.97	k star (bias corrected MLE)	9.438
Theta hat (MLE)	17.88	Theta star (bias corrected MLE)	18.89
nu hat (MLE)	1097	nu star (bias corrected)	1038
MLE Mean (bias corrected)	178.2	MLE Sd (bias corrected)	58.02
		Approximate Chi Square Value (0.05)	964.4
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	962.5
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	191.9	95% Adjusted Gamma UCL (use when n<50)	192.3
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.819	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	8.2731E-9	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.172	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	3.329	Mean of logged Data	5.132
Maximum of Logged Data	5.9	SD of logged Data	0.353
Assuming Lognormal Distribution			
95% H-UCL	196.1	90% Chebyshev (MVUE) UCL	206.5
95% Chebyshev (MVUE) UCL	218.5	97.5% Chebyshev (MVUE) UCL	235.1
99% Chebyshev (MVUE) UCL	267.7		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	190.2	95% Jackknife UCL	190.4
95% Standard Bootstrap UCL	190.4	95% Bootstrap-t UCL	192
95% Hall's Bootstrap UCL	193.3	95% Percentile Bootstrap UCL	190
95% BCA Bootstrap UCL	191.1		
90% Chebyshev(Mean, Sd) UCL	200	95% Chebyshev(Mean, Sd) UCL	209.8
97.5% Chebyshev(Mean, Sd) UCL	223.5	99% Chebyshev(Mean, Sd) UCL	250.4
Suggested UCL to Use			
95% Student's-t UCL	190.4	or 95% Modified-t UCL	190.5
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Beryllium			

General Statistics			
Total Number of Observations	55	Number of Distinct Observations	28
		Number of Missing Observations	0
Minimum	0.43	Mean	0.786
Maximum	1.4	Median	0.79
SD	0.124	Std. Error of Mean	0.0167
Coefficient of Variation	0.158	Skewness	1.765
Normal GOF Test			
Shapiro Wilk Test Statistic	0.829	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	2.7815E-8	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.167	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	0.814	95% Adjusted-CLT UCL (Chen-1995)	0.818
		95% Modified-t UCL (Johnson-1978)	0.815
Gamma GOF Test			
A-D Test Statistic	2.267	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.748	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.149	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	43.58	k star (bias corrected MLE)	41.22
Theta hat (MLE)	0.018	Theta star (bias corrected MLE)	0.0191
nu hat (MLE)	4794	nu star (bias corrected)	4534
MLE Mean (bias corrected)	0.786	MLE Sd (bias corrected)	0.122
		Approximate Chi Square Value (0.05)	4378
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	4374
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	0.814	95% Adjusted Gamma UCL (use when n<50)	0.815
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.873	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	4.3362E-6	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.146	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-0.844	Mean of logged Data	-0.252
Maximum of Logged Data	0.336	SD of logged Data	0.153
Assuming Lognormal Distribution			
95% H-UCL	0.815	90% Chebyshev (MVUE) UCL	0.835
95% Chebyshev (MVUE) UCL	0.858	97.5% Chebyshev (MVUE) UCL	0.888

99% Chebyshev (MVUE) UCL	0.949		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.814	95% Jackknife UCL	0.814
95% Standard Bootstrap UCL	0.813	95% Bootstrap-t UCL	0.819
95% Hall's Bootstrap UCL	0.832	95% Percentile Bootstrap UCL	0.814
95% BCA Bootstrap UCL	0.817		
90% Chebyshev(Mean, Sd) UCL	0.837	95% Chebyshev(Mean, Sd) UCL	0.859
97.5% Chebyshev(Mean, Sd) UCL	0.891	99% Chebyshev(Mean, Sd) UCL	0.953
Suggested UCL to Use			
95% Student's-t UCL	0.814	or 95% Modified-t UCL	0.815
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Cadmium			
General Statistics			
Total Number of Observations	55	Number of Distinct Observations	42
		Number of Missing Observations	0
Minimum	0.46	Mean	7.023
Maximum	23.6	Median	7.4
SD	3.806	Std. Error of Mean	0.513
Coefficient of Variation	0.542	Skewness	1.4
Normal GOF Test			
Shapiro Wilk Test Statistic	0.872	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	3.5672E-6	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.167	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	7.882	95% Adjusted-CLT UCL (Chen-1995)	7.971
		95% Modified-t UCL (Johnson-1978)	7.898
Gamma GOF Test			
A-D Test Statistic	3.185	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.76	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.194	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.121	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	2.624	k star (bias corrected MLE)	2.493

Theta hat (MLE)	2.677	Theta star (bias corrected MLE)	2.817
nu hat (MLE)	288.6	nu star (bias corrected)	274.2
MLE Mean (bias corrected)	7.023	MLE Sd (bias corrected)	4.448
		Approximate Chi Square Value (0.05)	236.9
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	235.9
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	8.131	95% Adjusted Gamma UCL (use when n<50)	8.163
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.8	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	1.1594E-9	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.233	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-0.777	Mean of logged Data	1.747
Maximum of Logged Data	3.161	SD of logged Data	0.763
Assuming Lognormal Distribution			
95% H-UCL	9.532	90% Chebyshev (MVUE) UCL	10.24
95% Chebyshev (MVUE) UCL	11.43	97.5% Chebyshev (MVUE) UCL	13.07
99% Chebyshev (MVUE) UCL	16.3		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	7.867	95% Jackknife UCL	7.882
95% Standard Bootstrap UCL	7.869	95% Bootstrap-t UCL	8.001
95% Hall's Bootstrap UCL	8.175	95% Percentile Bootstrap UCL	7.857
95% BCA Bootstrap UCL	7.956		
90% Chebyshev(Mean, Sd) UCL	8.563	95% Chebyshev(Mean, Sd) UCL	9.26
97.5% Chebyshev(Mean, Sd) UCL	10.23	99% Chebyshev(Mean, Sd) UCL	12.13
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	9.26		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Chromium			
General Statistics			
Total Number of Observations	55	Number of Distinct Observations	48
		Number of Missing Observations	0
Minimum	10.6	Mean	44.14
Maximum	484	Median	28
SD	82.73	Std. Error of Mean	11.16

Coefficient of Variation	1.874	Skewness	5.081
Normal GOF Test			
Shapiro Wilk Test Statistic	0.244	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.469	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	62.81	95% Adjusted-CLT UCL (Chen-1995)	70.66
		95% Modified-t UCL (Johnson-1978)	64.08
Gamma GOF Test			
A-D Test Statistic	14.58	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.768	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.425	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.122	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.534	k star (bias corrected MLE)	1.462
Theta hat (MLE)	28.78	Theta star (bias corrected MLE)	30.19
nu hat (MLE)	168.7	nu star (bias corrected)	160.8
MLE Mean (bias corrected)	44.14	MLE Sd (bias corrected)	36.5
		Approximate Chi Square Value (0.05)	132.5
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	131.8
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	53.57	95% Adjusted Gamma UCL (use when n<50)	53.85
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.468	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.355	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.361	Mean of logged Data	3.427
Maximum of Logged Data	6.182	SD of logged Data	0.565
Assuming Lognormal Distribution			
95% H-UCL	41.88	90% Chebyshev (MVUE) UCL	44.74
95% Chebyshev (MVUE) UCL	48.71	97.5% Chebyshev (MVUE) UCL	54.21
99% Chebyshev (MVUE) UCL	65.02		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	62.49	95% Jackknife UCL	62.81

95% Standard Bootstrap UCL	62.67	95% Bootstrap-t UCL	329.4
95% Hall's Bootstrap UCL	208.2	95% Percentile Bootstrap UCL	61.49
95% BCA Bootstrap UCL	76.4		
90% Chebyshev(Mean, Sd) UCL	77.61	95% Chebyshev(Mean, Sd) UCL	92.77
97.5% Chebyshev(Mean, Sd) UCL	113.8	99% Chebyshev(Mean, Sd) UCL	155.1
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	92.77		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Cobalt			
General Statistics			
Total Number of Observations	55	Number of Distinct Observations	33
		Number of Missing Observations	0
Minimum	9	Mean	12.33
Maximum	24.3	Median	12.2
SD	2.366	Std. Error of Mean	0.319
Coefficient of Variation	0.192	Skewness	2.974
Normal GOF Test			
Shapiro Wilk Test Statistic	0.736	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	1.529E-12	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.226	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	12.86	95% Adjusted-CLT UCL (Chen-1995)	12.99
		95% Modified-t UCL (Johnson-1978)	12.88
Gamma GOF Test			
A-D Test Statistic	2.658	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.748	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.192	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	35.09	k star (bias corrected MLE)	33.19
Theta hat (MLE)	0.351	Theta star (bias corrected MLE)	0.371
nu hat (MLE)	3860	nu star (bias corrected)	3651
MLE Mean (bias corrected)	12.33	MLE Sd (bias corrected)	2.139
		Approximate Chi Square Value (0.05)	3512
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	3508
Assuming Gamma Distribution			

95% Approximate Gamma UCL (use when n>=50))	12.81	95% Adjusted Gamma UCL (use when n<50)	12.83
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.859	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	7.8543E-7	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.176	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.197	Mean of logged Data	2.497
Maximum of Logged Data	3.19	SD of logged Data	0.163
Assuming Lognormal Distribution			
95% H-UCL	12.79	90% Chebyshev (MVUE) UCL	13.12
95% Chebyshev (MVUE) UCL	13.49	97.5% Chebyshev (MVUE) UCL	14
99% Chebyshev (MVUE) UCL	15.01		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	12.85	95% Jackknife UCL	12.86
95% Standard Bootstrap UCL	12.85	95% Bootstrap-t UCL	13.14
95% Hall's Bootstrap UCL	13.78	95% Percentile Bootstrap UCL	12.86
95% BCA Bootstrap UCL	13.09		
90% Chebyshev(Mean, Sd) UCL	13.28	95% Chebyshev(Mean, Sd) UCL	13.72
97.5% Chebyshev(Mean, Sd) UCL	14.32	99% Chebyshev(Mean, Sd) UCL	15.5
Suggested UCL to Use			
95% Student's-t UCL	12.86	or 95% Modified-t UCL	12.88
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Copper			
General Statistics			
Total Number of Observations	55	Number of Distinct Observations	52
		Number of Missing Observations	0
Minimum	31.5	Mean	458.4
Maximum	4180	Median	411
SD	556.1	Std. Error of Mean	74.98
Coefficient of Variation	1.213	Skewness	5.736
Normal GOF Test			
Shapiro Wilk Test Statistic	0.477	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.298	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	

Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	583.9	95% Adjusted-CLT UCL (Chen-1995)	643.7
		95% Modified-t UCL (Johnson-1978)	593.5
Gamma GOF Test			
A-D Test Statistic	2.06	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.768	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.173	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.122	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.537	k star (bias corrected MLE)	1.465
Theta hat (MLE)	298.2	Theta star (bias corrected MLE)	312.8
nu hat (MLE)	169.1	nu star (bias corrected)	161.2
MLE Mean (bias corrected)	458.4	MLE Sd (bias corrected)	378.7
		Approximate Chi Square Value (0.05)	132.8
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	132.1
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	556.2	95% Adjusted Gamma UCL (use when n<50)	559.1
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.875	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	4.9394E-6	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.175	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	3.45	Mean of logged Data	5.768
Maximum of Logged Data	8.338	SD of logged Data	0.906
Assuming Lognormal Distribution			
95% H-UCL	634.4	90% Chebyshev (MVUE) UCL	679
95% Chebyshev (MVUE) UCL	770.3	97.5% Chebyshev (MVUE) UCL	897
99% Chebyshev (MVUE) UCL	1146		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	581.7	95% Jackknife UCL	583.9
95% Standard Bootstrap UCL	578.4	95% Bootstrap-t UCL	727.4
95% Hall's Bootstrap UCL	1093	95% Percentile Bootstrap UCL	592.6
95% BCA Bootstrap UCL	686		
90% Chebyshev(Mean, Sd) UCL	683.3	95% Chebyshev(Mean, Sd) UCL	785.2
97.5% Chebyshev(Mean, Sd) UCL	926.7	99% Chebyshev(Mean, Sd) UCL	1204
Suggested UCL to Use			

95% Chebyshev (Mean, Sd) UCL	785.2		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Iron			
General Statistics			
Total Number of Observations	55	Number of Distinct Observations	42
		Number of Missing Observations	0
Minimum	7600	Mean	28815
Maximum	75700	Median	26700
SD	9107	Std. Error of Mean	1228
Coefficient of Variation	0.316	Skewness	3.067
Normal GOF Test			
Shapiro Wilk Test Statistic	0.652	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	4.441E-16	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.285	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	30870	95% Adjusted-CLT UCL (Chen-1995)	31377
		95% Modified-t UCL (Johnson-1978)	30954
Gamma GOF Test			
A-D Test Statistic	5.633	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.75	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.241	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	13.07	k star (bias corrected MLE)	12.37
Theta hat (MLE)	2204	Theta star (bias corrected MLE)	2329
nu hat (MLE)	1438	nu star (bias corrected)	1361
MLE Mean (bias corrected)	28815	MLE Sd (bias corrected)	8193
		Approximate Chi Square Value (0.05)	1276
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	1274
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	30726	95% Adjusted Gamma UCL (use when n<50)	30779
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.736	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	1.505E-12	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.225	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	8.936	Mean of logged Data	10.23
Maximum of Logged Data	11.23	SD of logged Data	0.279
Assuming Lognormal Distribution			
95% H-UCL	30758	90% Chebyshev (MVUE) UCL	32109
95% Chebyshev (MVUE) UCL	33607	97.5% Chebyshev (MVUE) UCL	35687
99% Chebyshev (MVUE) UCL	39772		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	30834	95% Jackknife UCL	30870
95% Standard Bootstrap UCL	30846	95% Bootstrap-t UCL	32195
95% Hall's Bootstrap UCL	34219	95% Percentile Bootstrap UCL	30991
95% BCA Bootstrap UCL	31435		
90% Chebyshev(Mean, Sd) UCL	32498	95% Chebyshev(Mean, Sd) UCL	34167
97.5% Chebyshev(Mean, Sd) UCL	36483	99% Chebyshev(Mean, Sd) UCL	41033
Suggested UCL to Use			
95% Student's-t UCL	30870	or 95% Modified-t UCL	30954
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

Lead

General Statistics			
Total Number of Observations	55	Number of Distinct Observations	54
		Number of Missing Observations	0
Minimum	11.9	Mean	67.35
Maximum	352	Median	59.9
SD	51.35	Std. Error of Mean	6.924
Coefficient of Variation	0.762	Skewness	3.902
Normal GOF Test			
Shapiro Wilk Test Statistic	0.592	Shapiro Wilk GOF Test	
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.298	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	78.94	95% Adjusted-CLT UCL (Chen-1995)	82.63
		95% Modified-t UCL (Johnson-1978)	79.54

Gamma GOF Test			
A-D Test Statistic	3.287	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.757	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.213	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.121	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	3.221	k star (bias corrected MLE)	3.057
Theta hat (MLE)	20.91	Theta star (bias corrected MLE)	22.03
nu hat (MLE)	354.3	nu star (bias corrected)	336.3
MLE Mean (bias corrected)	67.35	MLE Sd (bias corrected)	38.52
		Approximate Chi Square Value (0.05)	294.8
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	293.8
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	76.83	95% Adjusted Gamma UCL (use when n<50)	77.1
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.896	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk P Value	6.3055E-5	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.188	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.477	Mean of logged Data	4.047
Maximum of Logged Data	5.864	SD of logged Data	0.549
Assuming Lognormal Distribution			
95% H-UCL	76.76	90% Chebyshev (MVUE) UCL	81.94
95% Chebyshev (MVUE) UCL	89.02	97.5% Chebyshev (MVUE) UCL	98.85
99% Chebyshev (MVUE) UCL	118.1		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	78.74	95% Jackknife UCL	78.94
95% Standard Bootstrap UCL	78.5	95% Bootstrap-t UCL	88.57
95% Hall's Bootstrap UCL	132.7	95% Percentile Bootstrap UCL	79.77
95% BCA Bootstrap UCL	82.33		
90% Chebyshev(Mean, Sd) UCL	88.12	95% Chebyshev(Mean, Sd) UCL	97.53
97.5% Chebyshev(Mean, Sd) UCL	110.6	99% Chebyshev(Mean, Sd) UCL	136.2
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	97.53		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

Manganese

General Statistics

Total Number of Observations	55	Number of Distinct Observations	47
		Number of Missing Observations	0
Minimum	336	Mean	597.6
Maximum	1080	Median	582
SD	133.2	Std. Error of Mean	17.97
Coefficient of Variation	0.223	Skewness	1.313

Normal GOF Test

Shapiro Wilk Test Statistic	0.894	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	4.9241E-5	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.133	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	627.7	95% Adjusted-CLT UCL (Chen-1995)	630.5
		95% Modified-t UCL (Johnson-1978)	628.2

Gamma GOF Test

A-D Test Statistic	1.096	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.748	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.109	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.12	Detected data appear Gamma Distributed at 5% Significance Level

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

Gamma Statistics

k hat (MLE)	22.12	k star (bias corrected MLE)	20.93
Theta hat (MLE)	27.02	Theta star (bias corrected MLE)	28.56
nu hat (MLE)	2433	nu star (bias corrected)	2302
MLE Mean (bias corrected)	597.6	MLE Sd (bias corrected)	130.6
		Approximate Chi Square Value (0.05)	2191
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	2188

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	627.7	95% Adjusted Gamma UCL (use when n<50)	628.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.947	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	0.0305	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.115	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.119	Data appear Lognormal at 5% Significance Level

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	5.817	Mean of logged Data	6.37
Maximum of Logged Data	6.985	SD of logged Data	0.214

Assuming Lognormal Distribution

95% H-UCL	628.5	90% Chebyshev (MVUE) UCL	649.7
95% Chebyshev (MVUE) UCL	673.4	97.5% Chebyshev (MVUE) UCL	706.3
99% Chebyshev (MVUE) UCL	770.9		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	627.1	95% Jackknife UCL	627.7
95% Standard Bootstrap UCL	626.5	95% Bootstrap-t UCL	632.1
95% Hall's Bootstrap UCL	635.2	95% Percentile Bootstrap UCL	627.6
95% BCA Bootstrap UCL	631.9		
90% Chebyshev(Mean, Sd) UCL	651.5	95% Chebyshev(Mean, Sd) UCL	675.9
97.5% Chebyshev(Mean, Sd) UCL	709.8	99% Chebyshev(Mean, Sd) UCL	776.4

Suggested UCL to Use

95% Approximate Gamma UCL	627.7		

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

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Mercury

General Statistics

Total Number of Observations	55	Number of Distinct Observations	40
		Number of Missing Observations	0
Minimum	0.03	Mean	3.199
Maximum	7	Median	3.4
SD	1.814	Std. Error of Mean	0.245
Coefficient of Variation	0.567	Skewness	0.139

Normal GOF Test

Shapiro Wilk Test Statistic	0.963	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0.174	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.0568	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.119	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	3.608	95% Adjusted-CLT UCL (Chen-1995)	3.606
		95% Modified-t UCL (Johnson-1978)	3.609

Gamma GOF Test

A-D Test Statistic	2.093	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.767	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.174	**Kolmogorov-Smirnov Gamma GOF Test**

5% K-S Critical Value	0.122	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.647	k star (bias corrected MLE)	1.57
Theta hat (MLE)	1.942	Theta star (bias corrected MLE)	2.038
nu hat (MLE)	181.2	nu star (bias corrected)	172.6
MLE Mean (bias corrected)	3.199	MLE Sd (bias corrected)	2.553
		Approximate Chi Square Value (0.05)	143.3
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	142.5
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	3.855	95% Adjusted Gamma UCL (use when n<50)	3.874
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.745	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	3.681E-12	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.201	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-3.507	Mean of logged Data	0.83
Maximum of Logged Data	1.946	SD of logged Data	1.127
Assuming Lognormal Distribution			
95% H-UCL	6.346	90% Chebyshev (MVUE) UCL	6.607
95% Chebyshev (MVUE) UCL	7.676	97.5% Chebyshev (MVUE) UCL	9.16
99% Chebyshev (MVUE) UCL	12.08		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	3.601	95% Jackknife UCL	3.608
95% Standard Bootstrap UCL	3.591	95% Bootstrap-t UCL	3.609
95% Hall's Bootstrap UCL	3.607	95% Percentile Bootstrap UCL	3.604
95% BCA Bootstrap UCL	3.62		
90% Chebyshev(Mean, Sd) UCL	3.932	95% Chebyshev(Mean, Sd) UCL	4.265
97.5% Chebyshev(Mean, Sd) UCL	4.726	99% Chebyshev(Mean, Sd) UCL	5.632
Suggested UCL to Use			
95% Student's-t UCL	3.608		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Nickel			
General Statistics			

Total Number of Observations	55	Number of Distinct Observations	44
		Number of Missing Observations	0
Minimum	23.8	Mean	39.7
Maximum	67.7	Median	39.6
SD	7.01	Std. Error of Mean	0.945
Coefficient of Variation	0.177	Skewness	1.423
Normal GOF Test			
Shapiro Wilk Test Statistic	0.872	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	3.5532E-6	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.195	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	41.28	95% Adjusted-CLT UCL (Chen-1995)	41.44
		95% Modified-t UCL (Johnson-1978)	41.31
Gamma GOF Test			
A-D Test Statistic	1.989	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.748	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.17	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	35.36	k star (bias corrected MLE)	33.45
Theta hat (MLE)	1.123	Theta star (bias corrected MLE)	1.187
nu hat (MLE)	3890	nu star (bias corrected)	3679
MLE Mean (bias corrected)	39.7	MLE Sd (bias corrected)	6.864
		Approximate Chi Square Value (0.05)	3539
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	3536
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	41.27	95% Adjusted Gamma UCL (use when n<50)	41.31
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.921	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.0014	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.161	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	3.17	Mean of logged Data	3.667
Maximum of Logged Data	4.215	SD of logged Data	0.169
Assuming Lognormal Distribution			
95% H-UCL	41.29	90% Chebyshev (MVUE) UCL	42.41
95% Chebyshev (MVUE) UCL	43.64	97.5% Chebyshev (MVUE) UCL	45.35
99% Chebyshev (MVUE) UCL	48.72		

Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	41.25	95% Jackknife UCL	41.28
95% Standard Bootstrap UCL	41.22	95% Bootstrap-t UCL	41.62
95% Hall's Bootstrap UCL	41.81	95% Percentile Bootstrap UCL	41.21
95% BCA Bootstrap UCL	41.55		
90% Chebyshev(Mean, Sd) UCL	42.53	95% Chebyshev(Mean, Sd) UCL	43.82
97.5% Chebyshev(Mean, Sd) UCL	45.6	99% Chebyshev(Mean, Sd) UCL	49.1
Suggested UCL to Use			
95% Student's-t UCL	41.28	or 95% Modified-t UCL	41.31
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

Selenium

General Statistics			
Total Number of Observations	55	Number of Distinct Observations	34
		Number of Missing Observations	0
Minimum	0.18	Mean	0.471
Maximum	1.7	Median	0.4
SD	0.313	Std. Error of Mean	0.0421
Coefficient of Variation	0.663	Skewness	2.365
Normal GOF Test			
Shapiro Wilk Test Statistic	0.752	Shapiro Wilk GOF Test	
5% Shapiro Wilk P Value	6.947E-12	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.241	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	0.542	95% Adjusted-CLT UCL (Chen-1995)	0.555
		95% Modified-t UCL (Johnson-1978)	0.544
Gamma GOF Test			
A-D Test Statistic	1.312	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.756	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.172	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.121	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	3.357	k star (bias corrected MLE)	3.186
Theta hat (MLE)	0.14	Theta star (bias corrected MLE)	0.148
nu hat (MLE)	369.3	nu star (bias corrected)	350.5

MLE Mean (bias corrected)	0.471	MLE Sd (bias corrected)	0.264
		Approximate Chi Square Value (0.05)	308.1
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	307
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	0.536	95% Adjusted Gamma UCL (use when n<50)	0.538
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.94	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk P Value	0.0131	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.13	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-1.715	Mean of logged Data	-0.909
Maximum of Logged Data	0.531	SD of logged Data	0.537
Assuming Lognormal Distribution			
95% H-UCL	0.535	90% Chebyshev (MVUE) UCL	0.571
95% Chebyshev (MVUE) UCL	0.619	97.5% Chebyshev (MVUE) UCL	0.686
99% Chebyshev (MVUE) UCL	0.818		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.54	95% Jackknife UCL	0.542
95% Standard Bootstrap UCL	0.542	95% Bootstrap-t UCL	0.568
95% Hall's Bootstrap UCL	0.581	95% Percentile Bootstrap UCL	0.543
95% BCA Bootstrap UCL	0.557		
90% Chebyshev(Mean, Sd) UCL	0.598	95% Chebyshev(Mean, Sd) UCL	0.655
97.5% Chebyshev(Mean, Sd) UCL	0.734	99% Chebyshev(Mean, Sd) UCL	0.89
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	0.655		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

Silver

General Statistics			
Total Number of Observations	55	Number of Distinct Observations	35
		Number of Missing Observations	0
Minimum	0.04	Mean	2.821
Maximum	8.7	Median	3
SD	1.65	Std. Error of Mean	0.222
Coefficient of Variation	0.585	Skewness	0.513

Normal GOF Test			
Shapiro Wilk Test Statistic	0.935	Shapiro Wilk GOF Test	
5% Shapiro Wilk P Value	0.0071	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.128	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	3.193	95% Adjusted-CLT UCL (Chen-1995)	3.203
		95% Modified-t UCL (Johnson-1978)	3.196
Gamma GOF Test			
A-D Test Statistic	3.755	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.768	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.226	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.122	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.49	k star (bias corrected MLE)	1.421
Theta hat (MLE)	1.893	Theta star (bias corrected MLE)	1.985
nu hat (MLE)	163.9	nu star (bias corrected)	156.3
MLE Mean (bias corrected)	2.821	MLE Sd (bias corrected)	2.366
		Approximate Chi Square Value (0.05)	128.4
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	127.7
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	3.434	95% Adjusted Gamma UCL (use when n<50)	3.452
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.735	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk P Value	1.309E-12	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.269	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-3.219	Mean of logged Data	0.665
Maximum of Logged Data	2.163	SD of logged Data	1.183
Assuming Lognormal Distribution			
95% H-UCL	5.943	90% Chebyshev (MVUE) UCL	6.108
95% Chebyshev (MVUE) UCL	7.138	97.5% Chebyshev (MVUE) UCL	8.566
99% Chebyshev (MVUE) UCL	11.37		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	3.187	95% Jackknife UCL	3.193
95% Standard Bootstrap UCL	3.186	95% Bootstrap-t UCL	3.212
95% Hall's Bootstrap UCL	3.224	95% Percentile Bootstrap UCL	3.198

95% BCA Bootstrap UCL	3.234		
90% Chebyshev(Mean, Sd) UCL	3.488	95% Chebyshev(Mean, Sd) UCL	3.79
97.5% Chebyshev(Mean, Sd) UCL	4.21	99% Chebyshev(Mean, Sd) UCL	5.034
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	3.79		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Thallium			
General Statistics			
Total Number of Observations	55	Number of Distinct Observations	23
		Number of Missing Observations	0
Minimum	0.08	Mean	0.209
Maximum	0.38	Median	0.19
SD	0.078	Std. Error of Mean	0.0105
Coefficient of Variation	0.373	Skewness	0.512
Normal GOF Test			
Shapiro Wilk Test Statistic	0.939	Shapiro Wilk GOF Test	
5% Shapiro Wilk P Value	0.0111	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.183	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	0.227	95% Adjusted-CLT UCL (Chen-1995)	0.227
		95% Modified-t UCL (Johnson-1978)	0.227
Gamma GOF Test			
A-D Test Statistic	0.545	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.752	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.134	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level	
Detected data follow Appr. Gamma Distribution at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	7.257	k star (bias corrected MLE)	6.873
Theta hat (MLE)	0.0288	Theta star (bias corrected MLE)	0.0304
nu hat (MLE)	798.3	nu star (bias corrected)	756
MLE Mean (bias corrected)	0.209	MLE Sd (bias corrected)	0.0798
		Approximate Chi Square Value (0.05)	693.2
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	691.6
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50)	0.228	95% Adjusted Gamma UCL (use when n<50)	0.229

Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.959	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk P Value	0.112	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.109	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.119	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-2.526	Mean of logged Data	-1.635
Maximum of Logged Data	-0.968	SD of logged Data	0.386
Assuming Lognormal Distribution			
95% H-UCL	0.231	90% Chebyshev (MVUE) UCL	0.243
95% Chebyshev (MVUE) UCL	0.259	97.5% Chebyshev (MVUE) UCL	0.28
99% Chebyshev (MVUE) UCL	0.321		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.226	95% Jackknife UCL	0.227
95% Standard Bootstrap UCL	0.226	95% Bootstrap-t UCL	0.228
95% Hall's Bootstrap UCL	0.227	95% Percentile Bootstrap UCL	0.226
95% BCA Bootstrap UCL	0.226		
90% Chebyshev(Mean, Sd) UCL	0.241	95% Chebyshev(Mean, Sd) UCL	0.255
97.5% Chebyshev(Mean, Sd) UCL	0.275	99% Chebyshev(Mean, Sd) UCL	0.314
Suggested UCL to Use			
95% Approximate Gamma UCL	0.228		
When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test			
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL			
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Vanadium			
General Statistics			
Total Number of Observations	55	Number of Distinct Observations	43
		Number of Missing Observations	0
Minimum	16.6	Mean	29.54
Maximum	53.7	Median	28.7
SD	5.744	Std. Error of Mean	0.775
Coefficient of Variation	0.194	Skewness	2.577
Normal GOF Test			
Shapiro Wilk Test Statistic	0.723	Shapiro Wilk GOF Test	
5% Shapiro Wilk P Value	3.997E-13	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.231	Lilliefors GOF Test	

5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	30.84	95% Adjusted-CLT UCL (Chen-1995)	31.11
		95% Modified-t UCL (Johnson-1978)	30.88
Gamma GOF Test			
A-D Test Statistic	3.497	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.748	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.198	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	32.56	k star (bias corrected MLE)	30.79
Theta hat (MLE)	0.907	Theta star (bias corrected MLE)	0.959
nu hat (MLE)	3581	nu star (bias corrected)	3387
MLE Mean (bias corrected)	29.54	MLE Sd (bias corrected)	5.324
		Approximate Chi Square Value (0.05)	3253
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	3250
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	30.76	95% Adjusted Gamma UCL (use when n<50)	30.8
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.831	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk P Value	3.4284E-8	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.188	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.809	Mean of logged Data	3.37
Maximum of Logged Data	3.983	SD of logged Data	0.172
Assuming Lognormal Distribution			
95% H-UCL	30.73	90% Chebyshev (MVUE) UCL	31.58
95% Chebyshev (MVUE) UCL	32.51	97.5% Chebyshev (MVUE) UCL	33.81
99% Chebyshev (MVUE) UCL	36.36		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	30.82	95% Jackknife UCL	30.84
95% Standard Bootstrap UCL	30.81	95% Bootstrap-t UCL	31.52
95% Hall's Bootstrap UCL	32.89	95% Percentile Bootstrap UCL	30.84
95% BCA Bootstrap UCL	31.16		
90% Chebyshev(Mean, Sd) UCL	31.87	95% Chebyshev(Mean, Sd) UCL	32.92
97.5% Chebyshev(Mean, Sd) UCL	34.38	99% Chebyshev(Mean, Sd) UCL	37.25

Suggested UCL to Use			
95% Student's-t UCL	30.84	or 95% Modified-t UCL	30.88

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
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Zinc

General Statistics			
Total Number of Observations	55	Number of Distinct Observations	49
		Number of Missing Observations	0
Minimum	66.8	Mean	347.5
Maximum	1350	Median	327
SD	198.9	Std. Error of Mean	26.82
Coefficient of Variation	0.572	Skewness	2.876

Normal GOF Test			
Shapiro Wilk Test Statistic	0.706	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	8.005E-14	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.248	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			

Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	392.4	95% Adjusted-CLT UCL (Chen-1995)	402.7
		95% Modified-t UCL (Johnson-1978)	394.1

Gamma GOF Test			
A-D Test Statistic	3.899	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.754	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.223	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			

Gamma Statistics			
k hat (MLE)	3.863	k star (bias corrected MLE)	3.665
Theta hat (MLE)	89.96	Theta star (bias corrected MLE)	94.83
nu hat (MLE)	424.9	nu star (bias corrected)	403.1
MLE Mean (bias corrected)	347.5	MLE Sd (bias corrected)	181.5
		Approximate Chi Square Value (0.05)	357.6
Adjusted Level of Significance	0.0456	Adjusted Chi Square Value	356.4

Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	391.8	95% Adjusted Gamma UCL (use when n<50)	393

Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.834	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	4.4633E-8	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.257	**Lilliefors Lognormal GOF Test**	

5% Lilliefors Critical Value	0.119	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			

Lognormal Statistics			
Minimum of Logged Data	4.202	Mean of logged Data	5.716
Maximum of Logged Data	7.208	SD of logged Data	0.547

Assuming Lognormal Distribution			
95% H-UCL	406.7	90% Chebyshev (MVUE) UCL	434.2
95% Chebyshev (MVUE) UCL	471.6	97.5% Chebyshev (MVUE) UCL	523.5
99% Chebyshev (MVUE) UCL	625.4		

Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			

Nonparametric Distribution Free UCLs			
95% CLT UCL	391.6	95% Jackknife UCL	392.4
95% Standard Bootstrap UCL	391.8	95% Bootstrap-t UCL	413.6
95% Hall's Bootstrap UCL	487.1	95% Percentile Bootstrap UCL	390.7
95% BCA Bootstrap UCL	404.2		
90% Chebyshev(Mean, Sd) UCL	428	95% Chebyshev(Mean, Sd) UCL	464.4
97.5% Chebyshev(Mean, Sd) UCL	515	99% Chebyshev(Mean, Sd) UCL	614.3

Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	464.4		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
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Open Detonation (OD) Grounds -- Kickout Area
Seneca Army Depot Activity (SEDA)
Baseline Ecological Risk Assessment

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.17/25/2018 12:45:51 PM
From File	Surfsoil_ProUCL_temp.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Aluminum

General Statistics

Total Number of Observations	25	Number of Distinct Observations	22
		Number of Missing Observations	0
Minimum	14200	Mean	18904
Maximum	25000	Median	18900
SD	2509	Std. Error of Mean	501.7
Coefficient of Variation	0.133	Skewness	0.24

Normal GOF Test

Shapiro Wilk Test Statistic	0.985	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.918	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.0689	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.173	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	19762	95% Adjusted-CLT UCL (Chen-1995)	19755
		95% Modified-t UCL (Johnson-1978)	19766

Gamma GOF Test

A-D Test Statistic	0.14	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.742	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0842	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.174	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	59	k star (bias corrected MLE)	51.95
Theta hat (MLE)	320.4	Theta star (bias corrected MLE)	363.9
nu hat (MLE)	2950	nu star (bias corrected)	2597
MLE Mean (bias corrected)	18904	MLE Sd (bias corrected)	2623
		Approximate Chi Square Value (0.05)	2480
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	2472

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	19799	95% Adjusted Gamma UCL (use when n<50)	19861

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.984	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.918	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.093	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.173	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	9.561	Mean of logged Data	9.839
Maximum of Logged Data	10.13	SD of logged Data	0.134

Assuming Lognormal Distribution

95% H-UCL	19822	90% Chebyshev (MVUE) UCL	20424
95% Chebyshev (MVUE) UCL	21112	97.5% Chebyshev (MVUE) UCL	22067
99% Chebyshev (MVUE) UCL	23943		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	19729	95% Jackknife UCL	19762
95% Standard Bootstrap UCL	19720	95% Bootstrap-t UCL	19771
95% Hall's Bootstrap UCL	19816	95% Percentile Bootstrap UCL	19688
95% BCA Bootstrap UCL	19692		
90% Chebyshev(Mean, Sd) UCL	20409	95% Chebyshev(Mean, Sd) UCL	21091
97.5% Chebyshev(Mean, Sd) UCL	22037	99% Chebyshev(Mean, Sd) UCL	23896

Suggested UCL to Use

95% Student's-t UCL	19762		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
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Antimony

General Statistics

Total Number of Observations	25	Number of Distinct Observations	19
		Number of Missing Observations	0
Minimum	0.09	Mean	3.122
Maximum	11.7	Median	0.18
SD	4.54	Std. Error of Mean	0.908
Coefficient of Variation	1.454	Skewness	1.087

Normal GOF Test

Shapiro Wilk Test Statistic	0.663	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.329	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	4.675	95% Adjusted-CLT UCL (Chen-1995)	4.826
		95% Modified-t UCL (Johnson-1978)	4.708
Gamma GOF Test			
A-D Test Statistic	2.681	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.829	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.28	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.187	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	0.403	k star (bias corrected MLE)	0.381
Theta hat (MLE)	7.755	Theta star (bias corrected MLE)	8.195
nu hat (MLE)	20.13	nu star (bias corrected)	19.04
MLE Mean (bias corrected)	3.122	MLE Sd (bias corrected)	5.058
		Approximate Chi Square Value (0.05)	10.15
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	9.708
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	5.857	95% Adjusted Gamma UCL (use when n<50)	6.124
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.779	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.251	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-2.408	Mean of logged Data	-0.495
Maximum of Logged Data	2.46	SD of logged Data	1.978
Assuming Lognormal Distribution			
95% H-UCL	21.16	90% Chebyshev (MVUE) UCL	9.001
95% Chebyshev (MVUE) UCL	11.47	97.5% Chebyshev (MVUE) UCL	14.9
99% Chebyshev (MVUE) UCL	21.63		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	4.615	95% Jackknife UCL	4.675
95% Standard Bootstrap UCL	4.615	95% Bootstrap-t UCL	4.954
95% Hall's Bootstrap UCL	4.585	95% Percentile Bootstrap UCL	4.63
95% BCA Bootstrap UCL	4.826		
90% Chebyshev(Mean, Sd) UCL	5.845	95% Chebyshev(Mean, Sd) UCL	7.079
97.5% Chebyshev(Mean, Sd) UCL	8.792	99% Chebyshev(Mean, Sd) UCL	12.16
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	7.079		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Arsenic

General Statistics			
Total Number of Observations	25	Number of Distinct Observations	18
		Number of Missing Observations	0
Minimum	3.9	Mean	5.732
Maximum	16.1	Median	5.1
SD	2.332	Std. Error of Mean	0.466
Coefficient of Variation	0.407	Skewness	3.954
Normal GOF Test			
Shapiro Wilk Test Statistic	0.524	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.305	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	6.53	95% Adjusted-CLT UCL (Chen-1995)	6.893
		95% Modified-t UCL (Johnson-1978)	6.591
Gamma GOF Test			
A-D Test Statistic	2.759	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.745	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.274	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.174	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	11.02	k star (bias corrected MLE)	9.725
Theta hat (MLE)	0.52	Theta star (bias corrected MLE)	0.589
nu hat (MLE)	551	nu star (bias corrected)	486.2
MLE Mean (bias corrected)	5.732	MLE Sd (bias corrected)	1.838
		Approximate Chi Square Value (0.05)	436.1
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	432.9
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	6.391	95% Adjusted Gamma UCL (use when n<50)	6.439
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.72	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.253	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			

Lognormal Statistics			
Minimum of Logged Data	1.361	Mean of logged Data	1.7
Maximum of Logged Data	2.779	SD of logged Data	0.274
Assuming Lognormal Distribution			
95% H-UCL	6.283	90% Chebyshev (MVUE) UCL	6.618
95% Chebyshev (MVUE) UCL	7.046	97.5% Chebyshev (MVUE) UCL	7.639
99% Chebyshev (MVUE) UCL	8.805		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	6.499	95% Jackknife UCL	6.53
95% Standard Bootstrap UCL	6.459	95% Bootstrap-t UCL	7.73
95% Hall's Bootstrap UCL	9.447	95% Percentile Bootstrap UCL	6.58
95% BCA Bootstrap UCL	7.076		
90% Chebyshev(Mean, Sd) UCL	7.131	95% Chebyshev(Mean, Sd) UCL	7.765
97.5% Chebyshev(Mean, Sd) UCL	8.645	99% Chebyshev(Mean, Sd) UCL	10.37
Suggested UCL to Use			
95% Student's-t UCL	6.53	or 95% Modified-t UCL	6.591
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

Barium

General Statistics			
Total Number of Observations	25	Number of Distinct Observations	23
		Number of Missing Observations	0
Minimum	55.4	Mean	151.9
Maximum	287	Median	140
SD	56.54	Std. Error of Mean	11.31
Coefficient of Variation	0.372	Skewness	0.866
Normal GOF Test			
Shapiro Wilk Test Statistic	0.926	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.137	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	171.3	95% Adjusted-CLT UCL (Chen-1995)	172.6
		95% Modified-t UCL (Johnson-1978)	171.6
Gamma GOF Test			
A-D Test Statistic	0.396	**Anderson-Darling Gamma GOF Test**	

5% A-D Critical Value	0.746	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.13	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.175	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	7.846	k star (bias corrected MLE)	6.931
Theta hat (MLE)	19.36	Theta star (bias corrected MLE)	21.92
nu hat (MLE)	392.3	nu star (bias corrected)	346.6
MLE Mean (bias corrected)	151.9	MLE Sd (bias corrected)	57.7
		Approximate Chi Square Value (0.05)	304.4
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	301.7
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	172.9	95% Adjusted Gamma UCL (use when n<50)	174.5
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.965	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.141	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	4.015	Mean of logged Data	4.958
Maximum of Logged Data	5.659	SD of logged Data	0.372
Assuming Lognormal Distribution			
95% H-UCL	175.7	90% Chebyshev (MVUE) UCL	186.8
95% Chebyshev (MVUE) UCL	202.5	97.5% Chebyshev (MVUE) UCL	224.4
99% Chebyshev (MVUE) UCL	267.3		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	170.5	95% Jackknife UCL	171.3
95% Standard Bootstrap UCL	170.5	95% Bootstrap-t UCL	174.4
95% Hall's Bootstrap UCL	172.9	95% Percentile Bootstrap UCL	171.1
95% BCA Bootstrap UCL	172.2		
90% Chebyshev(Mean, Sd) UCL	185.8	95% Chebyshev(Mean, Sd) UCL	201.2
97.5% Chebyshev(Mean, Sd) UCL	222.5	99% Chebyshev(Mean, Sd) UCL	264.4
Suggested UCL to Use			
95% Student's-t UCL	171.3		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

Beryllium

General Statistics			
Total Number of Observations	25	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	0.62	Mean	0.816
Maximum	1	Median	0.8
SD	0.102	Std. Error of Mean	0.0204
Coefficient of Variation	0.125	Skewness	0.172

Normal GOF Test			
Shapiro Wilk Test Statistic	0.96	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.107	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			

Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	0.851	95% Adjusted-CLT UCL (Chen-1995)	0.851
		95% Modified-t UCL (Johnson-1978)	0.851

Gamma GOF Test			
A-D Test Statistic	0.311	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.742	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.101	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.174	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			

Gamma Statistics			
k hat (MLE)	66.39	k star (bias corrected MLE)	58.45
Theta hat (MLE)	0.0123	Theta star (bias corrected MLE)	0.014
nu hat (MLE)	3320	nu star (bias corrected)	2923
MLE Mean (bias corrected)	0.816	MLE Sd (bias corrected)	0.107
		Approximate Chi Square Value (0.05)	2798
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	2790

Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	0.853	95% Adjusted Gamma UCL (use when n<50)	0.855

Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.964	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.11	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			

Lognormal Statistics			
Minimum of Logged Data	-0.478	Mean of logged Data	-0.21
Maximum of Logged Data	0	SD of logged Data	0.126

Assuming Lognormal Distribution			
95% H-UCL	0.854	90% Chebyshev (MVUE) UCL	0.878
95% Chebyshev (MVUE) UCL	0.906	97.5% Chebyshev (MVUE) UCL	0.945
99% Chebyshev (MVUE) UCL	1.021		

Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.85	95% Jackknife UCL	0.851
95% Standard Bootstrap UCL	0.849	95% Bootstrap-t UCL	0.85
95% Hall's Bootstrap UCL	0.853	95% Percentile Bootstrap UCL	0.851
95% BCA Bootstrap UCL	0.85		
90% Chebyshev(Mean, Sd) UCL	0.878	95% Chebyshev(Mean, Sd) UCL	0.905
97.5% Chebyshev(Mean, Sd) UCL	0.944	99% Chebyshev(Mean, Sd) UCL	1.019
Suggested UCL to Use			
95% Student's-t UCL	0.851		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Cadmium

General Statistics			
Total Number of Observations	25	Number of Distinct Observations	21
		Number of Missing Observations	0
Minimum	0.62	Mean	3.25
Maximum	25.6	Median	1.6
SD	5.04	Std. Error of Mean	1.008
Coefficient of Variation	1.551	Skewness	3.953

Normal GOF Test			
Shapiro Wilk Test Statistic	0.493	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.301	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			

Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	4.975	95% Adjusted-CLT UCL (Chen-1995)	5.76
		95% Modified-t UCL (Johnson-1978)	5.108

Gamma GOF Test			
A-D Test Statistic	1.893	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.77	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.238	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.179	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			

Gamma Statistics			
k hat (MLE)	1.144	k star (bias corrected MLE)	1.034

Theta hat (MLE)	2.84	Theta star (bias corrected MLE)	3.144
nu hat (MLE)	57.22	nu star (bias corrected)	51.69
MLE Mean (bias corrected)	3.25	MLE Sd (bias corrected)	3.197
		Approximate Chi Square Value (0.05)	36.18
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	35.29
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	4.644	95% Adjusted Gamma UCL (use when n<50)	4.761
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.891	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.196	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-0.478	Mean of logged Data	0.682
Maximum of Logged Data	3.243	SD of logged Data	0.872
Assuming Lognormal Distribution			
95% H-UCL	4.383	90% Chebyshev (MVUE) UCL	4.479
95% Chebyshev (MVUE) UCL	5.224	97.5% Chebyshev (MVUE) UCL	6.258
99% Chebyshev (MVUE) UCL	8.289		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	4.909	95% Jackknife UCL	4.975
95% Standard Bootstrap UCL	4.852	95% Bootstrap-t UCL	8.118
95% Hall's Bootstrap UCL	10.96	95% Percentile Bootstrap UCL	4.956
95% BCA Bootstrap UCL	5.953		
90% Chebyshev(Mean, Sd) UCL	6.275	95% Chebyshev(Mean, Sd) UCL	7.645
97.5% Chebyshev(Mean, Sd) UCL	9.546	99% Chebyshev(Mean, Sd) UCL	13.28
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	7.645		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Chromium			
General Statistics			
Total Number of Observations	25	Number of Distinct Observations	21
		Number of Missing Observations	0
Minimum	22.4	Mean	27.43
Maximum	39.3	Median	27.4
SD	3.79	Std. Error of Mean	0.758

Coefficient of Variation	0.138	Skewness	1.198
Normal GOF Test			
Shapiro Wilk Test Statistic	0.912	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.0924	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Normal at 5% Significance Level	
Data appear Approximate Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	28.72	95% Adjusted-CLT UCL (Chen-1995)	28.87
		95% Modified-t UCL (Johnson-1978)	28.76
Gamma GOF Test			
A-D Test Statistic	0.36	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.742	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.101	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.174	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	58.61	k star (bias corrected MLE)	51.61
Theta hat (MLE)	0.468	Theta star (bias corrected MLE)	0.531
nu hat (MLE)	2931	nu star (bias corrected)	2580
MLE Mean (bias corrected)	27.43	MLE Sd (bias corrected)	3.818
		Approximate Chi Square Value (0.05)	2463
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	2456
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	28.73	95% Adjusted Gamma UCL (use when n<50)	28.82
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.948	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0971	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	3.109	Mean of logged Data	3.303
Maximum of Logged Data	3.671	SD of logged Data	0.132
Assuming Lognormal Distribution			
95% H-UCL	28.73	90% Chebyshev (MVUE) UCL	29.59
95% Chebyshev (MVUE) UCL	30.57	97.5% Chebyshev (MVUE) UCL	31.94
99% Chebyshev (MVUE) UCL	34.62		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	28.67	95% Jackknife UCL	28.72

95% Standard Bootstrap UCL	28.65	95% Bootstrap-t UCL	28.96
95% Hall's Bootstrap UCL	29.26	95% Percentile Bootstrap UCL	28.72
95% BCA Bootstrap UCL	28.84		
90% Chebyshev(Mean, Sd) UCL	29.7	95% Chebyshev(Mean, Sd) UCL	30.73
97.5% Chebyshev(Mean, Sd) UCL	32.16	99% Chebyshev(Mean, Sd) UCL	34.97
Suggested UCL to Use			
95% Student's-t UCL	28.72		
When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test			
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL			
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Cobalt			
General Statistics			
Total Number of Observations	25	Number of Distinct Observations	22
		Number of Missing Observations	0
Minimum	7.7	Mean	12.32
Maximum	26.8	Median	11.2
SD	4.361	Std. Error of Mean	0.872
Coefficient of Variation	0.354	Skewness	2.455
Normal GOF Test			
Shapiro Wilk Test Statistic	0.701	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.26	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	13.81	95% Adjusted-CLT UCL (Chen-1995)	14.21
		95% Modified-t UCL (Johnson-1978)	13.88
Gamma GOF Test			
A-D Test Statistic	1.577	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.745	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.209	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.174	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	11.61	k star (bias corrected MLE)	10.24
Theta hat (MLE)	1.062	Theta star (bias corrected MLE)	1.203
nu hat (MLE)	580.3	nu star (bias corrected)	512
MLE Mean (bias corrected)	12.32	MLE Sd (bias corrected)	3.85
		Approximate Chi Square Value (0.05)	460.5

Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	457.2
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	13.7	95% Adjusted Gamma UCL (use when n<50)	13.8
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.85	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.184	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.041	Mean of logged Data	2.468
Maximum of Logged Data	3.288	SD of logged Data	0.281
Assuming Lognormal Distribution			
95% H-UCL	13.6	90% Chebyshev (MVUE) UCL	14.34
95% Chebyshev (MVUE) UCL	15.29	97.5% Chebyshev (MVUE) UCL	16.6
99% Chebyshev (MVUE) UCL	19.19		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	13.75	95% Jackknife UCL	13.81
95% Standard Bootstrap UCL	13.74	95% Bootstrap-t UCL	15.6
95% Hall's Bootstrap UCL	22.22	95% Percentile Bootstrap UCL	13.86
95% BCA Bootstrap UCL	14.09		
90% Chebyshev(Mean, Sd) UCL	14.94	95% Chebyshev(Mean, Sd) UCL	16.12
97.5% Chebyshev(Mean, Sd) UCL	17.77	99% Chebyshev(Mean, Sd) UCL	21
Suggested UCL to Use			
95% Student's-t UCL	13.81	or 95% Modified-t UCL	13.88
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Copper			
General Statistics			
Total Number of Observations	25	Number of Distinct Observations	25
		Number of Missing Observations	0
Minimum	20	Mean	100.1
Maximum	323	Median	63.9
SD	89.3	Std. Error of Mean	17.86
Coefficient of Variation	0.892	Skewness	1.173
Normal GOF Test			
Shapiro Wilk Test Statistic	0.819	**Shapiro Wilk GOF Test**	

5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.218	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	130.7	95% Adjusted-CLT UCL (Chen-1995)	134
		95% Modified-t UCL (Johnson-1978)	131.4
Gamma GOF Test			
A-D Test Statistic	0.829	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.762	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.148	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.178	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data follow Appr. Gamma Distribution at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.483	k star (bias corrected MLE)	1.332
Theta hat (MLE)	67.53	Theta star (bias corrected MLE)	75.2
nu hat (MLE)	74.14	nu star (bias corrected)	66.58
MLE Mean (bias corrected)	100.1	MLE Sd (bias corrected)	86.78
		Approximate Chi Square Value (0.05)	48.8
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	47.76
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50)	136.6	95% Adjusted Gamma UCL (use when n<50)	139.6
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.928	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.116	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.996	Mean of logged Data	4.233
Maximum of Logged Data	5.778	SD of logged Data	0.886
Assuming Lognormal Distribution			
95% H-UCL	156.2	90% Chebyshev (MVUE) UCL	159
95% Chebyshev (MVUE) UCL	185.8	97.5% Chebyshev (MVUE) UCL	222.9
99% Chebyshev (MVUE) UCL	295.9		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	129.5	95% Jackknife UCL	130.7
95% Standard Bootstrap UCL	128.9	95% Bootstrap-t UCL	138
95% Hall's Bootstrap UCL	133.5	95% Percentile Bootstrap UCL	129.9
95% BCA Bootstrap UCL	133		
90% Chebyshev(Mean, Sd) UCL	153.7	95% Chebyshev(Mean, Sd) UCL	178

97.5% Chebyshev(Mean, Sd) UCL	211.7	99% Chebyshev(Mean, Sd) UCL	277.9
Suggested UCL to Use			
95% Adjusted Gamma UCL	139.6		
When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test			
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL			
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Iron			
General Statistics			
Total Number of Observations	25	Number of Distinct Observations	23
		Number of Missing Observations	0
Minimum	20400	Mean	28352
Maximum	75700	Median	25800
SD	10639	Std. Error of Mean	2128
Coefficient of Variation	0.375	Skewness	3.934
Normal GOF Test			
Shapiro Wilk Test Statistic	0.549	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.244	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	31992	95% Adjusted-CLT UCL (Chen-1995)	33641
		95% Modified-t UCL (Johnson-1978)	32271
Gamma GOF Test			
A-D Test Statistic	2.025	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.744	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.2	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.174	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	12.49	k star (bias corrected MLE)	11.02
Theta hat (MLE)	2269	Theta star (bias corrected MLE)	2573
nu hat (MLE)	624.7	nu star (bias corrected)	551
MLE Mean (bias corrected)	28352	MLE Sd (bias corrected)	8540
		Approximate Chi Square Value (0.05)	497.8
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	494.1
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	31397	95% Adjusted Gamma UCL (use when n<50)	31617

Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.754	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.174	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	9.923	Mean of logged Data	10.21
Maximum of Logged Data	11.23	SD of logged Data	0.259
Assuming Lognormal Distribution			
95% H-UCL	30949	90% Chebyshev (MVUE) UCL	32539
95% Chebyshev (MVUE) UCL	34542	97.5% Chebyshev (MVUE) UCL	37323
99% Chebyshev (MVUE) UCL	42785		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	31852	95% Jackknife UCL	31992
95% Standard Bootstrap UCL	31756	95% Bootstrap-t UCL	36557
95% Hall's Bootstrap UCL	45969	95% Percentile Bootstrap UCL	32332
95% BCA Bootstrap UCL	34608		
90% Chebyshev(Mean, Sd) UCL	34735	95% Chebyshev(Mean, Sd) UCL	37627
97.5% Chebyshev(Mean, Sd) UCL	41640	99% Chebyshev(Mean, Sd) UCL	49523
Suggested UCL to Use			
95% Student's-t UCL	31992	or 95% Modified-t UCL	32271
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Lead			
General Statistics			
Total Number of Observations	25	Number of Distinct Observations	25
		Number of Missing Observations	0
Minimum	12	Mean	49.02
Maximum	198	Median	26.6
SD	50.19	Std. Error of Mean	10.04
Coefficient of Variation	1.024	Skewness	2.201
Normal GOF Test			
Shapiro Wilk Test Statistic	0.673	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.267	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			

Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	66.19	95% Adjusted-CLT UCL (Chen-1995)	70.25
		95% Modified-t UCL (Johnson-1978)	66.93
Gamma GOF Test			
A-D Test Statistic	1.463	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.76	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.21	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.177	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.637	k star (bias corrected MLE)	1.468
Theta hat (MLE)	29.93	Theta star (bias corrected MLE)	33.4
nu hat (MLE)	81.87	nu star (bias corrected)	73.38
MLE Mean (bias corrected)	49.02	MLE Sd (bias corrected)	40.46
		Approximate Chi Square Value (0.05)	54.65
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	53.55
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	65.81	95% Adjusted Gamma UCL (use when n<50)	67.16
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.91	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.177	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.485	Mean of logged Data	3.557
Maximum of Logged Data	5.288	SD of logged Data	0.77
Assuming Lognormal Distribution			
95% H-UCL	66.79	90% Chebyshev (MVUE) UCL	69.78
95% Chebyshev (MVUE) UCL	80.35	97.5% Chebyshev (MVUE) UCL	95.03
99% Chebyshev (MVUE) UCL	123.9		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	65.53	95% Jackknife UCL	66.19
95% Standard Bootstrap UCL	65.12	95% Bootstrap-t UCL	82.14
95% Hall's Bootstrap UCL	76.59	95% Percentile Bootstrap UCL	67.71
95% BCA Bootstrap UCL	71.19		
90% Chebyshev(Mean, Sd) UCL	79.13	95% Chebyshev(Mean, Sd) UCL	92.77
97.5% Chebyshev(Mean, Sd) UCL	111.7	99% Chebyshev(Mean, Sd) UCL	148.9
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	92.77		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Manganese

General Statistics

Total Number of Observations	25	Number of Distinct Observations	24
		Number of Missing Observations	0
Minimum	256	Mean	786
Maximum	5040	Median	562
SD	917.8	Std. Error of Mean	183.6
Coefficient of Variation	1.168	Skewness	4.475

Normal GOF Test

Shapiro Wilk Test Statistic	0.429	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.306	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	1100	95% Adjusted-CLT UCL (Chen-1995)	1263
		95% Modified-t UCL (Johnson-1978)	1127

Gamma GOF Test

A-D Test Statistic	2.156	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.755	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.218	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.177	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.232	k star (bias corrected MLE)	1.991
Theta hat (MLE)	352.1	Theta star (bias corrected MLE)	394.8
nu hat (MLE)	111.6	nu star (bias corrected)	99.54
MLE Mean (bias corrected)	786	MLE Sd (bias corrected)	557.1
		Approximate Chi Square Value (0.05)	77.52
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	76.2

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1009	95% Adjusted Gamma UCL (use when n<50)	1027

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.838	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.17	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.173	Data appear Lognormal at 5% Significance Level

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	5.545	Mean of logged Data	6.427
Maximum of Logged Data	8.525	SD of logged Data	0.578

Assuming Lognormal Distribution

95% H-UCL	927.6	90% Chebyshev (MVUE) UCL	989.5
95% Chebyshev (MVUE) UCL	1109	97.5% Chebyshev (MVUE) UCL	1276
99% Chebyshev (MVUE) UCL	1603		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1088	95% Jackknife UCL	1100
95% Standard Bootstrap UCL	1083	95% Bootstrap-t UCL	1796
95% Hall's Bootstrap UCL	2204	95% Percentile Bootstrap UCL	1139
95% BCA Bootstrap UCL	1313		
90% Chebyshev(Mean, Sd) UCL	1337	95% Chebyshev(Mean, Sd) UCL	1586
97.5% Chebyshev(Mean, Sd) UCL	1932	99% Chebyshev(Mean, Sd) UCL	2612

Suggested UCL to Use

95% H-UCL	927.6		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

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

Mercury

General Statistics

Total Number of Observations	25	Number of Distinct Observations	19
		Number of Missing Observations	0
Minimum	0.06	Mean	0.754
Maximum	4.4	Median	0.38
SD	0.954	Std. Error of Mean	0.191
Coefficient of Variation	1.265	Skewness	2.655

Normal GOF Test

Shapiro Wilk Test Statistic	0.694	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.233	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	1.081	95% Adjusted-CLT UCL (Chen-1995)	1.177
		95% Modified-t UCL (Johnson-1978)	1.098
Gamma GOF Test			
A-D Test Statistic	0.49	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.774	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.145	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.18	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	0.966	k star (bias corrected MLE)	0.876
Theta hat (MLE)	0.781	Theta star (bias corrected MLE)	0.861
nu hat (MLE)	48.28	nu star (bias corrected)	43.82
MLE Mean (bias corrected)	0.754	MLE Sd (bias corrected)	0.806
		Approximate Chi Square Value (0.05)	29.64
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	28.85
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50)	1.115	95% Adjusted Gamma UCL (use when n<50)	1.146
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.975	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0957	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-2.813	Mean of logged Data	-0.882
Maximum of Logged Data	1.482	SD of logged Data	1.13
Assuming Lognormal Distribution			
95% H-UCL	1.448	90% Chebyshev (MVUE) UCL	1.347
95% Chebyshev (MVUE) UCL	1.616	97.5% Chebyshev (MVUE) UCL	1.99
99% Chebyshev (MVUE) UCL	2.723		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	1.068	95% Jackknife UCL	1.081
95% Standard Bootstrap UCL	1.062	95% Bootstrap-t UCL	1.29
95% Hall's Bootstrap UCL	2.353	95% Percentile Bootstrap UCL	1.066
95% BCA Bootstrap UCL	1.17		
90% Chebyshev(Mean, Sd) UCL	1.327	95% Chebyshev(Mean, Sd) UCL	1.586
97.5% Chebyshev(Mean, Sd) UCL	1.946	99% Chebyshev(Mean, Sd) UCL	2.653
Suggested UCL to Use			
95% Adjusted Gamma UCL	1.146		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			

Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Nickel			
General Statistics			
Total Number of Observations	25	Number of Distinct Observations	22
		Number of Missing Observations	0
Minimum	21.4	Mean	35.39
Maximum	52.1	Median	33.4
SD	9.049	Std. Error of Mean	1.81
Coefficient of Variation	0.256	Skewness	0.153
Normal GOF Test			
Shapiro Wilk Test Statistic	0.956	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.132	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	38.49	95% Adjusted-CLT UCL (Chen-1995)	38.43
		95% Modified-t UCL (Johnson-1978)	38.5
Gamma GOF Test			
A-D Test Statistic	0.367	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.744	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.121	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.174	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	15.53	k star (bias corrected MLE)	13.69
Theta hat (MLE)	2.279	Theta star (bias corrected MLE)	2.585
nu hat (MLE)	776.4	nu star (bias corrected)	684.6
MLE Mean (bias corrected)	35.39	MLE Sd (bias corrected)	9.565
		Approximate Chi Square Value (0.05)	624.9
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	621
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	38.77	95% Adjusted Gamma UCL (use when n<50)	39.02
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.955	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.125	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			

Minimum of Logged Data	3.063	Mean of logged Data	3.534
Maximum of Logged Data	3.953	SD of logged Data	0.263
Assuming Lognormal Distribution			
95% H-UCL	39.05	90% Chebyshev (MVUE) UCL	41.08
95% Chebyshev (MVUE) UCL	43.65	97.5% Chebyshev (MVUE) UCL	47.21
99% Chebyshev (MVUE) UCL	54.2		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	38.37	95% Jackknife UCL	38.49
95% Standard Bootstrap UCL	38.33	95% Bootstrap-t UCL	38.44
95% Hall's Bootstrap UCL	38.46	95% Percentile Bootstrap UCL	38.29
95% BCA Bootstrap UCL	38.29		
90% Chebyshev(Mean, Sd) UCL	40.82	95% Chebyshev(Mean, Sd) UCL	43.28
97.5% Chebyshev(Mean, Sd) UCL	46.69	99% Chebyshev(Mean, Sd) UCL	53.4
Suggested UCL to Use			
95% Student's-t UCL	38.49		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Selenium			
General Statistics			
Total Number of Observations	25	Number of Distinct Observations	15
		Number of Missing Observations	0
Minimum	0.18	Mean	0.333
Maximum	0.92	Median	0.26
SD	0.203	Std. Error of Mean	0.0405
Coefficient of Variation	0.608	Skewness	2.193
Normal GOF Test			
Shapiro Wilk Test Statistic	0.646	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.325	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	0.402	95% Adjusted-CLT UCL (Chen-1995)	0.419
		95% Modified-t UCL (Johnson-1978)	0.405
Gamma GOF Test			
A-D Test Statistic	2.653	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.748	Data Not Gamma Distributed at 5% Significance Level	

K-S Test Statistic	0.297	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.175	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	4.437	k star (bias corrected MLE)	3.931
Theta hat (MLE)	0.0751	Theta star (bias corrected MLE)	0.0848
nu hat (MLE)	221.8	nu star (bias corrected)	196.5
MLE Mean (bias corrected)	0.333	MLE Sd (bias corrected)	0.168
		Approximate Chi Square Value (0.05)	165.1
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	163.1
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	0.397	95% Adjusted Gamma UCL (use when n<50)	0.401
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.79	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.271	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-1.715	Mean of logged Data	-1.216
Maximum of Logged Data	-0.0834	SD of logged Data	0.446
Assuming Lognormal Distribution			
95% H-UCL	0.39	90% Chebyshev (MVUE) UCL	0.416
95% Chebyshev (MVUE) UCL	0.457	97.5% Chebyshev (MVUE) UCL	0.514
99% Chebyshev (MVUE) UCL	0.625		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.4	95% Jackknife UCL	0.402
95% Standard Bootstrap UCL	0.399	95% Bootstrap-t UCL	0.453
95% Hall's Bootstrap UCL	0.42	95% Percentile Bootstrap UCL	0.403
95% BCA Bootstrap UCL	0.418		
90% Chebyshev(Mean, Sd) UCL	0.455	95% Chebyshev(Mean, Sd) UCL	0.51
97.5% Chebyshev(Mean, Sd) UCL	0.586	99% Chebyshev(Mean, Sd) UCL	0.736
Suggested UCL to Use			
95% Student's-t UCL	0.402	or 95% Modified-t UCL	0.405
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Silver			

General Statistics			
Total Number of Observations	25	Number of Distinct Observations	15
		Number of Missing Observations	0
Minimum	0.06	Mean	0.806
Maximum	3.1	Median	0.18
SD	0.922	Std. Error of Mean	0.184
Coefficient of Variation	1.144	Skewness	0.985

Normal GOF Test		
Shapiro Wilk Test Statistic	0.787	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.279	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level
Data Not Normal at 5% Significance Level		

Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	1.122	95% Adjusted-CLT UCL (Chen-1995)	1.148
		95% Modified-t UCL (Johnson-1978)	1.128

Gamma GOF Test		
A-D Test Statistic	1.865	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.79	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.231	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.182	Data Not Gamma Distributed at 5% Significance Level
Data Not Gamma Distributed at 5% Significance Level		

Gamma Statistics			
k hat (MLE)	0.678	k star (bias corrected MLE)	0.624
Theta hat (MLE)	1.188	Theta star (bias corrected MLE)	1.292
nu hat (MLE)	33.92	nu star (bias corrected)	31.19
MLE Mean (bias corrected)	0.806	MLE Sd (bias corrected)	1.021
		Approximate Chi Square Value (0.05)	19.43
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	18.8

Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	1.294	95% Adjusted Gamma UCL (use when n<50)	1.337

Lognormal GOF Test		
Shapiro Wilk Test Statistic	0.834	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.225	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.173	Data Not Lognormal at 5% Significance Level
Data Not Lognormal at 5% Significance Level		

Lognormal Statistics			
Minimum of Logged Data	-2.813	Mean of logged Data	-1.11
Maximum of Logged Data	1.131	SD of logged Data	1.468

Assuming Lognormal Distribution			
95% H-UCL	2.485	90% Chebyshev (MVUE) UCL	1.859
95% Chebyshev (MVUE) UCL	2.296	97.5% Chebyshev (MVUE) UCL	2.903
99% Chebyshev (MVUE) UCL	4.096		

Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	1.109	95% Jackknife UCL	1.122
95% Standard Bootstrap UCL	1.107	95% Bootstrap-t UCL	1.133
95% Hall's Bootstrap UCL	1.133	95% Percentile Bootstrap UCL	1.124
95% BCA Bootstrap UCL	1.122		
90% Chebyshev(Mean, Sd) UCL	1.359	95% Chebyshev(Mean, Sd) UCL	1.61
97.5% Chebyshev(Mean, Sd) UCL	1.958	99% Chebyshev(Mean, Sd) UCL	2.641
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	1.61		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Thallium

General Statistics			
Total Number of Observations	25	Number of Distinct Observations	18
		Number of Missing Observations	0
Minimum	0.09	Mean	0.434
Maximum	2.6	Median	0.2
SD	0.716	Std. Error of Mean	0.143
Coefficient of Variation	1.649	Skewness	2.525

Normal GOF Test		
Shapiro Wilk Test Statistic	0.498	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.41	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level
Data Not Normal at 5% Significance Level		

Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	0.679	95% Adjusted-CLT UCL (Chen-1995)	0.747
		95% Modified-t UCL (Johnson-1978)	0.691

Gamma GOF Test		
A-D Test Statistic	3.398	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.779	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.311	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.18	Data Not Gamma Distributed at 5% Significance Level
Data Not Gamma Distributed at 5% Significance Level		

Gamma Statistics			
k hat (MLE)	0.869	k star (bias corrected MLE)	0.791
Theta hat (MLE)	0.499	Theta star (bias corrected MLE)	0.548

nu hat (MLE)	43.45	nu star (bias corrected)	39.57
MLE Mean (bias corrected)	0.434	MLE Sd (bias corrected)	0.488
		Approximate Chi Square Value (0.05)	26.16
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	25.42
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	0.656	95% Adjusted Gamma UCL (use when n<50)	0.676
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.777	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.206	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Lognormal at 5% Significance Level	
Data Not Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-2.408	Mean of logged Data	-1.51
Maximum of Logged Data	0.956	SD of logged Data	0.989
Assuming Lognormal Distribution			
95% H-UCL	0.594	90% Chebyshev (MVUE) UCL	0.586
95% Chebyshev (MVUE) UCL	0.693	97.5% Chebyshev (MVUE) UCL	0.841
99% Chebyshev (MVUE) UCL	1.132		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution (0.05)			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.669	95% Jackknife UCL	0.679
95% Standard Bootstrap UCL	0.669	95% Bootstrap-t UCL	0.836
95% Hall's Bootstrap UCL	0.624	95% Percentile Bootstrap UCL	0.674
95% BCA Bootstrap UCL	0.758		
90% Chebyshev(Mean, Sd) UCL	0.863	95% Chebyshev(Mean, Sd) UCL	1.058
97.5% Chebyshev(Mean, Sd) UCL	1.328	99% Chebyshev(Mean, Sd) UCL	1.858
Suggested UCL to Use			
95% Chebyshev (Mean, Sd) UCL	1.058		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Vanadium			
General Statistics			
Total Number of Observations	25	Number of Distinct Observations	25
		Number of Missing Observations	0
Minimum	22.5	Mean	30.94
Maximum	41.9	Median	30.7
SD	4.876	Std. Error of Mean	0.975
Coefficient of Variation	0.158	Skewness	0.216

Normal GOF Test			
Shapiro Wilk Test Statistic	0.98	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.0788	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	32.61	95% Adjusted-CLT UCL (Chen-1995)	32.59
		95% Modified-t UCL (Johnson-1978)	32.62
Gamma GOF Test			
A-D Test Statistic	0.189	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.743	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.0861	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.174	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	41.78	k star (bias corrected MLE)	36.79
Theta hat (MLE)	0.741	Theta star (bias corrected MLE)	0.841
nu hat (MLE)	2089	nu star (bias corrected)	1840
MLE Mean (bias corrected)	30.94	MLE Sd (bias corrected)	5.101
		Approximate Chi Square Value (0.05)	1741
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	1734
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	32.69	95% Adjusted Gamma UCL (use when n<50)	32.82
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.981	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0833	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	3.114	Mean of logged Data	3.42
Maximum of Logged Data	3.735	SD of logged Data	0.159
Assuming Lognormal Distribution			
95% H-UCL	32.75	90% Chebyshev (MVUE) UCL	33.9
95% Chebyshev (MVUE) UCL	35.24	97.5% Chebyshev (MVUE) UCL	37.11
99% Chebyshev (MVUE) UCL	40.76		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	32.54	95% Jackknife UCL	32.61
95% Standard Bootstrap UCL	32.46	95% Bootstrap-t UCL	32.65

95% Hall's Bootstrap UCL	32.7	95% Percentile Bootstrap UCL	32.5
95% BCA Bootstrap UCL	32.72		
90% Chebyshev(Mean, Sd) UCL	33.87	95% Chebyshev(Mean, Sd) UCL	35.19
97.5% Chebyshev(Mean, Sd) UCL	37.03	99% Chebyshev(Mean, Sd) UCL	40.64
Suggested UCL to Use			
95% Student's-t UCL	32.61		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

Zinc

General Statistics			
Total Number of Observations	25	Number of Distinct Observations	23
		Number of Missing Observations	0
Minimum	76	Mean	169.6
Maximum	383	Median	130
SD	95.43	Std. Error of Mean	19.09
Coefficient of Variation	0.563	Skewness	1.113
Normal GOF Test			
Shapiro Wilk Test Statistic	0.822	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.229	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.173	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	202.2	95% Adjusted-CLT UCL (Chen-1995)	205.5
		95% Modified-t UCL (Johnson-1978)	202.9
Gamma GOF Test			
A-D Test Statistic	1.152	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.749	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.178	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.175	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	3.941	k star (bias corrected MLE)	3.495
Theta hat (MLE)	43.02	Theta star (bias corrected MLE)	48.52
nu hat (MLE)	197	nu star (bias corrected)	174.7
MLE Mean (bias corrected)	169.6	MLE Sd (bias corrected)	90.7
		Approximate Chi Square Value (0.05)	145.2
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	143.3
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	204.1	95% Adjusted Gamma UCL (use when n<50)	206.7

Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.907	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.147	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.173	Data appear Lognormal at 5% Significance Level	
Data appear Approximate Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	4.331	Mean of logged Data	5.001
Maximum of Logged Data	5.948	SD of logged Data	0.508
Assuming Lognormal Distribution			
95% H-UCL	207.1	90% Chebyshev (MVUE) UCL	221.3
95% Chebyshev (MVUE) UCL	245.5	97.5% Chebyshev (MVUE) UCL	279
99% Chebyshev (MVUE) UCL	344.9		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	200.9	95% Jackknife UCL	202.2
95% Standard Bootstrap UCL	200	95% Bootstrap-t UCL	209.3
95% Hall's Bootstrap UCL	201.9	95% Percentile Bootstrap UCL	201.2
95% BCA Bootstrap UCL	202.2		
90% Chebyshev(Mean, Sd) UCL	226.8	95% Chebyshev(Mean, Sd) UCL	252.7
97.5% Chebyshev(Mean, Sd) UCL	288.7	99% Chebyshev(Mean, Sd) UCL	359.5
Suggested UCL to Use			
95% H-UCL	207.1		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
ProUCL computes and outputs H-statistic based UCLs for historical reasons only.			
H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.			
It is therefore recommended to avoid the use of H-statistic based 95% UCLs.			
Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.			

APPENDIX C1 AND C2

C1: MUNITIONS AND EXPLOSIVES OF CONCERN HAZARD ASSESSMENT (MEC HA)

C2: MUNITIONS AND EXPLOSIVES OF CONCERN RISK ASSESSMENT (MEC RA) AND ALTERNATIVES ANALYSIS

Appendix C1
Munitions and Explosives of Concern Hazard Assessment (MEC HA)

MUNITIONS AND EXPLOSIVES OF CONCERN HAZARD ASSESSMENT FOR

OPEN DETONATION GROUNDS

SENECA ARMY DEPOT ACTIVITY
ROMULUS, SENECA COUNTY, NEW YORK

Prepared for:

U.S. Army Engineering and Support Center, Huntsville

and
SENECA ARMY DEPOT ACTIVITY
ROMULUS, NEW YORK

Prepared by:

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Contract Number W912DY-08-D-0003
Task Order No. 0013
EPA Site ID# NY0213820830
NY Site ID# 8-50-006

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C.1 EXECUTIVE SUMMARY

Parsons was tasked by the U.S. Army Corps of Engineers (USACE), Huntsville District, under Contract No. W912DY-08-D-0003, Task Order No. 0013 to prepare a munitions and explosives of concern (MEC) hazard assessment (HA) for the Open Detonation (OD) Grounds, also known as SEAD-45, located at the Seneca Army Depot Activity (SEDA or the Depot) in Romulus, New York. The purpose of this MEC HA is to assess qualitatively the potential explosive hazards to human receptors associated with complete MEC exposure pathways at the OD Grounds munitions response site (MRS). This appendix contains a detailed description of the MEC HA conducted for the OD Grounds, including the information and assumptions used for this assessment.

The MEC HA method was developed by the Technical Working Group for Hazard Assessment, which included representatives from the Department of Defense (DoD), the U.S. Department of the Interior, the United State Environmental Protection Agency (USEPA), and various states and tribes. The method provides an assessment of the acute explosive hazards associated with remaining MEC at an MRS by analyzing site-specific conditions and human issues that affect the likelihood that a MEC accident will occur (Subchapter C.5). Under the MEC HA method, the potential MEC hazards are evaluated qualitatively for each MRS by evaluating site conditions and assigning related "input factors" that generate a total MEC HA score between 125 and 1,000, with the upper limit representing the maximum level of explosive hazard (Subchapters C.7 and C.8).

This MEC HA divides the OD Grounds into two areas for assessment purposes based on differing anticipated explosive hazard characteristics (Subchapter C.6). Previous investigations indicate the density of potential MEC is highest at the center of the OD Grounds, in the vicinity of the OD Hill where the demolition activities took place and areas in the immediate vicinity that received most of the "kick-outs" from those activities. This area is referred to as the "OD Hill area" in this MEC HA. The second assessment area includes areas further away from the OD Hill that received kick-outs, but in lower densities. This second assessment area is referred to as the "Kickout Area" in this MEC HA. The locations of these two assessment areas are shown on Figure 1-2 in the Feasibility Study (FS) Report.

A qualitative baseline evaluation of the potential MEC hazards posed was conducted by reviewing each of the MEC HA input factors for the OD Hill and Kickout areas (Subchapter C.9). Having generated baseline MEC HA scores for each assessment area, different remedial alternatives were further evaluated using the MEC HA method to compare how they might reduce the explosive hazards in each area (Subchapter C.10). The remedial alternatives evaluated were (1) the No Action Alternative, (2) LUCs only, including groundwater restriction, (3) Consolidate and Cap with Surface and Subsurface Clearance Outside the Cap and LUCs , (4) Excavate OD Hill and perform surface/subsurface clearance over the entire site, and LUCs , and (5) Excavate entire site to 1 foot below grade and perform surface/subsurface clearance. These are referred to here and, in the FS, as Remedial Alternatives 1, 2, 3, 4, and 5 respectively. Remedial Alternative 1, the no action alternative, is the baseline scenario for this MEC HA.

The results of the MEC HA conducted for both assessment areas are shown in Table C.8 (Subchapter C.9). For the OD Hill area, the baseline score (the no action alternative) results in a MEC HA score of 865. Remedial Alternative 2 (LUCs only, including groundwater use restriction) results in a

MEC HA score of 865, identical to the baseline. The Hazard Level remained at 1 ('highest potential explosive hazard conditions') for Alternative 2. Remedial Alternative 3 (consolidate and cap with surface and subsurface clearance outside the cap, followed by implementation of LUCs), Remedial Alternative 4 (excavate OD Hill to grade and perform surface/subsurface clearance over site and LUCs), and Remedial Alternative 5 (excavate entire site to 1 foot below grade and perform surface/subsurface clearance) were also evaluated for the OD Hill area, and result in a MEC HA score of 470. The reduction in MEC HA score from 865 to 470 for Alternatives 3, 4, and 5, reduces the corresponding Hazard Level rating from 1 ('highest potential explosive hazard conditions') to 4 ('low potential explosive hazard conditions'). Based on these results, there is no significant difference between these three remedial alternatives with respect to reduction of explosive hazards at the OD Hill area.

For the Kickout area, the baseline score (the no action alternative) results in a MEC HA score of 715. Alternative 2 results in no change in MEC HA score and Hazard Level from the baseline evaluation. Remedial Alternatives 3, 4 and 5 result in a MEC HA score of 445. This reduction in MEC HA score for Alternatives 3, 4, and 5 reduces the corresponding Hazard Level rating from 3 ('moderate potential explosive hazard conditions') to 4 ('low potential explosive hazard conditions'). Based on these results, there is no significant difference between Alternatives 3, 4, and 5 with respect to reduction of explosive hazards at the Kickout area.

The remaining sections of this appendix provide information on the site history, current and future land use, the MEC HA input and output factors, the details of the baseline MEC HA evaluation, the remedial action alternatives, and the adjusted MEC HA scores resulting from the implementation of these remedial action alternatives.

C.2 SITE HISTORY AND PREVIOUS DISCOVERIES

Since its inception in 1941, SEDA's military mission included receipt, storage, distribution, maintenance, and demilitarization of conventional ammunition, explosives, and special weapons.

The OD Grounds located in the northwestern corner of the Depot and is designated as SEAD-45. The site is largely meadow with some wooded and heavily brushed areas. Reeder Creek runs through the OD Grounds. Access is possible via a paved road that enters the area from the southeast and roughly parallels the path of Reeder Creek along its western bank. The unnamed access road branches off North-South Baseline Road near Building 2104, which is located in the southeastern corner of the OD Grounds.

The OD Grounds were used to destroy munitions resulting from SEDA's military mission. Operations at the OD Grounds began circa 1941 when the Depot was first constructed and continued at regular intervals until circa 2000 when the military mission of the Depot ceased. Detonations were conducted on an approximately 30-foot high man-made hill constructed to buffer the intensity of planned detonations (the 'OD Hill'). Detonations occurred intermittently since the Depot closed as part of continuing munitions response activities being performed at the Depot. During operations, off specification munitions were placed in an excavated opening in the side of the OD Hill with additional demolition material, covered with a minimum of 8 feet of soil, and detonated remotely. After demolition was completed, explosively displaced

portions of the mound were reconstructed by moving displaced and native soils back into the central earthen mound.

These historic operations resulted in MEC, material potentially presenting an explosive hazard (MPPEH), and munitions debris (MD) being expelled ("kicked out") from the OD Hill to the surrounding area. Investigations indicate the highest MPPEH densities are in the vicinity of the OD Hill, which is to be expected as this area contains both the former detonation location and the areas that would have received most "kick outs". Densities of "kick-outs" from the demolition operations decrease moving away from the demolition operations.

C.3 MEC POTENTIALLY PRESENT ONSITE

Several characterization efforts and investigations for MPPEH have been conducted at the OD Grounds and are summarized in the FS document. Based on historical data, previous investigations and removal actions, the MPPEH present at the site is summarized in Subchapter C.5.

C.4 CURRENT AND FUTURE LAND USE

The OD Grounds are currently closed. The planned future use for the area that encompasses the OD Grounds is projected to be a "Conservation/Recreation Area". For the remedial alternatives considered in this MEC HA, it is assumed LUCs will be implemented that will restrict the area to non-intrusive recreational activities such as hiking, with no camping allowed. The LUCs will also restrict access to groundwater, prohibit digging or any intrusive activities, and prohibit the use of the site for residential or day care uses.

C.5 EXPLOSIVE HAZARDS AND HAZARD ASSESSMENT

An explosive hazard exists at a site if there is a potentially complete MEC exposure pathway. A complete MEC exposure pathway is present any time a receptor can come near or into contact with MEC and interact with the item in a manner that might result in its detonation. There are three elements of a complete MEC exposure pathway: (1) a source of MEC, (2) a receptor, and (3) the potential for interaction between the MEC source and the receptor. All three of these elements must be present for a potentially complete MEC exposure pathway to exist.

Based on the findings of previous investigations, MPPEH remains or has the potential to remain within the OD Grounds area. Known or suspected munitions include 81mm HE mortars, 60mm illumination mortars, 75mm HE projectiles, 75mm HEAT projectiles, 57 mm HE projectiles, 40mm practice projectiles, 37mm HE projectiles, 20mm HEI projectiles, 3.5-inch HEAT rockets, sub-caliber aircraft rockets, 4-lb. fragmentation bombs (Butterfly), 40mm HE grenades, antitank rifle grenades, fragmentation hand grenades, riot hand grenades, bomb nose fuzes, bomb tail fuzes, point detonating fuzes, base detonating fuzes, parachute flares, and illuminating ground signals.

The qualitative hazard assessment technique presented here follows the MEC HA method, which provides an assessment of the acute explosive hazards associated with remaining MEC at a MRS by analyzing site-specific conditions and human issues that affect the likelihood that a MEC accident will

occur. The MEC HA method focuses on hazards to human receptors and does not directly address environmental or ecological concerns that might be associated with MEC. The process for conducting the MEC HA is described in the MEC HA interim guidance document (USEPA, 2008) and uses input data based on historical documentation, field observations, and the results of previous studies and removal actions. The MEC HA interim guidance was developed by the Technical Working Group for Hazard Assessment, which included representatives from the DoD, the U.S. Department of the Interior, the USEPA, and various states and tribes. The DoD has encouraged use of this method on a trial basis (DoD 2009).

The MEC HA method reflects the basic difference between assessing acute hazards from exposure to MEC and assessing chronic environmental risks from exposure to potential contaminants, such as munitions constituents (MC). An explosive hazard can result in immediate injury or death; therefore, risks from explosive hazards are evaluated either as being present or not present. If the potential for an encounter with MEC exists, then the potential that the encounter may result in injury or death also exists. This MEC HA was conducted to evaluate the baseline conditions for the site with regard to explosive hazards. These baseline evaluations provide the basis for the evaluation and implementation of effective management response alternatives in a FS for this property. The MEC HA also supports hazard communication among stakeholders by organizing site information in a consistent manner for the hazard management decision-making process. However, the MEC HA does not provide a quantitative assessment of MEC hazards and is not used to determine whether or not further action is necessary at a site.

C.6 DEFINING THE AREAS TO BE ASSESSED

A MEC HA is focused on each MRS at a site. However, the MEC-related characteristics of discrete areas within an MRS may differ with regard to the ordnance types and quantities, land uses, receptors, and other factors. If these factors vary significantly, the qualitative MEC hazards associated with the discrete areas are likely to differ. For example, the characteristics of a range impact area and its safety fan are likely to differ with regard to the amount of MEC potentially present or different land use activities may exist that create differing potentials for MEC interaction with human receptors within a large maneuver area.

Different MEC hazards may result in different response alternatives being appropriate for these discrete areas; consequently, an MRS may be subdivided into two or more distinct "assessment areas," each of which will be the subject of a separate MEC HA for purposes of hazard assessment and subsequent response alternative evaluation. However, if an MRS is likely to be the subject of only one response alternative (e.g., the MRS is small), the MRS may be evaluated as a single assessment area, despite the potential for differing MEC-related characteristics. In this event, the most conservative MEC HA input factors (see below) are selected for purposes of the MEC HA.

Based on the history of the site and the results of previous investigations, the area at and in the immediate vicinity of the OD Hill (within 1,000 feet), where demolition activities were previously conducted, are known to exhibit higher densities of MPPEH than the surrounding areas (e.g., the Kickout area). Due to these differing MEC-related characteristics, the OD Grounds is divided into two areas for assessment purposes: the OD Hill area and the Kickout area.

The OD Hill area, includes the OD Hill where detonations occurred, and the area in the immediate vicinity (within 1,000 feet) that received most of the kick-outs from those detonations. The Kickout area (more than 1,000 feet from the OD Hill) received lower quantities of kick-outs and therefore has a lower potential for MPPEH to be present. Separate MEC HA scores are calculated for each of these assessment areas. The two areas are shown on Figure 1-2 of the FS Report.

C.7 OVERVIEW OF MEC HA INPUT FACTORS

Under the MEC HA method, the potential MEC hazards are evaluated qualitatively for each MRS or assessment area by evaluating three primary factors. These primary factors are related to the three critical elements noted previously are:

- *Severity*: the potential consequences of the effect on a human receptor should a MEC item detonate;
- *Accessibility*: the likelihood that a human receptor will come into contact with a MEC item; and
- *Sensitivity*: the likelihood that a MEC item will detonate if a human receptor interacts with the item.

To complete the baseline MEC HA for each MRS/assessment area, the input factors are reviewed and suitable categories (baseline, surface MEC cleanup, or subsurface MEC cleanup) are selected based on historical documentation and field observations. The input factors for the MEC HA method are highlighted below (USEPA, 2008):

Energetic Material Type: This factor describes the general type of energetic material associated with the munition(s) known or suspected to be present within the MRS or assessment area. The six possible categories for this factor, ranging from the most to least potentially hazardous, are 'high explosives and low explosive fillers in fragmenting rounds,' 'white phosphorus (WP),' 'pyrotechnics,' 'propellants,' 'spotting charges,' and 'incendiaries.' The category selected for each MRS or assessment area is based on the energetic material with the greatest potential explosive hazard known or suspected to be present.

Location of Additional Human Receptors: Human receptors other than the individual who causes a detonation may be exposed to overpressure and/or fragmentation hazards from the detonation of MEC. This factor describes whether or not there are additional human receptors located within the MRS/assessment area or within the explosive safety quantity-distance (ESQD) arc surrounding the MRS/assessment area. The two possible categories for this factor are "inside the MRS or inside the ESQD arc surrounding the MRS" and "outside the ESQD arc."

Site Accessibility: The site accessibility factor describes how easily human receptors can gain access to the MRS or assessment area and takes into account the various barriers to entry that might be present. The four possible categories of site accessibility range from "full accessibility" (i.e., a site with no barriers to entry) to "very limited accessibility" (i.e., a site with guarded chain link fences or terrain that requires special skills and equipment to access). This factor differs from the Potential Contact Hours factor (see below) and does not include or account for LUCs that might restrict site access. The effects of LUCs are assessed in the FS alternatives assessment.

Potential Contact Hours: This factor accounts for the amount of time receptors spend within the MRS or assessment area during which they might come into contact with MEC and intentionally or unintentionally cause a detonation. Both the number of receptors and the amount of time each receptor spends in the MRS/assessment area are used to calculate the total "receptor-hours/year." This total is calculated for all activities that might result in potential MEC interaction and there are four possible categories, ranging from "many hours" (≥ 1,000,000 receptor-hours/year) to "very few hours" (< 10,000 receptor-hours/year).

Amount of MEC: This input factor describes the relative quantity of MEC anticipated to remain within the MRS or assessment area as a result of past munitions-related activities. For example, a greater quantity of MEC would be expected to be present in a former target area than at a former firing point. The nine possible categories for this factor, from the largest to the least anticipated amount of MEC, range from "target area" and "Open Burning/Open Detonation (OB/OD) area," through "burial pit" and "firing point," to "storage" and "explosives-related industrial facility."

Minimum MEC Depth Relative to the Maximum Receptor Intrusive Depth: This factor indicates whether the MEC in the MRS or assessment area are located at depths that might be reached by the anticipated human receptor activities. For the baseline MEC HA, the four possible categories concern whether or not MEC are located at the surface and in the subsurface within the MRS or assessment area, or whether MEC are present in the subsurface only, and whether or not the receptor intrusive depth overlaps with this MEC location.

Migration Potential: The migration potential factor addresses the likelihood that MEC in the MRS or assessment area might migrate by natural processes (e.g., erosion or frost heave) thereby increasing the chance of subsequent exposure to potential human receptors. The two possible categories for this factor are "possible" and "unlikely."

MEC Classification: This factor accounts for how easily a human receptor might cause a detonation of the MEC and relates directly to the MEC sensitivity. The six possible categories for this factor, ranging from the highest to lowest sensitivity (and explosive hazard) are "sensitive unexploded ordnance (UXO)," "other UXO," fuzed sensitive discarded military munitions (DMM)," "fuzed DMM," "unfuzed DMM," and "bulk explosives." The selection of category for each MRS or assessment area is made using the MEC with the highest potential sensitivity known or suspected to be present and, where uncertainty exists, conservative assumptions are made and documented. For example, UXO is always assumed to be present within a known target area, whether or not the investigation uncovers UXO at the site.

MEC Size: This factor indicates how easy it is for a typical human receptor to move the MEC item(s) present within the MRS or assessment area. For example, an individual is considerably more likely to pick up or accidentally kick a hand grenade than a 200-lb. bomb. The basic assumption used in this category is that MEC weighing 90-lbs or more is unlikely to be moved without the use of special equipment. Based on this assumption, the two possible categories for this factor are "small" (i.e., items weighing less than 90-lbs.) and "large" (items weighing 90-lbs. or more). The selection of category for each MRS or assessment area is based on the MEC known or suspected to be present with the highest potential to be moved (i.e., the smallest item).

Each category for each of the MEC HA input factors has an assigned score that relates to the relative contributions of the different input factors to the overall MEC hazard. These scores were developed by the Technical Working Group for HA. These factors and their associated scores for the baseline condition and after cleanup conditions are provided in Table C.1a. The detailed technical basis for the scores assigned is provided in the MEC HA interim guidance document (USEPA, 2008).

C.8 OVERVIEW OF MEC HA OUTPUT FACTORS

Once the categories and scores for all input factors are defined for each MRS or assessment area at the site, the related scores for each category are totaled to calculate an overall MEC HA score for each MRS/assessment area. The total maximum possible MEC HA score for an MRS/assessment area ranges from 125 - 1,000. The MEC HA method identified the associated hazard levels for these scores, which range from 1 to 4. A Hazard Level of 1 indicates the highest potential explosive hazard conditions and a hazard level of 4 indicates low potential explosive hazard conditions. The basis for these hazard levels is detailed in the MEC HA interim guidance document (USEPA, 2008). The total MEC HA scores and associated hazard levels are *qualitative references only* and should not be interpreted as quantitative measures of explosive hazard or as the sole basis for determining whether or not further action is necessary at a site. A summary of the hazard levels and their related MEC HA scores is presented in Table C.2.

Table C.1a
Summary of MEC HA Input Factors and Associated Baseline Scores

Input Factor	Input Factor Category	Baseline Score	Score After Subsurface Cleanup
Energetic Material Type	HE and Low Explosive Fillers in Fragmenting Rounds	100	100
	White Phosphorus	70	70
	Pyrotechnic	60	60
	Propellant	50	50
	Spotting Charge	40	40
	Incendiary	30	30
Location of Additional Human Receptors	Inside the MRS or inside the ESQD arc surrounding the MRS	30	30
	Outside of the ESQD arc	0	0
Site Accessibility	Full Accessibility	80	80
	Moderate Accessibility	55	55
	Limited Accessibility	15	15
	Very Limited Accessibility	5	5
Potential Contact Hours	Many Hours	120	30
	Some Hours	70	20
	Few Hours	40	10
	Very Few Hours	15	5
Amount of MEC	Target Area	180	30
	Open Burning/Open Detonation (OB/OD) Area	180	30
	Function Test Range	165	25
	Burial Pit	140	10
	Maneuver Areas	115	5
	Firing Points	75	5
	Safety Buffer Areas	30	5
	Storage	25	5
	Explosive-Related Industrial Facility	10	5

Table C.1a, cont'd.
Summary of MEC HA Input Factors and Associated Baseline Scores

Input Factor	Input Factor Category	Baseline Score	Score After Subsurface Cleanup
Minimum MEC Depth vs. Maximum Intrusive Depth	**Baseline Condition**: MEC located on surface and in subsurface; **After Cleanup**: intrusive depth overlaps with minimum MEC depth	240	95
	Baseline Condition: MEC located on surface and in subsurface; **After Cleanup**: intrusive depth *does not* overlap with minimum MEC depth	240	25
	Baseline Condition: MEC located only in subsurface; **Baseline Condition or After Cleanup**: intrusive depth overlaps with minimum MEC depth	150	95
	Baseline Condition: MEC located only in subsurface; **Baseline Condition or After Cleanup**: intrusive depth *does not* overlap with minimum MEC depth	50	25
Migration Potential	Possible	30	10
	Unlikely	10	10
MEC Classification	Sensitive UXO	180	180
	UXO	110	110
	Fuzed Sensitive DMM	105	105
	Fuzed DMM	55	55
	Unfuzed DMM	45	45
	Bulk Explosives	45	45
MEC Size	Small	40	40
	Large	0	0

Source: MEC HA interim guidance document (USEPA, 2008)

NOTE: For Alternative 3 (Consolidate and cap with surface and subsurface clearance to 2 feet bgs outside the cap and LUCs), the installation of a cap is functionally equivalent to a subsurface clearance for MEC HA purposes as it places a barrier of clean soil between the receptors and the ground surface.

Scores for the categories are in multiples of five, with a total maximum possible score for all factors of 1,000 and a minimum possible score of 125. These MEC HA scores are *qualitative references only* and should not be interpreted as quantitative measures of explosive hazard. A summary of the maximum possible scores and their related weights with regard to the overall MEC HA score are shown in Table C.1b.

Table C.1b
Summary of MEC HA Scoring

Explosive Hazard Component	Input Factor	Maximum Scores	Weights
Severity	Energetic Material Type	100	10%
	Location of Additional Human Receptors	30	3%
	Component Total	*130*	*13%*
Accessibility	Site Accessibility	80	8%
	Total Contact Hours	120	12%
	Amount of MEC	180	18%
	Minimum MEC Depth vs. Maximum Intrusive Depth	240	24%
	Migration Potential	30	3%
	Component Total	*650*	*65%*
Sensitivity	MEC Classification	180	18%
	MEC Size	40	4%
	Component Total	*220*	*22%*
Maximum Total Score		**1,000**	**100%**

Source: MEC HA interim guidance document (USEPA, 2008)

Table C.2
Hazard Level Scoring Rankings Table

Hazard Level	Maximum MEC HA Score	Minimum MEC HA Score	Associated Relative Explosive Hazard
1	1,000	840	Highest potential explosive hazard conditions
2	835	725	High potential explosive hazard conditions
3	720	530	Moderate potential explosive hazard conditions
4	525	125	Low potential explosive hazard conditions

Source: MEC HA interim guidance document (USEPA, 2008).

C.9 BASELINE MEC HAZARD EVALUATION

A qualitative baseline evaluation of the potential MEC hazards posed was conducted by reviewing each of the MEC HA input factors described above for the two assessment areas, the OD Hill and Kickout areas. Historical and field investigation data were used to determine the appropriate categories for each MEC HA input factor (see Subchapter C.7).

Based on the site history and previous investigations, the OD Grounds was the location of an area used to destroy munitions by detonation in support of the Army mission. The site is currently closed, although hunting is performed. Numerous MPPEH items including mortars, large or medium caliber projectiles, rockets, bombs, grenades, and fuzes have been removed from this site, some of which were configured with explosives, explosive bursters, and/or fuzes. All of the MPPEH items found were described as UXO based on the terminology used during the time of the investigation.

Assessment Area Definition: The assessment areas that are the subject of the MEC HA for the OD Grounds are the OD Hill and Kickout areas. The primary differences between these two assessment areas are the potential amount of MEC and contact hours in each one; most other site characteristics are identical for each assessment area.

Energetic Material Type: The MEC items known or suspected to be present within the OD Grounds include mortars, large or medium caliber projectiles, rockets, bombs, grenades, and fuzes. Items with various fillers have been found, and some of these items contain high explosives or are fragmenting rounds. The energetic material type selected for both assessment areas is determined to be 'high explosives and low explosive filler in fragmenting rounds', which is the most potentially hazardous of the available selections.

Location of Additional Human Receptors: The MEC item anticipated to be present within the OD Grounds that is considered to be the most hazardous, based on Hazardous Fragment Distance (HFD), is the Mortar, 81mm, HE, M374. For this item, the HFD is 239 feet. On this basis, the ESQD used for this MEC HA is 239 feet for both the OD Hill and Kickout areas. Although receptors are present in both assessment areas, there are no locations within the ESQD of either assessment area where people will congregate. Based on this information, the location of additional human receptors for the OD Hill and Kickout assessment areas is assessed to be 'outside the ESQD arc.'

Site Accessibility: The Current Site Conditions for both assessment areas assumes that no fence is present to limit access. Based on this information, both the OD Hill and Kickout assessment areas are classified as having 'full accessibility' under the Current Site Conditions scenario.

Potential Contact Hours: As described above, the Current Site Conditions for the OD Grounds MRS assumes the site is located at a closed military installation, and the OD Grounds are closed. Hunting is performed in the area. The deer hunting season begins in mid-November and ends during the second week of December.

- Under this scenario for both the OD Hill and the Kickout area, 10 hunters are assumed to hunt in the area, with each spending an average of 12 hours per day, 16 days per year, for a total of 192 hours per year per receptor. Based on this information, the total potential contact hours for the assessment area are calculated to be 1,920 receptor-hours/year, which corresponds to a

classification of 'very few hours' (less than 10,000 receptor-hours/year) for the OD Hill assessment area.

Amount of MEC: The potential for MEC presence varies within the OD Grounds MRS.

- In the OD Hill assessment area, the primary cause of MPPEH presence is munitions disposal by open detonation. For this reason, a classification of 'OB/OD Area' is considered appropriate for purposes of this MEC HA.
- In the Kickout assessment area, which is outside the former OD area and is not where disposal activities were conducted, the presence of MPPEH is the result of potential kick-outs only. For this reason, a MEC HA classification of "Safety Buffer Area" is considered appropriate for purposes of this MEC HA.

Minimum MEC Depth Relative to the Maximum Receptor Intrusive Depth: At the OD Grounds MRS, MPPEH has been found on the ground surface and to depths of 36 inches bgs. There are currently no intrusive activities performed in this area so the maximum receptor intrusive depth at the site is assumed to be 0 inches. Based on this information, for the OD Hill and the Kickout areas, the minimum MEC depth relative to the maximum receptor intrusive depth for the assessment area is assessed to be 'MEC located surface and subsurface – intrusive depth overlaps with minimum MEC depth'.

Migration Potential: The site conditions at the OD Grounds are currently largely meadow with some wooded and, heavily brushed areas. The primary natural process that can result in the migration or exposure of MEC items that might be present at the OD Grounds is erosion. Natural erosion of soil over time by the wind or by water (surface water or precipitation) can result in the exposure of MEC below grade by the removal of the overlying soil. In some cases, if soil is unstable and the erosive force is sufficient to act on items(s) the size of the MEC present, this process can result in the movement of MEC from its original position to another location (typically somewhere downstream of the wash). This is not anticipated to be the case at the OD Grounds as no visual indication of this occurring on-site has been observed.

MEC Classification: As described previously, the MPPEH items known or suspected to be present at the OD Grounds MRS include mortars, large or medium caliber projectiles, rockets, bombs, grenades, and fuzes. Some of these items also contain high explosive anti-tank (HEAT) fillers. Mortars, hand grenades, and HEAT munitions are all classified as 'special case' items in the MEC HA guidance. Because UXO items have been found in both assessment areas during prior investigations and because MEC found would be the result of munitions disposal, it is assumed that UXO might be present. Therefore, according to the criteria listed in the MEC HA method, the MEC classification for MPPEH items that might remain at the site is 'Sensitive UXO.'

MEC Size: The MEC items known or suspected to be present within both assessment areas of the OD Grounds MRS include mortars, large or medium caliber projectiles, rockets, bombs, grenades, and fuzes. Based on the criteria defined in the MEC HA method, because many of the munitions known or suspected to be present weigh less than 90 pounds, the MEC size for the site is classified as having the highest potential to be moved or 'small' for purposes of this MEC HA.

MEC HA Baseline Results: The two assessment areas within the OD Grounds MRS, were evaluated separately. The primary differences between the two evaluations were the "Amount of MEC" and "Potential Contact Hours" classifications. The OD Hill assessment area was classified as an "OB/OD Area", while the Kickout assessment area was classified as a "Safety Buffer Area." Total receptor contact hours differed between the two assessment areas, though the classification for both areas was "very few hours." The resulting MEC HA scores are summarized below:

- The OD Hill assessment area has a total MEC HA score of 865 under the current site conditions, which equates to a Hazard Level of 1 (Table C.3). This hazard level indicates an area with 'Highest potential explosive hazard conditions' (USEPA, 2008).
- The Kickout assessment area has a total MEC HA score of 715 under the current site conditions, which equates to a Hazard Level of 3 (Table C.3). This hazard level indicates an area with 'moderate potential explosive hazard conditions' (USEPA, 2008).

This information provides the baseline for the assessment of response alternatives presented in Subchapter C.10.

Note that the total MEC HA score and the associated hazard level are *qualitative references only* and should not be interpreted as quantitative measures of explosive hazard. Also, this MEC HA does not address or otherwise evaluate potential risks related to munitions constituents posed by that might be present at the site.

Table C.3
Summary of MEC HA Baseline Scores
OD Hill and Kickout Assessment Areas
Current Site Conditions

Explosive Hazard Component	Input Factors	Category Selected for MRS/Area	Score [1], [2] (*Max. Score*)	
			OD Hill	Kickout
Severity	Energetic Material Type	High explosives and low explosive filler in fragmenting rounds	100 (*100*)	100 (*100*)
	Location of Additional Human Receptors	Outside of the ESQD arc	0 (*30*)	0 (*30*)
Accessibility	Site Accessibility	Full accessibility	80 (*80*)	80 (*80*)
	Total Contact Hours	Very few hours	15 (*120*)	15 (*120*)
	Amount of MEC	OB/OD Area (180) Safety Buffer Area (30)	180 (*180*)	30 (*180*)
	Minimum MEC Depth vs. Maximum Intrusive Depth	MEC located in surface and subsurface; max. intrusive depth overlaps min. MEC depth	240 (*240*)	240 (*240*)
	Migration Potential	Unlikely	10 (*30*)	10 (*30*)
Sensitivity	MEC Classification	Sensitive UXO	180 (*180*)	180 (*180*)
	MEC Size	Small	40 (*40*)	40 (*40*)
Total MEC HA Score [2]			**845 (*1,000*)**	**695 (*1,000*)**
MEC HA Hazard Level			**1**[3]	**3**[4]

(1) Scores assigned for each factor as listed and described in MEC HA interim guidance document (USEPA, 2008). The maximum possible MEC HA score is listed in parentheses beneath the assigned score(s) for reference purposes.

(2) The scores for the input factors are based on the baseline condition.

(3) A MEC HA Hazard Level of 1 indicates an area with "Highest potential explosive hazard conditions".

(4) A MEC HA Hazard Level of 3 indicates an area with "Moderate potential explosive hazard conditions".

C.10 EVALUATION OF POTENTIAL REMEDIAL ACTIONS

In addition to providing a technique to evaluate baseline MEC hazards, the MEC HA method also establishes a process to evaluate qualitatively the hazard mitigation that would be achieved by remedial actions. This process is based on assumptions made regarding the effects of a given remedial response (e.g., LUCs, surface cleanup, subsurface cleanup), coupled with modified scores for MEC HA input factors, to evaluate how the MEC HA score might be reduced following implementation of the response. The primary purpose of this process is to support the evaluation of response alternatives conducted during an FS; i.e., this evaluation should not be used as the sole basis upon which to recommend a remedial response. As with the baseline score, these total MEC HA scores and the associated hazard levels are *qualitative references only* and should not be interpreted as quantitative measures of explosive hazard.

Four potential remedial scenarios are evaluated against the baseline in this MEC HA: Alternatives 2, 3, 4, and 5. Alternative 1, the no action alternative, is equivalent to the baseline scenario for this MEC HA. Future land use under all these scenarios is assumed to be non-intrusive recreational land use (e.g., hiking, no camping). A brief description of Alternatives 2, 3, 4, and 5 is provided in the following subchapters, together with the associated modifications to the MEC HA score. More detailed descriptions of these remedial alternatives are provided in Chapter 4 of the FS report.

Alternative 2 would include LUCs only, including a groundwater use restriction. Under this scenario, activities at the property would be changed to non-intrusive conservation/recreational use (hiking, no camping) and LUCs.

Alternative 3 would involve consolidating the soil around OD Hill and installing a cap over the consolidated soil. The net effect of installing the cap is considered equivalent to a subsurface MEC clearance to a depth of 1.5 feet. This alternative would also include completing a surface and subsurface clearance to 2 feet bgs outside the cap and implementing LUCs. LUCs will prohibit residential land use and use for playgrounds and prohibit intrusive activities. Under this scenario, activities at the property would be change to non-intrusive conservation/recreational use (hiking, no camping).

Alternative 4 would involve excavating OD Hill to grade and performing mechanical separation to remove MPPEH from the excavated soil, performing surface/subsurface clearance to 2 feet bgs over the site, and then implementing LUCs. LUCs will prohibit residential land use and use for playgrounds, prohibit intrusive activities, and prohibit access to or use of groundwater. Under this scenario, activities at the property would change to conservation/recreational use (hiking, no camping).

Alternative 5 would involve excavating the entire site to 1 foot below grade and performing mechanical separation to remove MPPEH from the excavated soil. Following the excavation to 1 foot below grade, a surface/subsurface clearance would be performed to achieve a post excavation clearance depth of 3 feet bgs. LUCs will prohibit residential land use and use for playgrounds, prohibit digging, and prohibit access to or use of groundwater. Under this scenario, activities at the property would change to conservation/recreational use (hiking, no camping).

All remedial alternatives considered in this MEC HA reflect a scenario under which the property is remediated and can revert to restricted public use. Under all alternatives, the LUCs would prohibit intrusive

activities, prohibit access to or use of groundwater, and prohibit future land uses other than non-intrusive recreation (e.g., no residential or day care use).

C.10.1 OD Hill Area

All remedial alternatives were considered for the OD Hill Assessment Area. For Alternative 2, input assumptions and related MEC HA scores are unchanged from the baseline evaluation. Accounting for the lack of score modifications resulting from Remedial Alternative 2, the total MEC HA score remained at 845 and the Hazard Level rating remained at 1 ("highest potential explosive hazard conditions"). The MEC HA scores for Alternative 2 are shown in Table C.4.

Alternatives 3, 4, and 5 modify the input assumptions for the assessment area with regard to *potential contact hours, amount of MEC, minimum MEC depth vs. maximum intrusive depth, and migration potential.* All other input assumptions and related MEC HA scores for these three scenarios are unchanged. In accordance with USEPA (2008) guidance, the scores assigned for these categories under the baseline condition are reduced to reflect subsurface MEC clearance to either 1.5 feet bgs (Remedial Alternative 3), estimated 2 feet bgs (Remedial Alternative 4) or estimated 3 feet bgs (Remedial Alternative 5). Alternative 3 would also include a cap that would cover the surface of the assessment area, increasing the minimum MEC depth. Therefore, in Alternatives 3, 4, and 5, after cleanup, activities do not overlap with MEC location. Consequently, human receptors are no longer as likely to come into contact with MEC in the assessment area. The modified assumptions and their effect on the associated MEC HA input factors are described below. The effect of these scenarios is the same on MEC HA scoring and these scenarios are addressed together in the following sections.

MRS Definition: Unchanged from baseline evaluation.

Energetic Material Type: Unchanged from baseline evaluation.

Location of Additional Human Receptors: Unchanged from baseline evaluation.

Site Accessibility: Unchanged from baseline evaluation.

Potential Contact Hours: As described above, the future land use scenario considered for the OD Hill once a remedial response has been implemented assumes the future use of conservation/recreation, which includes hiking but no camping. Though it is not anticipated that the OD Grounds will become a hiking destination, for the purposes of this evaluation, this MEC HA conservatively assumes that 2,000 people visit the area each year and each person is assumed to spend an average of 4 hours on the site, for a total of 8,000 hours per year. No intrusive activities are permitted or expected to occur. Based on this information, the total potential contact hours for the assessment area under the future scenario are calculated to be 8,000 receptor-hours/year. This value corresponds to a classification of 'very few hours' (less than 10,000 receptor-hours/year). Even though the potential contact hours classification does not change, the MEC HA scores for Alternatives 3, 4, and 5 are reduced from *15* to *5* for this input factor, because the remedial action (surface clearance or cap installation) is equivalent to a subsurface MEC clearance of 1.5 feet.

Amount of MEC: The potential MEC presence at the OD Hill assessment area is the result of open detonation; therefore, the classification of 'OB/OD Area' is selected. However, for Alternatives 3, 4, and 5, the MEC HA associated scores for this input factor are reduced from *180* to *30* due to the remedial action (surface clearance or cap installation) which is equivalent to a subsurface MEC clearance of 1.5 feet.

Minimum MEC Depth Relative to the Maximum Receptor Intrusive Depth: The maximum receptor intrusive depth at the site is anticipated to be 0 feet with a future land use of non-intrusive conservation/recreation (hiking, no camping) and LUCs that restrict intrusive activity. To change the minimum MEC depth, Alternative 3 would install a cap over the assessment area and Alternatives 4 and 5 would conduct subsurface clearance to a depth of 2 feet bgs. As a result of the remedial actions, the minimum MEC depth would change to 1.5 feet (Remedial Alternative 3) and 2 feet (Remedial Alternative 4), and 3 feet (Remedial Alternative 5). The maximum intrusive depth for these three scenarios would no longer overlap with the minimum MEC depth. The input parameter would change to 'MEC located only in subsurface – intrusive depth *does not* overlap with minimum MEC depth'. This approach has the result of reducing the score for this input factor from *240* to *25* for Alternatives 3, 4, and 5.

Migration Potential: Unchanged from the baseline evaluation.

MEC Classification: Unchanged from baseline evaluation.

MEC Size: Unchanged from baseline evaluation.

MEC HA Results: Accounting for these score modifications resulting from either Remedial Alternative 3, 4, or 5 and a land use change to non-intrusive conservation/recreational (hiking, no camping), the total MEC HA score for the OD Hill assessment area would be reduced from 845 to 470. This reduction in the MEC HA score reduces the corresponding Hazard Level rating from 1 ('highest potential explosive hazard conditions') to 4 ('low potential explosive hazard conditions') for these three remedial alternatives. The revised MEC HA scores for Alternatives 3, 4, and 5 are shown in Table C.5.

Table C.4
Summary of MEC HA Score
Remedial Alternative 2
OD Hill Assessment Area

Explosive Hazard Component	Input Factors	Category Selected for Area	Score [1][2] (*Max. Score*) Alt 2
Severity	Energetic Material Type	High explosives and low explosive filler in fragmenting rounds	100 (100)
	Location of Additional Human Receptors	Outside of the ESQD arc	0 (30)
Accessibility	Site Accessibility	Full accessibility	80 (80)
	Total Contact Hours	Very few hours	15 (120)
	Amount of MEC	OB/OD Area	180 (180)
	Minimum MEC Depth vs. Maximum Intrusive Depth	***MEC located only in subsurface; max. intrusive depth does not overlap with min. MEC depth***	240 (240)
	Migration Potential	Unlikely	10 (30)
Sensitivity	MEC Classification	Sensitive UXO	180 (180)
	MEC Size	Small	40 (40)
Total MEC HA Score			845 (1,000)
MEC HA Hazard Level			**1** [2]

(1) Categories and/or scores that change from the baseline because of the assumed future scenario are shown in ***bold italics***.

(2) A MEC HA Hazard Level of 1 indicates an area with "Highest potential explosive hazard conditions" (USEPA, 2008).

Table C.5
Summary of MEC HA Score
Remedial Alternative 3, 4, and 5
OD Hill Assessment Area

Explosive Hazard Component	Input Factors	Category Selected for Area	Score [1][2] (*Max. Score*) Alt 3, Alt 4, and Alt 5
Severity	Energetic Material Type	High explosives and low explosive filler in fragmenting rounds	100 (*100*)
	Location of Additional Human Receptors	Outside of the ESQD arc	0 (*30*)
Accessibility	Site Accessibility	Full accessibility	80 *(80)*
	Total Contact Hours	Very few hours	***5*** ***(120)***
	Amount of MEC	OB/OD Area	***30*** ***(180)***
	Minimum MEC Depth vs. Maximum Intrusive Depth	***MEC located only in subsurface; max. intrusive depth does not overlap with min. MEC depth***	***25*** *(240)*
	Migration Potential	Unlikely	10 (30)
Sensitivity	MEC Classification	Sensitive UXO	180 (*180*)
	MEC Size	Small	40 (*40*)
Total MEC HA Score			**470** ***(1,000)***
MEC HA Hazard Level			**4** [3]

(1) Scores assigned for each factor for Alternative 3 are considered equivalent to subsurface cleanup and are scored under a "subsurface cleanup" scenario as listed and described in USEPA (2008). The maximum possible MEC HA score is listed in parentheses beneath the assigned score(s) for reference purposes.

(2) Categories and/or scores that change from the baseline as a result of the assumed future scenario are shown in ***bold italics***.

(3) A MEC HA Hazard Level of 4 indicates an area with "Low potential explosive hazard conditions" (USEPA, 2008).

C.10.2 Kickout Area

Alternatives 2, 3, 4, and 5 were also considered for the Kickout Area. For Alternative 2, input assumptions and related MEC HA scores are unchanged from the baseline evaluation. Accounting for the lack in score modifications resulting from Remedial Alternative 2, the total MEC HA score for the Kickout Area remained at 695 and the Hazard Level rating remained at 3 ('moderate potential explosive hazard conditions'). The revised MEC HA scores for the Kickout assessment area are shown in Table C.6.

Alternatives 3, 4, and 5 modified the input assumptions for this assessment area with regard to *potential contact hours, amount of MEC, minimum MEC depth vs. maximum intrusive depth, and migration potential.* All other input assumptions and related MEC HA scores for these three scenarios are unchanged. In accordance with USEPA (2008) guidance, the scores assigned for these categories under the baseline condition are reduced to reflect subsurface MEC clearance to either an estimated 2 feet bgs (Remedial Alternatives 3 and 4) or an estimated 3 feet bgs (Remedial Alternative 5). After cleanup, activities do not overlap with MEC location. Consequently, human receptors are no longer as likely to come into contact with MEC in the assessment area. The modified assumptions and their effect on the associated MEC HA input factors are described below.

MRS Definition: Unchanged from baseline evaluation.

Energetic Material Type: Unchanged from baseline evaluation.

Location of Additional Human Receptors: Unchanged from baseline evaluation.

Site Accessibility: Unchanged from baseline evaluation.

Potential Contact Hours: As described above, the future land use scenario considered for the Kickout assessment area after a remedial response has been implemented assumes the future use of conservation/recreation, which includes hiking but no camping. Though it is not anticipated that the OD Grounds will become a hiking destination, for the purposes of this evaluation, this MEC HA conservatively assumes that 2,000 people visit the area each year and each person is assumed to spend an average of 4 hours on the site, for a total of 8,000 hours per year. No intrusive activities are permitted or expected to occur. Based on this information, the total potential contact hours for the assessment area under the future scenario are calculated to be 8,000 receptor-hours/year. This value corresponds to a classification of 'very few hours' (less than 10,000 receptor-hours/year). Even though the potential contact hours classification does not change, the MEC HA scores for Alternatives 3, 4, and 5 are reduced from *15* to *5* for this input factor, due to the remedial action (subsurface clearance) (USEPA, 2008).

Amount of MEC: The potential MEC presence in the Kickout assessment area is the result of kick-outs from open detonation, but with no actual detonation occurring in the area. Therefore, the MEC HA classification of 'Safety Buffer Area' is selected. However, the MEC HA associated scores for Alternatives 3, 4, and 5 for this input factor are reduced from *30* to *5* due to the remedial action (subsurface clearance) (USEPA, 2008).

Minimum MEC Depth Relative to the Maximum Receptor Intrusive Depth: The maximum receptor intrusive depth at the site is anticipated to be 0 feet with a future land use of non-intrusive

conservation/recreation (hiking, no camping) and LUCs that restrict intrusive activity. As a result of the remedial action (subsurface clearance), the minimum MEC depth would change to either 2 feet bgs (Remedial Alternatives 3 and 4) or 3 feet bgs (Remedial Alternative 5). The maximum intrusive depth would no longer overlap with the minimum MEC depth. The input parameter would change to 'MEC located only in subsurface – intrusive depth *does not* overlap with minimum MEC depth'. This approach has the result of reducing the scores for this input factor from *240* to *25*.

Migration Potential: Unchanged from baseline evaluation.

MEC Classification: Unchanged from baseline evaluation.

MEC Size: Unchanged from baseline evaluation.

MEC HA Results: Accounting for these score modifications resulting from Remedial Alternatives 3, 4, and 5, the total MEC HA score for the Kickout assessment area would be reduced from 695 to 445 under these three remedial alternatives. This reduction in MEC HA score reduces the corresponding Hazard Level rating from 3 ('moderate potential explosive hazard conditions') to 4 ('low potential explosive hazard conditions'). The revised MEC HA scores for the Kickout assessment area are shown in Table C.7.

Table C.6
Summary of MEC HA Score
Remedial Alternative 2
Kickout Assessment Area

Explosive Hazard Component	Input Factors	Category Selected for Area	Score (1)(2) (*Max. Score*) Alt 2
Severity	Energetic Material Type	High explosives and low explosive filler in fragmenting rounds	100 (100)
	Location of Additional Human Receptors	Outside of the ESQD arc	0 (30)
Accessibility	Site Accessibility	Full accessibility	80 *(80)*
	Total Contact Hours	Very few hours	***15*** ***(120)***
	Amount of MEC	Safety Buffer Area	***30*** ***(180)***
	Minimum MEC Depth vs. Maximum Intrusive Depth	***MEC located only in subsurface; max. intrusive depth does not overlap with min. MEC depth***	***240*** ***(240)***
	Migration Potential	Unlikely	10 (30)
Sensitivity	MEC Classification	Sensitive UXO	180 (180)
	MEC Size	Small	40 (40)
Total MEC HA Score			**695** **(1,000)**
MEC HA Hazard Level			**3** (2)

(1) Categories and/or scores that change from the baseline because of the assumed future scenario are shown in bold italics.

(2) A MEC HA Hazard Level of 3 indicates an area with "Moderate potential explosive hazard conditions" (USEPA, 2008).

Table C.7
Summary of MEC HA Score
Remedial Alternative 3, 4, and 5
Kickout Assessment Area

Explosive Hazard Component	Input Factors	Category Selected for Area	Score [1][2] (*Max. Score*) Alt 3, Alt 4, and Alt 5
Severity	Energetic Material Type	High explosives and low explosive filler in fragmenting rounds	100 (100)
	Location of Additional Human Receptors	Outside of the ESQD arc	0 (30)
Accessibility	Site Accessibility	Full accessibility	80 *(80)*
	Total Contact Hours	Very few hours	***5*** ***(120)***
	Amount of MEC	Safety Buffer Area	***5*** ***(180)***
	Minimum MEC Depth vs. Maximum Intrusive Depth	***MEC located only in subsurface; max. intrusive depth does not overlap with min. MEC depth***	***25*** ***(240)***
	Migration Potential	Unlikely	10 (30)
Sensitivity	MEC Classification	Sensitive UXO	180 (180)
	MEC Size	Small	40 (40)
Total MEC HA Score			**445 (1,000)**
MEC HA Hazard Level			**4** [3]

(1) Scores assigned for each factor are scored under a "subsurface cleanup" scenario as listed and described in USEPA (2008). The maximum possible MEC HA score is listed in parentheses beneath the assigned score(s) for reference purposes.

(2) Categories and/or scores that change from the baseline because of the assumed future scenario are shown in bold italics.

(3) A MEC HA Hazard Level of 4 indicates an area with "Low potential explosive hazard conditions" (USEPA, 2008).

C.11 DISCUSSION OF RESULTS

A summary of the results of the MEC HAs conducted for the baseline and possible future remedial alternatives at the OD Grounds is presented in Table C.8. For the OD Hill area, the baseline score (the no action alternative) results in a MEC HA score of 845 and a Hazard Level of 1 ('highest potential explosive hazard conditions'). As shown in the table, Remedial Alternative 2 results in a MEC HA score of 845, same as the baseline. Remedial Alternative 3, 4, and 5 all result in the same MEC HA score of 470 for the OD Hill assessment area. Based on this result, remedial alternatives 3, 4, and 5, if implemented, would significantly reduce the MEC hazards at the site (from 'highest potential explosive hazard conditions' to 'low potential explosive hazard conditions'). There would be no differences between these remedial alternatives with regard to reduction explosive hazards at the OD Hill area. The revised MEC HA scores for all the alternatives are shown in Table C.8.

For the Kickout area, the baseline score (the no action alternative) results in a MEC HA score of 695 and a Hazard Level of 3 ('moderate potential explosive hazard conditions'). For Remedial Alternative 2, the MEC HA score and Hazard Level remained unchanged from the baseline evaluation. Alternatives 3, 4, and 5 result in the same MEC HA score of 445. Based on this result, the remedial alternative 3, 4, or 5, if implemented, would reduce the MEC hazards at the site (from 'moderate potential explosive hazard conditions' to 'low potential explosive hazard conditions'). The revised MEC HA score for this alternative is shown in Table C.8.

Based on these results, there is no significant difference between the remedial alternatives 3, 4, and 5 with respect to reduction of explosive hazards at the OD Hill area. As has been noted before, these total MEC HA scores and the associated hazard levels are *qualitative references only* and should not be interpreted as quantitative measures of explosive hazard, nor should the results of this evaluation be used as the sole basis on which to recommend a remedial response. Also, this MEC HA does not address or otherwise evaluate potential risks related to MC that might be present at the site.

Table C.8
Summary of MEC HA Results for All Evaluated Scenarios and Assessment Areas
OD Grounds

Scenario Description	Assessment Area	Energetic Material Type	Location of Additional Human Receptors	Site Accessibility	Total Contact Hours	Amount of MEC	Minimum MEC Depth vs. Maximum Intrusive Depth	Migration Potential	MEC Classification	MEC Size	Total MEC HA Score (125-1,000)	MEC HA Hazard Level (1-4)
Maximum MEC HA Score		*100*	*30*	*80*	*120*	*180*	*240*	*30*	*180*	*40*	***1,000***	*1*
BASELINE SCENARIO: Current Conditions/No Action Alternative **Current Site Conditions No Public Use**	OD Hill	100 *HE or fragmenting rounds*	0 *Outside MRS or ESQD arc*	*80* *Full accessibility*	15 *Very few hours*	180 *OB/OD Area*	240 *MEC located surface and subsurface; max. intrusive depth overlaps min. MEC depth*	10 *Unlikely*	180 *Sensitive UXO*	40 *Small*	845	1
	Kickout	100 *HE or fragmenting rounds*	0 *Outside MRS or ESQD arc*	*80* *Full accessibility*	15 *Very few hours*	30 *Safety Buffer Area*	240 *MEC located surface and subsurface; max. intrusive depth overlaps min. MEC depth*	10 *Unlikely*	180 *Sensitive UXO*	40 *Small*	695	3
REMEDIAL ACTION Alternative - 2: LUCs Only, including groundwater restriction. Future Use: Restricted Recreational	OD Hill	100 *HE or fragmenting rounds*	0 *Outside MRS or ESQD arc*	*80* *Full accessibility*	15 *Very few hours*	180 *OB/OD Area*	240 *MEC located surface and subsurface; max. intrusive depth overlaps min. MEC depth*	10 *Unlikely*	180 *Sensitive UXO*	40 *Small*	845	1
	Kickout	100 *HE or fragmenting rounds*	0 *Outside MRS or ESQD arc*	*80* *Full accessibility*	15 *Very few hours*	30 *Safety Buffer Area*	240 *MEC located surface and subsurface; max. intrusive depth overlaps min. MEC depth*	10 *Unlikely*	180 *Sensitive UXO*	40 *Small*	695	3
REMEDIAL ACTION Alternative - 3: Consolidate and Cap with Surface and Subsurface Clearance Outside the Cap and LUCs. Future Use: Restricted Recreational	OD Hill	100 *HE or fragmenting rounds*	0 *Outside MRS or ESQD arc*	*80* *Full accessibility*	***5*** *Very few hours*	***30*** *OB/OD Area*	***25*** ***MEC located only in subsurface; max. intrusive depth does not overlap with min. MEC depth***	10 *Unlikely*	180 *Sensitive UXO*	40 *Small*	***470***	*4*
	Kickout	100 *HE or fragmenting rounds*	0 *Outside MRS or ESQD arc*	*80* *Full accessibility*	***5*** *Very few hours*	***5*** *Safety Buffer Area*	***25*** ***MEC located only in subsurface; max. intrusive depth does not overlap with min. MEC depth***	10 *Unlikely*	180 *Sensitive UXO*	40 *Small*	***445***	*4*

Scenario Description	Assessment Area	Energetic Material Type	Location of Additional Human Receptors	Site Accessibility	Total Contact Hours	Amount of MEC	Minimum MEC Depth vs. Maximum Intrusive Depth	Migration Potential	MEC Classification	MEC Size	Total MEC HA Score (125-1,000)	MEC HA Hazard Level (1-4)
REMEDIAL ACTION Alternative – 4: **Excavate OD Hill to grade and perform surface/subsurface clearance over the entire site, and LUCs.** Future Use: Restricted Recreational	OD Hill	100 *HE or fragmenting rounds*	0 *Outside MRS or ESQD arc*	80 *Full accessibility*	***5*** *Very few hours*	***30*** *OB/OD Area*	***25*** ***MEC located only in subsurface; max. intrusive depth does not overlap with min. MEC depth***	10 *Unlikely*	180 *Sensitive UXO*	40 *Small*	***470***	***4***
	Kickout	100 *HE or fragmenting rounds*	0 *Outside MRS or ESQD arc*	80 *Full accessibility*	***5*** *Very few hours*	***5*** *Safety Buffer Area*	***25*** ***MEC located only in subsurface; max. intrusive depth does not overlap with min. MEC depth***	10 *Unlikely*	180 *Sensitive UXO*	40 *Small*	***445***	***4***
REMEDIAL ACTION Alternative – 5: **Excavate entire site to 1 foot below grade and perform surface/subsurface clearance.** Future Use: Restricted Recreational	OD Hill	100 *HE or fragmenting rounds*	0 *Outside MRS or ESQD arc*	80 *Full accessibility*	***5*** *Very few hours*	***30*** *OB/OD Area*	***25*** ***MEC located only in subsurface; max. intrusive depth does not overlap with min. MEC depth***	10 *Unlikely*	180 *Sensitive UXO*	40 *Small*	***470***	***4***
	Kickout	100 *HE or fragmenting rounds*	0 *Outside MRS or ESQD arc*	80 *Full accessibility*	***5*** *Very few hours*	***5*** *Safety Buffer Area*	***25*** ***MEC located only in subsurface; max. intrusive depth does not overlap with min. MEC depth***	10 *Unlikely*	180 *Sensitive UXO*	40 *Small*	***445***	***4***

(1) For these remedial actions, scores are assigned for each factor assuming a 'subsurface cleanup' scenario as listed and described in the MEC HA interim guidance document (USEPA, 2008). The installation of a cap is considered equivalent to a subsurface clearance.

(2) Categories and/or scores that change from the baseline as a result of the assumed future scenario are shown in ***bold italics***.

C.12 GLOSSARY OF TERMS

Discarded Military Munitions (DMM): Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations (10 U.S.C. 2710(e)(2)).

Munitions and Explosives of Concern (MEC): This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks, means: (a) Unexploded Ordnance (UXO), as defined in 10 U.S.C. 101 (e)(5); (b) Discarded Military Munitions (DMM), as defined in 10 U.S.C. 2710(e)(2), or (c) Munitions constituents (e.g., TNT, RDX) present in high enough concentrations to pose an explosive hazard.

Munitions Potentially Presenting an Explosive Hazard (MPPEH): Material that, prior to determination of its explosives safety status, potentially contains explosives or munitions (e.g., munitions containers and packaging material; munitions debris remaining after munitions use, demilitarization, or disposal; and range-related debris); or potentially contains a high enough concentration of explosives such that the material presents an explosive hazard (e.g., equipment, drainage systems, holding tanks, piping, or ventilation ducts that were associated with munitions production, demilitarization or disposal operations). Excluded from MPPEH are munitions within the DoD established munitions management system and other hazardous items that may present explosion hazards (e.g., gasoline cans, compressed gas cylinders) that are not munitions and are not intended for use as munitions.

Unexploded Ordnance (UXO): Military munitions that: (a) Have been primed, fuzed, armed, or otherwise prepared for action; (b) Have been fired, dropped, launched, projected or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material; and (c) Remain unexploded either by malfunction, design, or any other cause (10 U.S.C. 101 (e)(5)).

C.13 REFERENCES

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