SOVEREIGN CONSULTING INC.

TRANSMITTAL MEMO

To	Carol Keating – USEPA	2 – Hard Copy and CD
	Jane Dolan – USEPA	Hard Copy and CD
	David Chaffin – MADEP	Hard Copy and CD
	Ron Ostrowski – Mass Development	Hard Copy and CD
	Julie Corenzwit – Co-Chair, Devens Restoration Advisory Board	Hard Copy and CD
	Laurie Nehring – PACE	Hard Copy and CD
	Richard Doherty – Engineering and Consultant Resources, Inc.	Hard Copy and CD
	Ken Munney – USFWS	Hard Copy and CD
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	Peter Lowitt – Devens Enterprise Commission	Hard Copy and CD
	Robert Burns – Boston and Maine Corporation	Hard Copy and CD

From: Steven Passafaro – Sovereign Consulting Inc.

Cc:	Robert Simeone – BEC, Devens RFTA	Hard Copy and CD
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	Eric Simpson – Sovereign Consulting	Electronic copy

Date 05 January 2015

Subject: **Proposed Plan for AOC 72 and SA 71 (Final Version)**
Contract Number W912WJ-10-D-0003, Delivery Order 0009

On behalf of the US Army Corps of Engineers (USACE) New England District and the Army BRAC Environmental Office at Devens, Sovereign is pleased to provide the following attachments:

1. Proposed Plan for AOC 72 and SA 71 (Final Version)
2. SA 71 Risk Characterization Update Memo
3. CD with Electronic Copy

Sovereign Consulting Inc
16 Chestnut Street, Suite 520
Foxborough, Massachusetts 02035
Tel 508-339-3200 / Fax 508-339-3248

The Proposed Plan has been provided to facilitate public involvement in the remedy selection process for Plow Shop Pond (Area of Contamination [AOC] 72) and the Former Railroad Roundhouse (Study Area [SA] 71) located at the former Fort Devens Army installation (Devens) in Devens, Massachusetts. The document presents the Department of the Army's preferred alternatives for AOC 72 and SA 71.

Please note that the public comment period for this Proposed Plan will begin on 05 January 2015 and end on 03 February 2015. A public meeting will be held at 7:00PM on 15 January 2015, at the Devens Commerce Center, 33 Andrews Parkway, Devens, MA to provide an additional opportunity for public comments on the Proposed Plan. All interested parties are encouraged to attend and learn more about the alternatives developed and the elements of the preferred alternatives.

Sincerely,

Steven Passafaro, PE, LSP
Senior Project Manager

Enclosure: As noted above

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Department of the Army *January 5, 2015*

Superfund Program
Proposed Plan
Former Fort Devens Army Installation

Army Announces Proposed Plan:

No Further Action for The Plow Shop Pond Operable Unit - Area Of Contamination 72;

Limited Action For Study Area 71 – Former Railroad Roundhouse Site

This Proposed Plan is provided to facilitate public involvement in the remedy selection process for Plow Shop Pond (Area of Contamination [AOC] 72) and the Former Railroad Roundhouse (Study Area [SA] 71) located at the former Fort Devens Army installation (Devens) in Devens, Massachusetts. The document presents the Department of the Army's (Army's) preferred alternatives for AOC 72 and SA 71. The Plan has been developed with support from the United States Environmental Protection Agency (USEPA) and Massachusetts Department of Environmental Protection (MassDEP) in accordance with CERCLA. Before making a final decision on the remedy, the Army will consider public comments it receives on the Proposed Plan and may modify the proposed remedy with concurrence from USEPA and MassDEP based on these comments. After a 30-day public comment period, the final decision regarding the selected alternatives will be documented in a Record of Decision (ROD) for AOC 72 and SA 71 after all comments are reviewed.

Dates to Remember

PUBLIC COMMENT PERIOD:
January 5, 2015 to February 3, 2015
The Army invites you to participate during the public comment period by submitting comments on the Proposed Plan.

PUBLIC MEETING:
January 15, 2015
The Army will hold a public meeting to explain the Proposed Plan and remedial alternatives evaluated. Oral and written comments will also be accepted at the meeting. The meeting will be held at

Devens Commerce Center
33 Andrews Parkway
Devens, MA 01434

For more information, see the Administrative Record at the following locations:

Devens BRAC Environmental Office
Building 666, Rm 132,
Devens, MA 01432
Contact:978-796-2205

Send written comments postmarked by February 3rd to the following:

Base Realignment and Closure Division
U.S. Army Garrison Fort Devens
Devens Reserve Forces Training Area
30 Quebec Street
Devens, MA 01432-4429

1. INTRODUCTION

This Proposed Plan provides a summary of the background and characteristics of Plow Shop Pond AOC72 and the Former Railroad Roundhouse site SA71, and rationale for proposing the preferred remedy. The conceptual site model and risk assessments that were used as the basis for taking action in 2013 at Plow Shop Pond AOC72 and in 1999 at the Former Railroad Roundhouse SA71 have been updated. These updates are presented in **Sections 2** and **4** Summary of Site Risks and serve as the basis for the current proposed remedy.

This Proposed Plan is issued by the Army for public comment and participation in accordance with Section 117(a) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended, and Sections 300.430 (f)(2) and (f)(3) of the National Oil and Hazardous Substances Pollution Contingency Plan.

This Proposed Plan summarizes information contained in the documents listed in **Section 9** of this plan, including:

- *Final Remedial Investigations Report for Areas of Contamination 4, 5, 18, 40, Fort Devens, MA*. Prepared by Ecology & Environment, Inc., April 1993;
- *Draft Railroad Roundhouse Site Investigation Report.* Feasibility Study for Group 1A Sites, Fort Devens Massachusetts. Prepared by ABB Environmental Services, Inc., September 1993;
- *Final Remedial Investigation Addendum Report*. Prepared by ABB Environmental Services, Inc. December 1993;
- *Railroad Roundhouse Supplemental Site Investigation*. Feasibility Study for Group 1A Sites, Fort Devens Massachusetts. Prepared by ABB Environmental Services, Inc., September 1995;
- *Draft Plow Shop Pond/Grove Pond Sediment Evaluation Report*. Prepared by ABB Environmental Services, Inc., October 1995;
- *Action Memorandum Railroad Roundhouse Study Area 71*. Prepared by Stone and Webster Environmental Technologies and Services, November 1999;*Final Closure Report for Study Area 71, Former Railroad Roundhouse Site Various Removal Actions – Phase II, Devens, Massachusetts*. Prepared by Roy F. Weston, Inc. January 2001;
- *Final SA 71 Sediment Risk Characterization, Devens, Massachusetts.* Prepared by MACTEC. May 2008;
- *Final Remedial Investigation for AOC 72.* Prepared by AMEC, March 2011.
- *Final Engineering Evaluation and Cost Analysis, AOC 72, Former Fort Devens Army Installation, Devens, Massachusetts.* Prepared by Sovereign Consulting Inc., March 2012;
- *Action Memorandum for Removal of Contaminated Sediment in Plow Shop Pond, AOC 72, Former Fort Devens Army Installation, Devens, Massachusetts*. Prepared by Sovereign Consulting Inc., June 2012;

- *Final Removal Action Completion Report, Shepley's Hill Landfill, Former Fort Devens Army Installation, Devens, Massachusetts*. Prepared by Sovereign Consulting Inc., July 2013; and
- *Final Removal Action Completion Report, AOC 72, Former Fort Devens Army Installation, Devens, Massachusetts.* Prepared by Sovereign Consulting Inc., June 2014.

The Army, USEPA, and MassDEP encourage the public to review these documents and other supporting documents in the Devens Administrative Record[1] to gain a better understanding of completed investigations and the proposed response actions that will be conducted for this site.

2. SITE BACKGROUND

The former Fort Devens was established in 1917 for military training and logistical support during World War I. Devens became a permanent Base in 1931, and continued service until its Base Realignment and Closure (BRAC) Committee closure in 1996. The 30-acre Plow Shop Pond (AOC 72) is located southwest of the business and residential district in Ayer, Massachusetts. See **Figure 1** for a site location map.

1 - These reports and others identified in this Proposed Plan are included in the Devens Administrative Record and are available for public review at the Devens BRAC Environmental Office, Building 666, Rm 132, Devens, Massachusetts.

2.1 Plow Shop Pond (AOC 72)

Sediment data collected through the 1990s from AOC 72 documented elevated levels of several contaminants including arsenic, cadmium, chromium, mercury, and lead at concentrations that could potentially pose human health and ecological risks throughout Plow Shop Pond. Based on a remedial investigation conducted in 2010, the sources of the contaminants were attributed to current and historic releases of groundwater from the SHL site for arsenic in the Red Cove area of Plow Shop Pond as well as historic releases of liquid wastes from the Hartnett Tannery formerly located upstream at Grove Pond for the remainder of the AOC 72. Because lower concentrations of arsenic in sediment east of the Red Cove area were consistent with concentrations detected upstream in Grove Pond and in the area of the Hartnett Tannery, a portion of the arsenic detected in Plow Shop Pond outside the Red Cove area was attributable to historic releases in Grove Pond (AMEC, 2010).

Therefore, in 2013 and as part of a Non-Time Critical Removal Action (NTCRA), approximately 3,000 cubic yards of impacted material was removed from the Red Cove area to reduce arsenic concentrations within the removal action area to meet or be below the pond-wide local conditions mean concentration, and over 900 cubic yards of sediment containing maintenance byproduct material was subsequently removed from Plow Shop Pond along the shoreline of former Railroad Roundhouse to reduce antimony concentrations within the removal action

area to meet or be below the risk-based preliminary remedial goal and to remove all visual evidence of maintenance byproduct material (Sovereign, 2013b). Prior to the implementation of the removal actions at AOC 72, public comment was solicited during the Action Memorandum process to involve the public in the decision-making at AOC 72.

To mitigate arsenic-in-groundwater flux to Red Cove and Plow Shop Pond by groundwater flow from SHL, a low-permeability groundwater barrier wall was also installed from August to September 2012 between SHL and AOC 72 as part of another NTCRA (Sovereign, 2013a). Prior to the implementation of this action, public comment was also solicited.

Following the installation of the low-permeability barrier wall between SHL and Red Cove in 2012 and the removal actions completed at AOC 72 in 2013, impacted sediments and maintenance byproduct have been removed from AOC 72 and arsenic flux to Red Cove has been mitigated. Consequently, all remedial action objectives within AOC 72 have been achieved, through "[mitigation of] risk to environmental receptors posed by arsenic impacted sediments at Plow Shop Pond and Red Cove" and "[mitigation of] risk to environmental receptors posed by maintenance byproduct-impacted ash-sediment layer along the SA-71 shoreline" (Sovereign, 2014a).

2.2 Former Railroad Round House (SA 71)

Historic locomotive maintenance and repair activities from the former roundhouse contaminated the upland area known as the Maintenance By-Product Disposal Area. Site investigations conducted at SA 71 from 1992 through 1993 identified concentrations of polycyclic aromatic hydrocarbons, antimony, arsenic copper, lead, and zinc in soil. Preliminary risk evaluations conducted in 1995 concluded that with the exception of antimony, copper, and lead in soil, the remaining contaminants of concern were detected below anthropogenic background concentrations associated with coal ash (ABB, 1995). Consequently, response actions at SA 71 focused on the remediation of antimony, copper, and lead in soil.

In 1999, a Time Critical Removal Action (TCRA) was conducted at SA 71 to excavate approximately 2,400 cubic yards of soil within the former maintenance byproduct disposal area of the Railroad Roundhouse. This material was contaminated with antimony, copper, and lead and was removed to mitigate immediate risk to human health and welfare or the environment (SWETS, 1999). Prior to the implementation of this removal action, public comment was solicited to involve the public in the decision-making at SA 71.

3. SITE CHARACTERISTICS

3.1 Plow Shop Pond (AOC 72)

Plow Shop Pond is a man-made pond where water levels are maintained by a

concrete dam (Nonacoicus Brook Dam). Plow Shop Pond receives inflow from the Grove Pond to the east through the railroad causeway, and discharges to Nonacoicus Brook. Plow Shop Pond has a maximum depth of about 9 feet but most of the pond is less than 6 feet deep. Depth to bedrock under the pond is estimated to be 40 to 80 feet (AMEC, 2011).

Most of the pond is classified by the MassDEP as a "Deep Marsh". The pond is eutrophic, organically enriched, and supports dense growth of aquatic vegetation during summer months. The pond supports a warm water fish community, and there are no rare species in the pond (ABB-ES, 1992).

Plow Shop Pond currently has catch-and-release fishing advisory according to the Freshwater Fish Consumption Advisory List published August 2013 by the Massachusetts Department of Public Health Bureau of Environmental Health (MassDPH), and information provided in previous reports indicates that "Catch and Release Only" signs are posted at Plow Shop Pond (Gannett Fleming, 2006; AMEC, 2011). According to MassDPH, Plow Shop Pond is categorized as a "P6"advisory, meaning that "No one should consume any fish from this water body" (MassDPH, 2013).

The watershed of Plow Shop Pond above the dam is 16.5 square miles and 53% forested (USGS Streamstats). Emergent vegetation is limited to a narrow band along the shoreline. Note that adjacent land is largely developed (Railroad, Shepley's Hill Landfill [SHL], and industrial properties), but that there is a wooded buffer along much of the shoreline. Both ponds are in an Area of Critical Environmental Concern, which are Massachusetts' areas that are designated by the Secretary of Environmental Affairs in accordance with 301 CMR 12.00 that receive special recognition because of their ecological quality, uniqueness, and the significance of their natural and cultural resources.

In addition to the SHL which is located to the west, south, and hydraulically upgradient of the pond basin, Plow Shop Pond is bounded by the Molumco Industrial Park to the north, the former Railroad Roundhouse (SA 71) to the south, and the Guilford Transportation railroad right of way which crosses a causeway between Grove and Plow Shop Ponds to the east. The Hartnett Tannery was located near the northwest corner of Grove Pond, across the railroad causeway from the northeast corner of Plow Shop Pond, from approximately 1854 to 1961 when the tannery burned. The tannery discharged liquid wastes, including chromium, mercury, and arsenic, to Grove Pond until 1953 when a sewer connection was installed. The chemical signature from the tannery is evident throughout Grove and Plow Shop Ponds.

From 1992 to 1995, investigations in Plow Shop Pond were initiated under the SHL Remedial Investigation (E&E, 1993; ABB-ES, 1993b; ABB-ES, 1995b). The results of these investigations noted that metals had

accumulated in the sediments of Plow Shop Pond. Consequently, the Plow Shop Pond Operable Unit was established under AOC 72, and the USEPA took the lead on performing additional investigations at Plow Shop Pond and Grove Pond to determine other (non-Army) sources of contamination while the Army performed surface water and sediment investigations in Plow Shop Pond as it pertained to analytes related to the SHL and former railroad roundhouse area.

As part of the overall Plow Shop Pond remedial investigations conducted from 1995 to 2006, site investigations were conducted in the Red Cove area, which is a shallow cove located in the southwest corner of Plow Shop Pond, and along the southern shoreline of AOC 72 in the area of the former railroad roundhouse. The results of these investigations documented concentrations of arsenic in sediment located in the vicinity of Red Cove which were attributed to groundwater discharge from the SHL site (Gannett Fleming, 2006), and maintenance byproduct deposits and concentrations of polycyclic aromatic hydrocarbons, antimony, copper, and lead extending 15 to 25 feet offshore along the southern shoreline of the pond in the area of the former Railroad Roundhouse (ABB-ES, 1995a; MACTEC, 2008).

Following these investigations, the Army completed a comprehensive remedial investigation for AOC 72 in 2011. The results of this investigation confirmed that arsenic was transported to Red Cove via groundwater migrating from SHL, and arsenic was concentrated in a solid iron precipitate (floc) near the sediment surface at the point of groundwater discharge. In addition, the source of the other contaminants identified at AOC 72 was identified as historic releases of liquid wastes from the Hartnett Tannery for chromium, mercury, and arsenic distributed throughout the pond (AMEC, 2011).

Following the completion of the 2011 remedial investigation, the Army determined that it was appropriate to proceed with removal actions at AOC 72 under the Superfund Accelerated Cleanup Model (USEPA, 1994) and the criteria pursuant to CERCLA (40 USC §9604) and the National Contingency Plan (40 CFR 300.415). This model advances specific cleanup goals in a reduced timeframe for some NTCRA.

Consequently, the Army prepared an Engineering Evaluation/Cost Analysis (EE/CA) to evaluate response measures for a NTCRA at AOC 72 and to address impacted sediment in two specific areas of the pond: Red Cove and the former Railroad Roundhouse. The EE/CA served as a more streamlined analogous function to the remedial investigation/feasibility study approach conducted for remedial actions. Consequently, a feasibility study was not drafted for AOC 72.

The EE/CA defined the removal action objectives (RAOs), which are project objectives identified to ensure the protection of human health and welfare or the environment, for Red Cove as "mitigate

arsenic-impacted sediment in the Red Cove area in AOC 72 to reduce risk to environmental receptors consistent with local conditions in Plow Shop Pond" and for the former Railroad Roundhouse as "mitigate risk to environmental receptors posed by maintenance byproduct-impacted ash-sediment layer along the SA 71 shoreline". Based on the results of the EE/CA, the recommended removal action for AOC 72 was excavation (Sovereign, 2012a).

An Action Memorandum (Sovereign, 2012b) was subsequently prepared in 2012 to document the decision to perform the recommended NTCRA (excavation) in AOC 72 and to solicit public comment regarding the removal action. Following the approval of the AOC 72 Action Memorandum, removal actions were conducted at Plow Shop Pond (**Figures 3 and 4**) between July and October 2013. Prior to commencing work, wetlands and ecological surveys were completed and the pond level was lowered. The removal action area was separated into confirmation sampling grids, and the excavation was initiated at the furthest most cells before moving inland as the excavation progressed. As part of the removal action, approximately 3,000 cubic yards of impacted material was removed from the Red Cove area, and over 900 cubic yards of sediment containing maintenance byproduct was subsequently removed from the shoreline of former Railroad Roundhouse.

3.2 Former Railroad Round House (SA 71)

The Former Railroad Round House (also known as SA 71), located at the southeast corner of Plow Shop Pond between SHL and the railroad right-of-way, is the former location of a railroad roundhouse operated by the Boston and Maine Railroad (B&M) from approximately 1900 to 1935 to service the adjacent tracks and freight yard (E&E, 1993). The site consists of a 200- to 300-foot wide strip of land extending south from Plow Shop Pond along the northeast boundary of Devens for approximately 1,100 feet. The roundhouse was located at the northern end of this strip, immediately adjacent to the southern shore of Plow Shop Pond. The shoreline adjacent to the railroad roundhouse is the location of the Maintenance By-Product Disposal Area that was used as a dumping area for locomotive waste deposits.

The location of the former railroad roundhouse has been inferred from site observations and from overlaying a B&M drawing (Right-of-Way and Track Map) prepared by the Office of Valuation Engineer (B&M, 1919) on existing maps (see **Figure 2**). The track map identified areas such as an ash pit, coal trestle, water tower, office, and oil house. There were also several unnamed small buildings or sheds. The roundhouse and structures occupied about 6 acres, while the nearby tracks and freight yard occupied approximately 35 additional acres. According to historical insurance maps, by 1942, all of the buildings except the brick storeroom and the water tower had been removed (MACTEC, 2008).

The Army purchased a 53 acre parcel from the B&M in 1942 and following the 1996 base closure, the Army then leased the land formerly occupied by the roundhouse to MassDevelopment as part of the larger lease parcel known as A.1SHL that includes the SHL (see **Figure 1**). The buildings and tracks at the site had been removed, but a few concrete foundations remained in the area. SA 71 is presently not used for any purposes (i.e., it is open space), and access to the site is not restricted.

From 1993 to 1994, the Army conducted site investigations in the area of the railroad roundhouse site. Data gathered during the investigations indicated the widespread presence of coal ash and maintenance byproduct materials in surface and deeper soil across much of the site. The deposits of maintenance byproduct formed a sloping pond bank on their northern side, underlain by naturally deposited sand, silty sand, and peat and extending out into the pond. High concentrations of inorganic analytes, in particular antimony, copper, and lead, were identified in the area of the observed maintenance byproduct materials, and the probable source of these analytes was attributed to be the disposal of maintenance byproducts from the former roundhouse (ABB-ES, 1993a). However, the contamination in soil did not appear to be a source of groundwater contamination (ABB-ES, 1995a).

Because the majority of soil contaminants occurred in the maintenance byproduct disposal area, and because concentrations of antimony, copper, and lead in soil from that area were substantially above concentrations in the local background area (ABB-ES, 1995a), remediation of these soils was deemed appropriate. Consequently, an Action Memorandum (SWETS, 1999) was subsequently prepared in 1999 to propose a TCRA consisting of the excavation and disposal of impacted soil and to solicit public comment regarding the removal action.

The removal action was conducted at SA 71 from November 1999 to May 2000 and resulted in the removal of approximately 2,400 cubic yards of metals-contaminated soil. The excavation was backfilled with clean soil, and in May 2000 was covered with loam and seed. Final sidewall confirmatory samples from the excavation identified concentrations of antimony and lead above the remediation goals. However, due to the large volume of soil already removed, additional excavation was put on hold pending results of additional risk evaluations (Weston, 2001).

4. SUMMARY OF SITE RISKS

4.1 AOC 72

The 2011 Remedial Investigation Report evaluated whether a significant risk to human health and welfare or environment existed at AOC 72, a waterbody located east of the SHL, based on results from all surface water and sediment investigations conducted in and prior to 2009. The 2011 human health risk assessment indicated that potential exposures to contaminants (principally arsenic) in surface water and sediment in Plow Shop Pond, including Red

Cove and in the area of the former Railroad Roundhouse, by recreational receptors, are within the USEPA's acceptable cancer risk range and do not exceed a Hazard Index limit of 1. Furthermore, the results of a qualitative evaluation of the potential for fish ingestion indicate that the estimated risks and hazards associated with arsenic do not exceed the risk management limits, even with conservative exposure assumptions. As a result, no contaminant was identified in either surface water or sediment in Plow Shop Pond, including Red Cove and in the area of the former Railroad Roundhouse, exceeding risk thresholds based on the quantitative human health risk characterization (AMEC, 2011).

The ecological risk assessment indicated a risk of adverse effects for several receptors from exposure to contaminants of concern not only in Red Cove and in the area of the former Railroad Roundhouse but throughout both Plow Shop Pond and Grove Pond. These results suggested that a weight of evidence finding on the potential for ecological impacts associated with Red Cove and the former Railroad Roundhouse was not possible. This was because all locations associated with the study showed significant indications of impact related to either exceedance of threshold effect concentrations or diminishment of benthic and/or epibenthic markers (AMEC, 2011). This was similar to the results of the 2006 EPA site investigation at Plow Shop Pond (Gannett Fleming, 2006) and the 2008 sediment risk assessment at SA 71 during which a noticeable difference between study areas could not be identified which resulted in the conclusion that observed impacts were possibly not due solely to contaminants originating from SA 71 (MACTEC, 2008).

The installation of a low-permeability groundwater barrier wall between SHL and Red Cove in 2012 (Sovereign, 2013a) and sediment removal actions within the Red Cove area and former Railroad Roundhouse area of AOC 72 in 2013 have mitigated the potential risk associated with Plow Shop Pond sediments. The results of post-excavation confirmatory sediment sampling within Red Cove were below the remedial goals for arsenic (270 mg/kg), consistent with local condition concentrations of arsenic in sediment east of the Red Cove area. At Railroad Roundhouse, concentrations of metals were reduced to below the remedial goals and were consistent with pond local condition concentrations. In addition, all visual evidence of the maintenance byproduct was removed. With the removal of impacted sediment from both Red Cove and in the area of the former Railroad Roundhouse, exposure point concentrations have been reduced, and the benthic community is expected to improve (Sovereign, 2014a).

4.2 SA 71

The removal of 2,400 cubic yards of soil in 1999 has resulted in a reduction of risk to human health and welfare or the environment at SA 71, and the residual conditions in the upland area of SA 71 are consistent with industrial fill containing coal ash. Following the removal action, a human health and ecological risk evaluation

was conducted in 2001 (Harding, 2002) to evaluate the risk associated with post-remedial conditions at SA 71. A revised human health and welfare risk evaluation was then conducted in 2014 at the request of the USEPA and MassDEP to update all risk assessment assumptions and address additional state and federal regulatory agency comments (Sovereign, 2014c). As summarized below, the quantitative human health risk evaluation indicates a potential risk to human receptors. The ecological risk assessment indicates risk to the environment has been mitigated.

At this time, the current and future land use of SA 71 remains open space/recreational unrestricted (VHB, 1994). To be conservative, the quantitative human health risk assessment evaluated unrestricted residential use, using several algorithms and exposure variables, such as chemical-specific toxicity and derivation of exposure factors (Sovereign, 2014c). Based on 2014 updated human health risk evaluation for SA 71, the cumulative Excess Lifetime Cancer Risk (ELCR) for human receptors is above acceptable risk criteria for unrestricted residential use of SA 71. Specifically, the ELCR for residential human receptors is greater than one chance in 1,000,000 (10^{-6}). However, the updated human health risk evaluation demonstrates acceptable risk for the assumed future use (open space/recreation) of the site (Sovereign, 2014c).

Ecological receptors at SA 71 include terrestrial wildlife, plants, and invertebrates that may occur in or utilize the area. Potential contaminant exposure routes for these receptors include incidental soil ingestion and terrestrial food web exposure. Risk to terrestrial wildlife, plants, and invertebrates was evaluated through comparison of contaminant concentrations in surface soil to Protective Contaminant Levels, phytotoxicity benchmark values, and invertebrate toxicity benchmark values, respectively. The 2001 ecological risk assessment indicated that ecological receptors are unlikely to be at risk from contaminants of concern remaining in surface soil. Although concentrations at some locations still exceed some of the ecological screening values, most concentrations are consistent with background levels, and the overall magnitude of exceedance is small. The lower concentrations, combined with the general observation of a healthy ecological community indicated that ecological receptors are unlikely to be at risk from analytes remaining in the surface soil at SA 71 (Harding, 2002).

5. REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) are project objectives identified by the Army, USEPA, and MassDEP to ensure the protection of human health and the environment. The following subsections present the RAOs for AOC 72 and SA 71.

5.1 AOC 72

Following the 2012 installation of the barrier wall between SHL and Red Cove, arsenic-in-groundwater flux to Red Cove has been mitigated. In addition, the 2013 removal

action at AOC 72 removed arsenic impacted sediments that were associated with the arsenic-in-groundwater flux to Red Cove from beneath SHL prior to the installation of the barrier wall. Based on these two removal actions, risk to human health and welfare or the environment at AOC 72 have been mitigated. Therefore and due to the mitigation of risk at AOC 72, an RAO and Remedial Action Alternatives for AOC 72 are not necessary and the Preferred Remedy of No Further Action is presented in **Section 8** below.

5.2 SA 71

Based on investigations and removal actions completed to date, the RAO for SA 71 is as follows:

- Prevent ingestion/direct contact with residually impacted soil that could pose unacceptable human health risk at SA 71.

6. SUMMARY OF REMEDIAL ACTION ALTERNATIVES

For both sites, remedial alternatives were developed and assessed as part of the EE/CA and Action Memorandum process prior to the NTCRA for AOC 72 in 2013 and the TCRA for SA 71 in 2000. Pursuant to the Superfund Accelerated Cleanup Model (USEPA, 1994) and the criteria pursuant to CERCLA (40 USC §9604) and the National Contingency Plan (40 CFR 300.415), the EE/CA process for NTCRAs and TCRAs served as a more streamlined analogous function to the remedial investigation/feasibility study approach. Consequently, a feasibility study was not prepared for either site. However, the public was provided the opportunity to comment on all proposed alternatives as part of the 2012 Action Memorandum for AOC 72 and the 1999 Action Memorandum for SA 71.

6.1 AOC 72

The Army prepared an EE/CA in 2012 to evaluate response measures for the NTCRA at AOC 72 and to address impacted sediment at Red Cove and in the area of the former Railroad Roundhouse. The EE/CA defined the RAOs for Red Cove as "mitigate arsenic-impacted sediment in the Red Cove area in AOC 72 to reduce risk to environmental receptors consistent with local conditions in Plow Shop Pond" and for the area of the former Railroad Roundhouse as "mitigate risk to environmental receptors posed by maintenance byproduct-impacted ash-sediment layer along the SA 71 shoreline" (Sovereign, 2012a).

The EE/CA evaluated all of the remedies and/or alternatives based on implementability, cost, and effectiveness. The EE/CA compared six alternatives that would meet the selected RAOs: Alternative 1 - No Action, Alternative 2 - Excavation, Alternative 3 - Capping, Alternative 4 - Excavation and Backfilling, Alternative 5 - Excavation and Capping and Alternative 6 - Excavation and Capping with Sand/Iron Filter. These alternatives are summarized below and presented in greater detail in the aforementioned EE/CA report.

Although there was no cost associated with this alternative, Alternative 1 (No Action) was found to not meet the RAOs or protectiveness requirements. Alternative 2 (Excavation) was found to meet the RAOs and provide protectiveness and was deemed to be readily implementable. Alternative 3 (Capping) was found to meet the RAOs and provide protectiveness; however, there was a degree of uncertainty in the effectiveness because impacted sediment remained and impacted groundwater could discharge beyond the cap. Alternative 4 (Excavation and Backfilling) was found to meet the RAOs and provide protectiveness; however, the cost of this Alternative was more than Alternative 2. Alternative 5 (Excavation and Capping) was found to meet the RAOs and provide protectiveness; however, there was a degree of uncertainty in the effectiveness because impacted sediment remained and impacted groundwater could discharge beyond the cap. Finally, Alternative 6 (Excavation and Capping with Sand/Iron Filter) was found to meet the RAOs and provide protectiveness as well as provide additional protection in Red Cove by preventing groundwater discharge and the formation of iron floc. However, the cost of this alternative was considerably higher than Alternative 2. Consequently, Alternative 2 (Excavation) was selected based on a high degree of protectiveness, relative ease of implementation, relative cost, and compatibility with RAOs (Sovereign, 2012a). Based on the results of the EE/CA, the recommended removal action alternative for AOC 72 was Alternative 2 - Excavation, based on a high degree of protectiveness, relative ease of implementation, relative cost, and compatibility with RAOs (Sovereign, 2012a).

An Action Memorandum (Sovereign, 2012b) was subsequently prepared in 2012 to document the decision to perform the recommended NTCRA (excavation) in AOC 72 and to solicit public comment regarding the removal action. Following the approval of the AOC 72 Action Memorandum, removal actions were conducted at Plow Shop Pond between July and October 2013 as further detailed in **Section 3.1**.

Following the 2013 removal action at AOC 72 as well as the 2012 installation of the barrier wall at the SHL, risk to human health and welfare or the environment at AOC 72 was mitigated. Therefore, evaluation of additional Remedial Action Alternatives for AOC 72 are not necessary, and the Preferred Remedy based on current conditions is No Further Action.

6.2 SA 71

For SA 71, the Army prepared an Action Memorandum in 1999 to propose the TCRA of soil excavation and removal. Because the removal action was considered time critical, alternative technologies were not evaluated beyond the conceptual level at the time (SWETS, 1999). However, public comment was solicited during the Action Memorandum process. Following the approval of the SA 71 Action Memorandum, removal actions were conducted at SA 71 from November 1999 to May 2000 to remove approximately 2,400

cubic yards of impacted soil as further detailed in **Section 3.2**.

Final sidewall confirmatory samples from the excavation identified concentrations of contaminants above the remediation goals. However, further excavation was not warranted based on the current and future use of SA 71 (open space/recreation), the depth of the impacted soil, and the limited risk associated with the remaining soil (Weston, 2001).

Consequently, the development of additional remedial alternatives for SA 71 focused on limiting the exposure to site soils in excess of human health risk-based thresholds as identified in the site updated risk assessment. Based on this evaluation, two additional alternatives for SA 71 were retained for detailed analysis.

1. No Further Action
2. Limited Action: Implementation of Land Use Controls

6.3 SA 71 Alternative 1 – No Further Action

This baseline or No Further Action[2] alternative consists of taking no further action towards preventing direct contact with residually impacted soil that may remain at SA 71. No Further Action is easily implemented but leaves the area as is with no further measures to prevent exposure. There would be no technologies used and no cost associated with this alternative.

[2] CERCLA requires consideration of "No Action" as a baseline with which to compare other alternatives.

6.4 SA 71Alternative 2 – Limited Action: Implementation of Land Use Controls

Land Use Controls (LUCs) for SA 71 would be addressed through affirmative measures and legally enforceable institutional controls including soil management plans and deed restrictions. The intent is to limit potential exposure to any residual soil contamination associated with the former RRRH activities by (1) ensuring that any future soil disturbance activities, such as excavation are performed in accordance with site specific Soil Management Plan (SMP) and Health and Safety Plan (HASP) and (2) prohibiting residential reuse through the use of a property deed restriction. The LUCs for SA 71 would be implemented following the issuance of the ROD through a Land Use Control Implementation Plan (LUCIP). The LUCIP formalizes the roles and responsibilities of the Army, EPA, and MassDEP in the long-term administration and management of the alternative. Annual inspections and 5-year reviews will be conducted to confirm the overall effectiveness of the established LUCs. The approximate proposed boundaries of the LUCs would correspond to the SA 71 boundary as presented on **Figure 2** and would be maintained as per the LUCIP.

What are Land Use Controls?
Land use controls are various institutional (legal) and engineering measures put in place to reduce human exposure to remaining contamination. Engineering controls include physical barriers (concrete or asphalt surfaces). Examples of institutional controls are deed restrictions on the property (or environmental covenants), access limits, zoning restrictions, and permit requirements designed to ensure that engineering controls stay in place.

The capital cost of this alternative is estimated at $35,000 with a $20,000 annual cost.

6.5 SA 71 Evaluation of Alternatives

The current alternatives were subsequently evaluated using the threshold criteria, primary balancing criteria, and modifying criteria required by the National Contingency Plan. For current conditions at SA 71, Alternative 1 (No Further Action) is not effective in the long or short term and does not address the hazard of human exposure to remaining residual soil during construction and would therefore not be protective of human health. Alternative 2 (Limited Action – Implementation of Land Use Controls) is protective of human health and provides a means of educating the public to potential construction hazard that may exist by restricting future access to soils that contain residual impacts. This alternative is readily implementable and would be effective in the long and short term. Consequently, Alternative 2 (Limited Action – Implementation of Land Use Controls) provides the most appropriate and reasonable means of addressing any potential risk associated with future exposure to any residual soil contamination remaining in the upland area of SA 71. A summary of this evaluation is provided on **Table 1**.

7. PREFERRED REMEDY

As detailed in the proceeding sections, remedial alternatives were developed and assessed with respect to their effectiveness in meeting the RAO for SA 71. The preferred and appropriate alternative for AOC 72 is No Further Action, and the preferred and appropriate alternative for SA 71 is Alternative 2 – Limited Action: Implementation of LUCs.

Table 1 – Summary of Remedial Alternatives Evaluation

	Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost
AOC 72							
1 – No Further Action	●	●	●	○	●	●	●
SA 71							
1 – No Further Action	○	◐	○	○	○	●	●
2 – Limited Action - LUCs	●	●	●	○	●	●	●
● Fully meets criterion ◐ Partially meets criterion ○ Does not meet criterion							

Based on the information currently available, the Army believes these Alternatives meet the threshold criteria and modifying criteria. The Army's rationale and proposed plan for the preferred alternatives are presented in the following sections.

7.1 Rationale

AOC 72

Under CERCLA, if no unacceptable risks to human health and welfare or the environment are identified, then No Further Action is the appropriate remedy. Following the installation of the barrier wall between SHL and Red Cove and the successful implementation of the AOC 72 removal action in 2013 to address contaminated sediments in Plow Shop Pond, risk to human health and welfare or the environment has been mitigated; therefore, the "No Further Action" is proposed. Future monitoring of the effectiveness of the barrier wall will be incorporated into the SHL Long-Term Monitoring and Maintenance Plan (Sovereign, 2013c) and will be conducted as part of long-term monitoring at SHL. The results of the long-term groundwater monitoring in the area of the barrier wall and Red Cove will be presented in SHL Annual Reports (Sovereign, 2014b).

SA 71

Following the 1999 removal action, the presence of railroad maintenance byproduct materials in the upland soil and the risk to human health and welfare or the environment has been mitigated but not

reduced to acceptable risk levels for residential use. Based on the screening of alternatives, Alternative 2 (LUCs) provides the most appropriate and reasonable means of addressing any potential risk associated with future exposure to any residual soil contamination associated with the former RRRH activities remaining in the upland area of SA 71. The Army is recommending this alternative as it is protective of human health, complies with ARARs, is cost-effective and meets the RAO of preventing ingestion/direct contact with any residual soil contamination which may remain at the site.

The LUCs will require a deed restriction prohibiting residential reuse that runs with the land and is legally enforceable. All resources needed to implement Alternative 2 at SA 71 are readily available. LUCs, once finalized, would be implemented through a LUCIP. The LUCIP formalizes the roles and responsibilities of the Army, EPA, and MassDEP in the long-term administration and management of the LUCs. Annual reviews/inspections will be conducted to confirm the overall effectiveness of the established LUCs.

The LUCs will require notification to all current and future landowners to confirm they understand LUC requirements, restrictions and annual inspections to verify compliance with the LUCs.

7.2 Proposed Plan

Based on the information currently available, the U.S. Army believes the preferred alternatives for AOC 72 and SA 71 meets the threshold criteria and modifying criteria. The U.S. Army expects the preferred alternatives to satisfy the following statutory requirements of CERCLA Section 121(b): i) be protective of human health and the environment; ii) comply with ARARs; iii) be cost-effective; iv) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and v) satisfy the preference for treatment as a principle element when justified.

For SA 71, the Army will be responsible for implementing, maintaining, and enforcing the LUCs described in this Proposed Plan. The Army will specify the details of the LUCs to be implemented in a LUCIP to determine and define specific land use restrictions for SA 71. The LUCIP will be submitted to USEPA and MassDEP for review and approval, and the Army will coordinate with stakeholders to implement these controls.

USEPA and MassDEP have both reviewed the Proposed Plan. Based on new information that may become available or on public comments, the Army, in consultation with EPA and MassDEP, may modify the preferred alternatives outlined in this plan prior to completing the Record of Decision (ROD). Therefore, the public is encouraged to review and comment on all the alternatives discussed herein.

8. COMMUNITY PARTICIPATION

The Army provides information to the public regarding the ongoing

environmental programs at Devens through public meetings and the administrative record. The Army encourages the public to gain a more comprehensive understanding of Plow Shop Pond, Shepley's Hill Landfill and CERCLA activities that have been conducted at the installation.

An Army Restoration Advisory Board (RAB) currently holds quarterly meetings to exchange information among community members and government agencies. These meetings are generally the third Thursday of each quarter. The RAB meetings are open to the public. For additional information regarding the RAB meeting, schedules, and locations, contact the Base Environmental Coordinator at 978-796-2205.

The public comment period for this Proposed Plan offers the public the opportunity to provide input to the AOC 72 and SA 71 action planning process (see "Dates to Remember", Page 1). The Proposed Plan is available in the Administrative Record. The public comment period will begin on 05 January 2015 and end on 03 February 2015. A public meeting will be held at 7:00PM on 15 January 2015, at the Devens Commerce Center, 33 Andrews Parkway, Devens, MA to provide an additional opportunity for public comments on the Proposed Plan. All interested parties are encouraged to attend and learn more about the alternatives developed and the elements of the preferred alternatives.

After this Proposed Plan has been reviewed during the public comment period and public comments have been evaluated, the selected alternatives for AOC 72 and SA 71, the basis for selection, and performance, expectations will be presented in a ROD. The Army's responses to all public comments will be provided in a Responsiveness Summary that will be included in the ROD.

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ACRONYMS AND ABBREVIATIONS

AOC	Area of Contamination
ARAR	Applicable or Relevant and Appropriate Requirement
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
EE/CA	Engineering Evaluation/Cost Analysis
ELCR	Excess Lifetime Cancer Risk
GSR	Green and Sustainable Remediation
LUCs	Land Use Controls
LUCIP	Land Use Control Implementation Plan
MassDEP	Massachusetts Department of Environmental Protection
MassDPH	Massachusetts Department of Public Health
NTCRA	Non-Time Critical Removal Action
RAB	Restoration Advisory Board
RAO	Remedial Action Objective
ROD	Record of Decision
SA	Study Area
SHL	Shepley's Hill Landfill
TCRA	Time Critical Removal Action
USAEC	U.S. Army Environmental Command
USEPA	U.S. Environmental Protection Agency

GLOSSARY OF TERMS

Administrative Record – The collection of documents that is referred to or relied upon to support a decision document or enforcement action, including information and reports generated during the site investigation and remediation. The Administrative Record is made available for public review.

Applicable or Relevant and Appropriate Requirements (ARARs) – The requirements set forth by Federal and State environmental statutes and regulations which must be met in the implementation of remedial alternatives.

Carcinogenic Risk – Cancer risks are expressed as numbers reflecting the increased chance that a person will develop cancer if exposed to chemicals or substances. For example, USEPA's acceptable risk range for Superfund sites is $1x10^{-4}$ to $1x10^{-6}$. This means that the probability of an individual contracting cancer should not be greater than a 1 in 10,000 chance to a 1 in 1,000,000 chance above background.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) – This Federal law was passed in 1980 and amended in 1986, and is commonly referred to as the Superfund Law. It provides for liability, compensation, cleanup, and emergency response in connection with the cleanup of inactive hazardous waste disposal sites that endanger public health and safety or the environment.

Exposure Pathway – Describes the course a chemical or physical agent takes from the source to the exposed individual. Elements of the exposure pathway are: (1) the source of the chemical release; (2) the medium (e.g., soil); (3) a point of contact with the medium; and (4) an exposure route (e.g., ingestion, inhalation) at a contact point.

Feasibility Study – This document provides a detailed analysis of remedial alternatives for a site. Analysis presented in the document supports risk management decision processes to select the most appropriate remedy.

Hazard Index – The sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. The HI is calculated separately for chronic, subchronic, and shorter-duration exposures, and only hazard quotients for constituents with the same target organ or effect should be summed to obtain an HI. The potential for effects on exposed individuals increases with the magnitude of the hazard quotient and/or HI.

National Contingency Plan – Officially the National Oil and Hazardous Substances Pollution Contingency Plan, these regulations give the Federal Government the authority to respond to the problems of abandoned or uncontrolled hazardous waste disposal sites as well as to certain incidents involving hazardous wastes.

National Environmental Policy Act – An act, enacted on January 1, 1970, stating that any Federal branch or agency proposing a project that might have a significant effect on the environment must include in the proposal statements concerning potential impacts.

GLOSSARY OF TERMS (continued)

National Priorities List – This list, developed by EPA, identifies the uncontrolled hazardous substance release sites in the United States that are considered priorities for long-term remedial evaluation and response.

Proposed Plan – this document presents a proposed cleanup alternative and requests public input regarding the remedial alternatives analyzed.

Record of Decision (ROD) – The Record of Decision, signed by the U.S. Army and USEPA, sets forth the selected cleanup action or remedy for a site, the basis for selecting that remedy, public comments on alternative remedies, responses to comments, and the cost of the remedy.

Remedial Action Objectives (RAOs) – Medium-specific goals for protecting human health and the environment, which can be achieved by reducing exposure (e.g., capping an area or limiting access) as well as by reducing the level of constituents of concern.

Remedial Investigation – A remedial investigation is a study performed to characterize possible contamination at a site, and to identify sites that may require remedial action.

Superfund Amendments and Reauthorization Act – This Act amended CERCLA in 1986 to add, among other things, the requirements that Federal Facilities comply with the requirements of CERCLA.

FIGURES

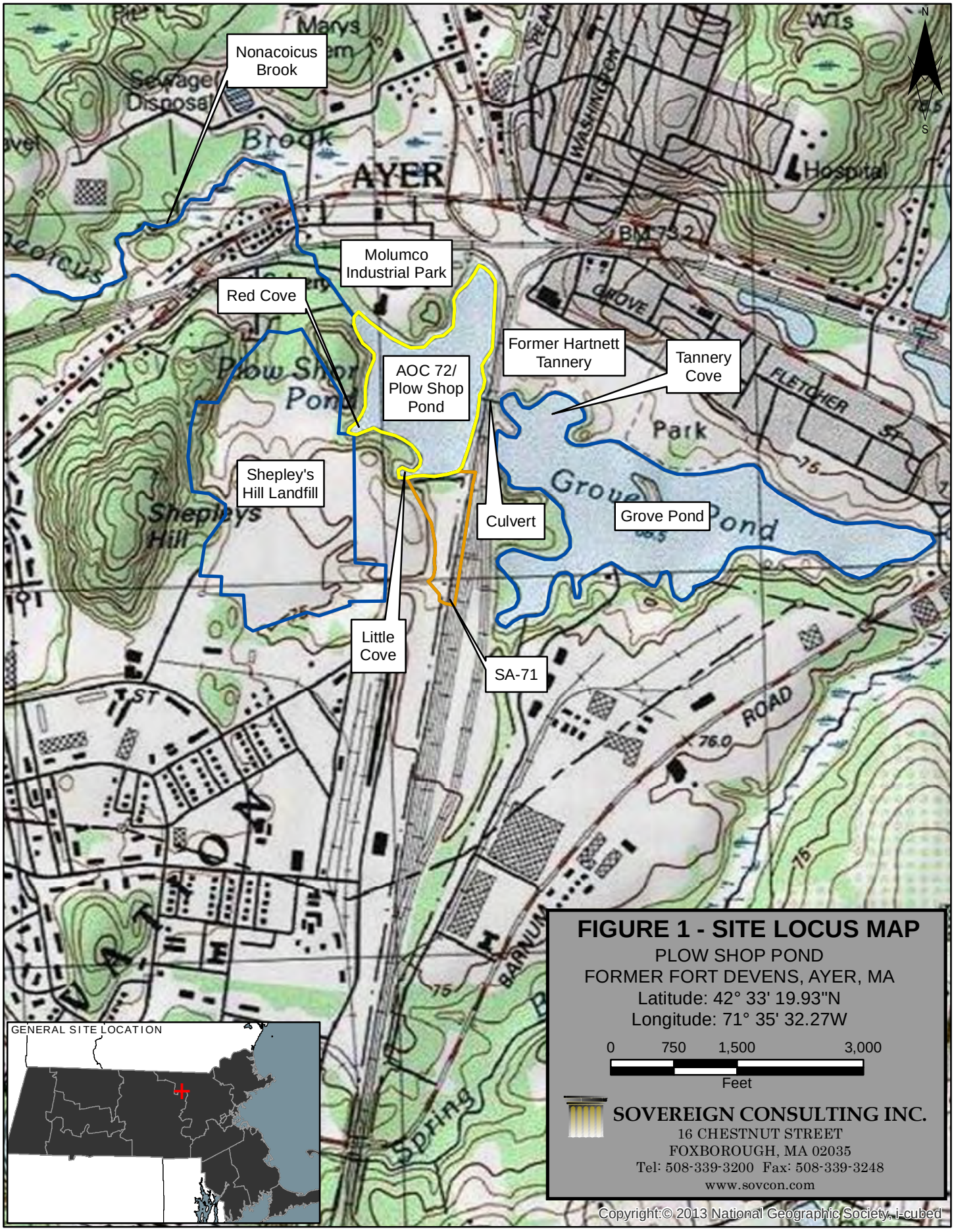

FIGURE 1 - SITE LOCUS MAP

PLOW SHOP POND
FORMER FORT DEVENS, AYER, MA
Latitude: 42° 33' 19.93"N
Longitude: 71° 35' 32.27W

SOVEREIGN CONSULTING INC.
16 CHESTNUT STREET
FOXBOROUGH, MA 02035
Tel: 508-339-3200 Fax: 508-339-3248
www.sovcon.com

07/11/14 MDM Updated 11/05/2014 ROV

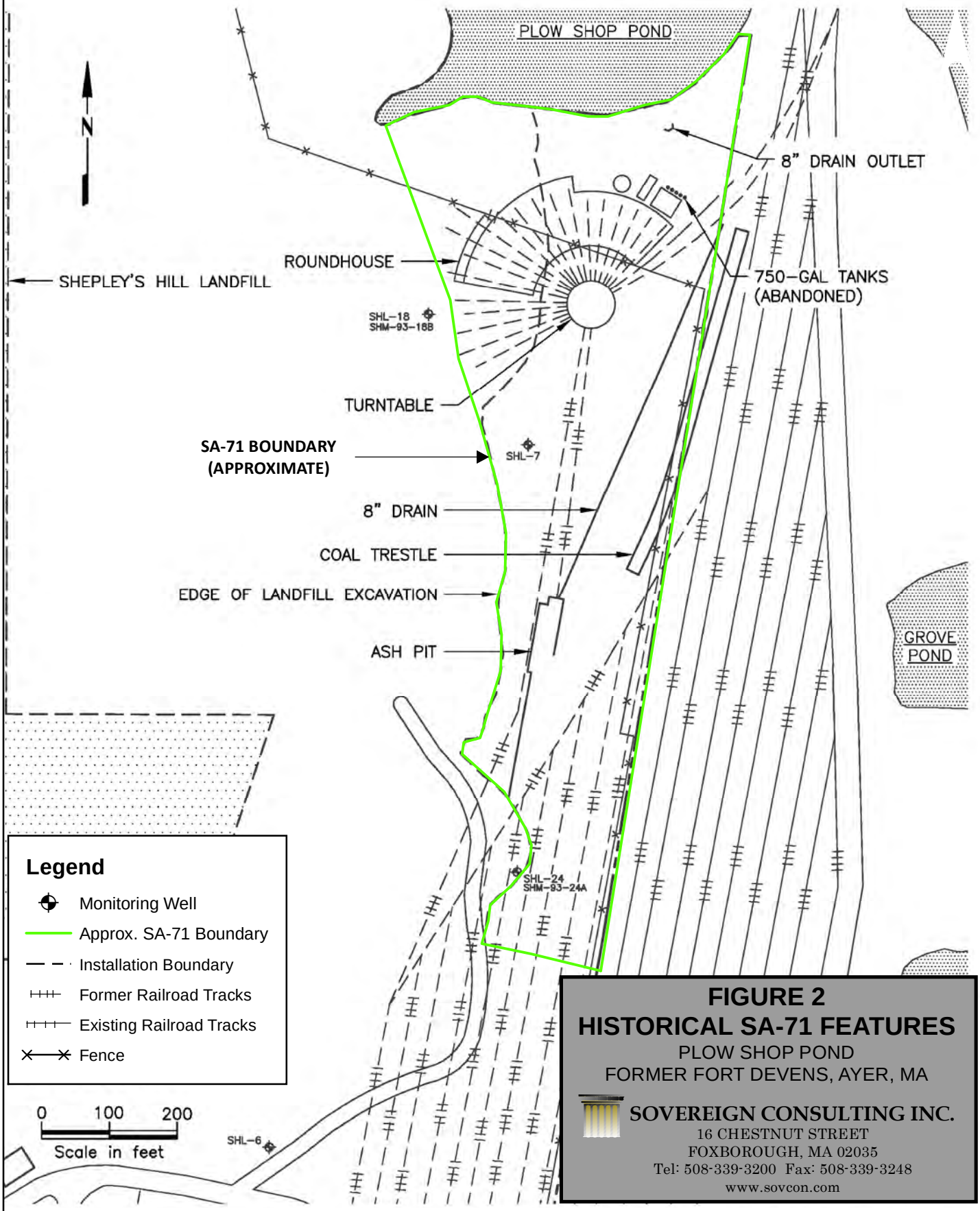

FIGURE 2
HISTORICAL SA-71 FEATURES

PLOW SHOP POND
FORMER FORT DEVENS, AYER, MA

SOVEREIGN CONSULTING INC.
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Taken from 'Previous Sample Locations, SA 71 Sediment Risk Characterization, Project 3618-04-8014, Figure 1-3' by MACTEC dated October 13, 2006.

07/03/2014 ROV Update: 11/05/2014 ROV

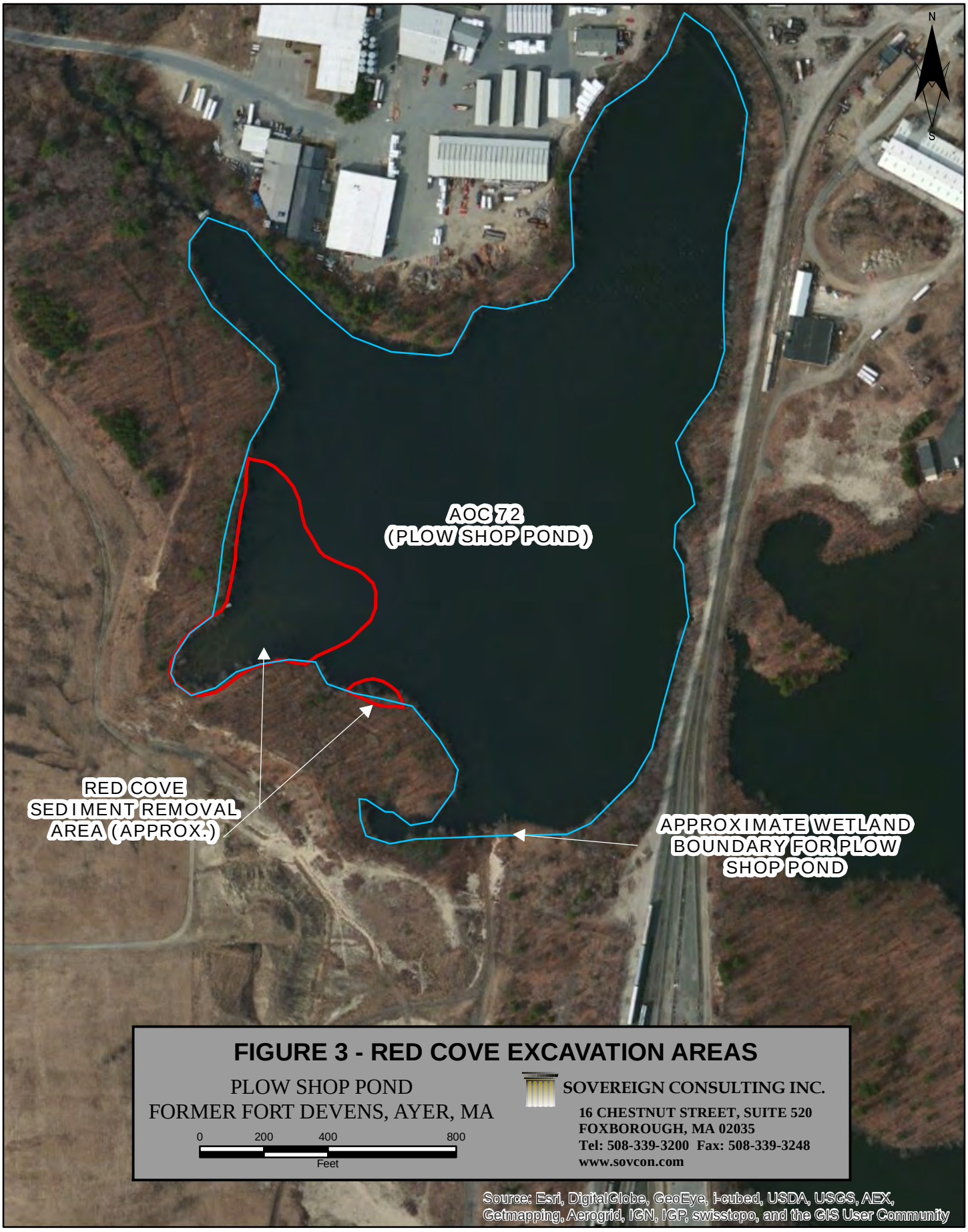

FIGURE 3 - RED COVE EXCAVATION AREAS

PLOW SHOP POND
FORMER FORT DEVENS, AYER, MA

0 200 400 800
Feet

SOVEREIGN CONSULTING INC.
16 CHESTNUT STREET, SUITE 520
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National Wetland Inventory Layer. 2010. US Fish & Wildlife Service.

02/03/2012 ROV
Updated 05/29/2014 ROV; 7/11/2014 MDM

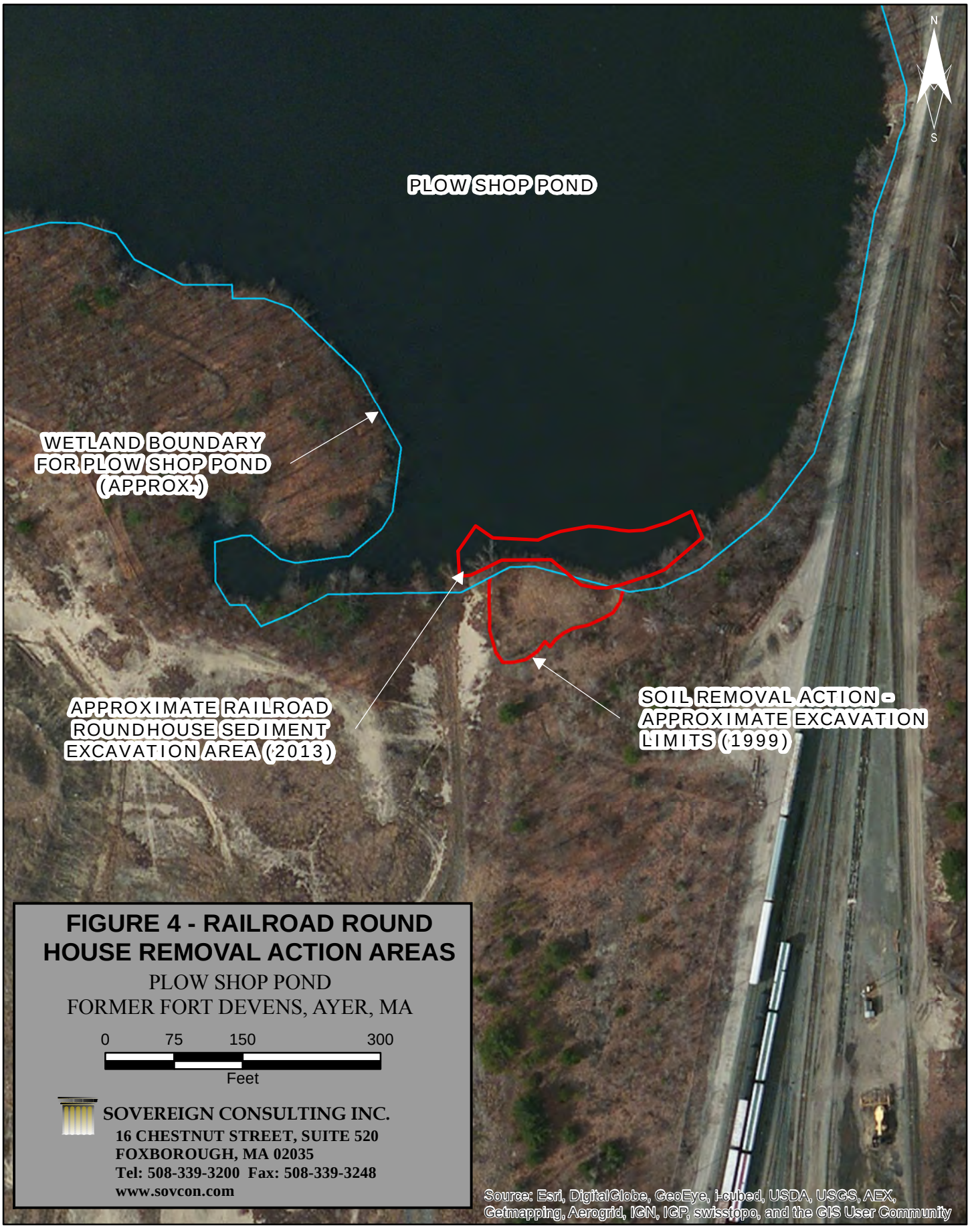

FIGURE 4 - RAILROAD ROUND HOUSE REMOVAL ACTION AREAS

PLOW SHOP POND
FORMER FORT DEVENS, AYER, MA

0 75 150 300
Feet

SOVEREIGN CONSULTING INC.
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Data Source: National Wetland Inventory Layer. 2010. US Fish & Wildlife Service.

06/23/2014 ROV UPDATED: 7/11/2014 MDM

SOVEREIGN CONSULTING INC.

TECHNICAL MEMORANDUM

TO: U.S. Army Corps of Engineers, New England District

FROM: Leah Smith, M.S. Toxicologist
Eric Simpson, P.G., LSP, Sovereign Consulting, Inc.

DATE: 23 December 2014

SUBJECT: Study Area 71 Risk Characterization Update
Railroad Roundhouse, Devens, Massachusetts

Pursuant to your request, a Sovereign toxicologist/risk assessor updated the above noted Risk Characterization prepared by Harding ESE, Inc. of Portland, Maine for Study Area 71 (SA 71) of Railroad Roundhouse, Devens, MA, dated January 2002. An updated Risk Characterization was requested to address United States Environmental Protection (EPA) revised exposure factors utilized in the 2002 Risk Characterization. A summary of the updated Risk Characterization for SA 71 is provided below.

Previous Risk Assessments

A human health and ecological risk evaluation was prepared for Study Area 71 (SA 71) as part of the January 2002 No Further Action Decision Under CERCLA for Study Area 71, Railroad Roundhouse, by Harding ESE, Inc. of Portland, Maine on behalf of the U.S. Army Corps of Engineers, New England District. The human health risk evaluation concluded that soil at SA 71 did not pose a significant risk to human health or the environment and that no potential health risks were evident from exposure to site groundwater. However, potential risk to sensitive ecological receptors might occur near shore sediments. The revised human health risk evaluation presented below was conducted at the request of Massachusetts Department of Environmental Protection (MassDEP) and EPA to address updated exposure factors and toxicity values since the submittal of the former 2002 risk evaluation. Several exposure factors have been updated since the 2002 risk evaluation including the residential exposure frequency, exposure duration, surface area, and body weight. As summarized below, the quantitative human health risk evaluation indicates a potential risk to residential receptors.

Toxicity Profile

The toxicity of a chemical is based upon the nature of the effect-caused and the dose, or concentration over time, required to cause effects. The route of entry into the body also affects the toxicity of many compounds introduced to the human body. Toxic affects may occur immediately or over long periods of time. For the purpose of risk assessment, health affects are divided into two categories, carcinogenic (cancer causing) and non-carcinogenic. Carcinogenic effects are evaluated for compounds that are known to cause cancer as outlined by the EPA and MassDEP, currently listed as known carcinogens. Select polycyclic aromatic hydrocarbons (PAHs) classified as carcinogens are considered chemicals of concern (COCs) associated with SA71 and were evaluated as part of this risk characterization.

Most chemicals have some level of toxicity; therefore, non-carcinogenic or systemic health affects were evaluated for all COCs at the site. Toxicity data used in this risk assessment originates from a variety of

sources including the EPA Integrated Risk Information System (IRIS), Federal Register, World Health Organization (WHO) toxicity equivalence factors (TEFs), Provisional Peer Reviewed Toxicity Values (PPRTVs), California Environmental Protection Agency/Office of Environmental Health Hazard Assessment, Agency for Toxic Substances and Disease Registry (ATSDR), and the EPA Superfund program's Health Effects Assessment Summary Table (HEAST). These agencies provide detailed summaries of health effects of toxic chemicals and supporting scientific research.

Potential Receptors and Exposure Potential

Potential receptors were evaluated with the assumption that potential future use of the site was unrestricted. Risk calculations are presented for all pathways assuming no Land Use Control (LUC) or other access restrictions are placed on the site.

Current and Potential Future Use

The current and future land use of SA 71 is presently unrestricted in the absence of LUCs. Potential current and future human receptors include residents and recreational visitors (children and adults), and construction and commercial/industrial workers (adults). Potential exposure routes for these receptors include direct contact exposure (ingestion, dermal contact, and/or dust inhalation) with surface and subsurface soils. This risk characterization specifically focused on potential residential and recreational receptors.

Potential Exposure Routes

Potential routes of exposure evaluated for current and future site use include direct contact exposure (ingestion, dermal contact, and/or dust inhalation) with surface and subsurface soils:

- Dermal exposure to soil due to direct contact with impacted soil;
- Incidental ingestion of impacted soil; and,
- Inhalation of particulate matter.

These exposure routes were evaluated for the following current and/or future site use human receptors:

- Residents (adults and children)
- Recreational visitors (adults and children)
- Construction and commercial/industrial workers (adults)

Residential receptors are considered the most sensitive receptor. Therefore, this risk characterization specifically focused on potential residential receptors. However, considering potential future use is likely designated as an open space, risk to recreational visitors was also quantified.

Identification of Exposure Point Concentrations (EPCs)

Exposure point concentrations (EPCs) were selected based on the data provided from the January 2002 No Further Action Decision Under CERCLA for Study Area 71 (Appendix B, Table 2). For potential residential and recreational receptors, EPCs were generated using the statistical software ProUCL 5.0.00. The highest of the suggested 95% upper confidence limit (UCL) was used as the EPC. Several analytes were eliminated as COCs because they were either below natural background standards and/or they were detected below EPA regional screening levels for residential soil. Soil COCs, including eliminated COCs, are presented on Table 1. The ProUCL output with EPCs generated for potential residential receptors is provided in Attachment A.

Dose Response Assessment

To evaluate the potential risk to the receptors and potential receptors at the site, a relationship between the toxicity of COCs, exposure pathways and the receptors must be determined. In order to evaluate risk, a quantitative assessment of risk was performed. The basis for significant risk as defined by the EPA as a hazard quotient (HQ), of greater than one (one significant figure), or cancer risk (CR) of greater than one chance in 1,000,000 (10-6) (one significant figure). Per the EPA Human Health Risk Assessment Protocol (2005), the HQ is the ratio of the receptor's exposure level, or dose, to an acceptable, or allowable, level. The CR represents the incremental probability of a receptor developing cancer as a result of their exposure to a carcinogen related to the site. The CR is similar to the HQ as it is also a measure of a calculated dose verses an acceptable (not likely to increase the chance of developing cancer) dose. A dose is the amount of the contaminant that the receptor receives from exposure. The dose is a function of the quantity, or concentration, of the contaminant in the environment, the means by which the receptor is exposed, the uptake of the COC by the body, and the duration of the exposure.

A HQ and CR are established for each receptor for each exposure pathway. The HQ and CR for each exposure pathway (i.e. dermal, ingestion, and inhalation) is added to produce the cumulative, or total HQ and total CR for each receptor. The methodologies for calculating HQ and CR for each receptor and receptor pathway are outlined below.

Potential Future Use of the Facility as Residential - Dermal Exposure, Incidental Ingestion, and Particulate Inhalation

In developing a HQ for each COC a Chronic Daily Intake (CDI) is calculated for dermal, ingestion, and inhalation routes of exposure. The CDI is a function of the concentration in soil, the exposure frequency (EF in events per day), the exposure duration (ED in hours per day), the exposure period (EP in years), a relative absorption factor (RAF, a function of how much is absorbed into the body), dermal contact or ingestion rates, receptor body weight (BW), exposure averaging period (AP), and appropriate unit conversion factors.

The exposure to residential receptors at this site was calculated using the Risk Assessment Information System (RAIS) calculator for residential exposure to contaminated soil. The exposure is based upon a hypothetical receptor in contact with the soil 350 days per week for seven years in calculating HQ or 70 years in calculating CR. These rates are effectively a time weighted average that accounts for a hypothetical receptor's age, body weight, soil contact rates, ingestion rates, body surface area, and seasonal variation (EF & ED). The CDI rates are based upon a receptor age one through six years of age when calculating the HQ and age 1 to 26 when calculating the CR. HQs for the inhalation and ingestion exposure routes are calculated by dividing the CDI by the inhalation reference concentration (RfC) or the oral reference dose (RfD), respectively. The HQ for the dermal exposure route is calculated by dividing the CDI by the product of the slope factor and the chemical specific gastrointestinal adsorption factor (GIABS).

To develop the CR a similar methodology to the HQ was followed. A CDI was developed for each COC for each route of exposure. The CDI is based upon an EP of 26 years and an averaging period (AP) of 70 years. CRs for the inhalation and ingestion exposure routes are a product of the CDI and the inhalation unit risk factor (IUR) or a slope factor, respectively. The CR for the dermal exposure route is a product of the CDI and the slope factor divided by the chemical specific GIABS. Exposure factors and equation inputs for soil/sediment exposure, and the RAIS output, which includes the calculated risk to residential receptors, are provided in Attachment B.

Potential Future Use of the Facility as Recreational - Dermal Exposure, Incidental Ingestion, and Particulate Inhalation

Risk to potential recreational visitors was quantified similar to potential residential receptors. The CR is comprised of the sum of ingestion, inhalation, and dermal CRs; and, the HQ is calculated as the sum of the ingestion, inhalation, and dermal HQs. The RAIS calculator for recreators was utilized. Exposure factors and equation inputs for soil/sediment exposure, and the RAIS output are provided in Attachment B.

Risk to Receptors

As outlined above, a HQ is calculated for each COC for each exposure pathway. For carcinogenic compounds, a CR is also calculated. The receptor's exposure to all of the COCs through all of the exposure routes is additive. The HQ for each COC is added to the other HQs for each exposure pathway. The HQ for each exposure pathway is added to the HQs for all of the exposure pathways for each receptor to determine the total HQ for that receptor. The total CR for each receptor is calculated in the same manner. As outlined above, the pathways and receptors evaluated represent a conservative evaluation of risk at the site. While additional receptors and exposure pathways can be calculated, the scope of this assessment is appropriate for the COCs detected and the potential receptors present at the site. The potential risk to potential receptors is outlined below.

Potential Current and Future Residential Receptors

Potential future residents at the disposal site may include residential property owners including adults and children present at the site 24 hours per day. Such future residents are expected to have high intensity uses of the property (including playground areas for children and growing and consumption of vegetable garden produce). In order to calculate the risk to potential future residential receptors, EPCs were input into the RAIS calculator to determine potential risks. The EPCs are provided in Attachment A. The RAIS exposure factors and output are provided in Attachment B. Table 1-1 below summarizes the risk calculated.

Table 1-1 Future Unrestricted Use, Residential Receptors – Soil Exposures

Exposure Pathways	Hazard Quotient	Cancer Risk
Soil Exposures		
Dermal	2.84E-08	1.58E-07
Incidental Ingestion	1.62E-01	4.27E-07
Inhalation	2.55E-02	9.65E-07
Sum of Exposures	1.88E-01	1.55E-06
EPA Target Risk	1.E+00	1.E-06
Significant Risk	NO	YES

Based upon the results of the quantitative assessment using the RAIS calculator, residential current and unrestricted future uses of the site exceed EPA screening levels. The exposure factors and equation inputs for soil exposure, and the RAIS output for residential receptors are provided in Attachment B. Therefore, based on these calculations, land use controls at SA 71 appear to be an appropriate means of reducing risk at the site to restrict potential future residential receptors. Such LUCs should, at a minimum, restrict the use of the property in the future against residential development and occupancy.

Potential Current and Future Recreational Visitor Receptors

Potential future recreational visitors at the disposal site may include adults and children present at the site. Such future residents are expected to have high intensity uses of the property for short periods of time. In order to calculate the risk to potential future recreational visitors, EPCs were input into the RAIS calculator to determine potential risks. Table 1-2 below summarizes the risk calculated.

Table 1-2 Future Recreational Visitor Receptors – Soil/Sediment Exposures

Exposure Pathways	Target Hazard Quotient	Target Cancer Risk
Soil Exposures		
Dermal	6.08E-05	3.39E-08
Incidental Ingestion	3.47E-02	9.15E-08
Inhalation	2.27E-04	8.61E-09
Sum of Exposures	3.50E-02	1.34E-07
EPA Target Risk	1.E+00	1.E-06
Significant Risk	NO	NO

Based upon the results of the RAIS quantitative output, recreational visitor current and unrestricted future uses of the site do not exceed EPA screening levels. The exposure factors and equation inputs for soil/sediment exposure, and the RAIS output for recreational visitors are provided in Attachment B. Therefore, based on these calculations, use of the disposal site as an open/recreational space does not result in significant risk for recreational visitors.

We appreciate the opportunity to provide assistance with your project and look forward to working with you in the future on this or other projects. If you have any questions, please contact us at 508-339-3200.

TABLES

TABLE 1
SOIL CONTAMINANT OF CONCERN TABLE
Railroad Roundhouse
Ft. Devens Study Area 71
Devens, Massachusetts

Compounds Detected During Subsurface Sampling Activities Master Listing	MassDEP Background Natural Soil	MassDEP Background Coal Ash Fill	Frequency of Detection	Highest Concentration Detected	Contaminant of Concern?	Justification For Removal From COC List	**Location**
	mg/kg	mg/kg	#/#	mg/kg			
VOLATILE ORGANICS							
Toluene	N/A	N/A	1/2	0.002	No	BRSLs	SHS-93-02X-0.0
Naphthalene	0.5	1	11/21	10.00	YES	COC	RHS-94-09X-0.0
PAHs				30			
2-methylnapthalene	N/A	N/A	10/21	20.00	No	BRSLs	RHS-94-08X-1.1
Acenapthene	0.5	2	6/19	10.00	No	BRSLs	RHS-94-09X-0.0
Acenaphthylene	0.5	1	3/19	1.00	No	ProUCL EPC Below Background	RHS-94-13X-0.2
Anthracene	1	4	11/21	30.00	No	BRSLs	RHS-94-09X-0.0
Benzo(a)anthracene	2	9	11/21	20.00	No	ProUCL EPC Below Background	RHS-94-09X-0.0
Benzo(a)pyrene	2	7	6/21	30.00	No	ProUCL EPC Below Background	RHS-94-09X-0.0
Benzo(b)fluoranthene	1	4	9/21	10.00	No	ProUCL EPC Below Background	RHS-94-09X-0.0
Benzo(g,h,i)perylene	1	3	6/19	9.00	No	No RSL	RHS-94-09X-0.0
Benzo(k)fluoranthene	1	4	10/21	10.00	No	ProUCL EPC Below Background	RHS-94-09X-0.0
Chrysene	2	7	12/21	30.00	YES	COC	RHS-94-09X-0.0
Dibenz(a,h)anthracene	0.5	1	2/19	3.00	No	ProUCL EPC Below Background	RHS-94-09X-0.0
Fluoranthene	4	10	13/21	60.00	No	BRSLs	RHS-94-09X-0.0
Fluorene	1	2	7/21	10.00	No	BRSLs	RHS-94-09X-0.0
Indeno(1,2,3-cd)pyrene	1	3	6/19	9.00	No	ProUCL EPC Below Background	RHS-94-09X-0.0
Phenanthrene	3	20	13/21	70.00	No	No RSL	RHS-94-09X-0.0
Pyrene	4	20	14/21	50.00	No	BRSLs	RHS-94-09X-0.0
INORGANICS							
Aluminum	10,000	10,000	21/21	4710.00	No	ProUCL EPC Below Background	RHS-94-12X-0.0
Antimony	1	7	23/35	38.00	YES	COC	SA71-HS2
Arsenic	20	20	35/35	26.00	No	ProUCL EPC Below Background	SA71-HS2
Barium	50	50	21/21	138.00	No	BRSLs	SHS-93-02X-0.0
Beryllium	0.4	0.9	1/21	1.10	No	BRSLs	SHS-93-02X-0.0
Cadmium	2	3	3/19	6.57	YES	COC	RHS-94-12X-0.0D
Calcium	N/A	N/A	21/21	11200.00	No	BRSLs	SHS-93-03X-0.0
Chromium	30	40	17/21	15.80	No	ProUCL EPC Below Background	RHS-94-12X-0.0
Cobalt	4	4	19/21	4.77	No	BRSLs	RHS-94-12X-0.0
Copper	40	200	21/21	153.00	No	BRSLs	RHS-94-12X-0.0
Iron	20,000	20,000	21/21	20300.00	No	BRSLs	RHS-94-12X-0.0
Lead	100	600	33/35	660.00	No	ProUCL EPC Below Background	SA71-FL33
Magnesium	5,000	5,000	21/21	170.00	No	ProUCL EPC Below Background	RHS-94-12X-0.0
Manganese	300	300	21/21	291.00	No	ProUCL EPC Below Background	RHS-94-12X-0.0
Mercury	0.3	1	9/21	0.33	No	BRSLs	RHS-94-08X-0.0
Nickel	20	30	21/21	19.50	No	ProUCL EPC Below Background	RHS-94-12X-0.0
Potassium	N/A	N/A	21/21	5352.00	No	No RSL	SHS-93-03X-0.0
Selenium	0.5	1	9/21	4.20	No	BRSLs	RHS-94-09X-0.0
Silver	0.6	5	1/21	2.97	No	ProUCL EPC Below Background	SHS-93-03X-0.0
Sodium	N/A	N/A	21/21	613.00	No	No RSL	RHS-94-12X-0.0D
Thallium	0.6	5	1/19	0.50	No	ProUCL EPC Below Background	RHS-94-11X-1.5
Tin	N/A	N/A	9/19	16.70	No	BRSLs	RHS-94-08X-0.8
Vanadium	30	30	18/21	15.80	No	ProUCL EPC Below Background	RHS-94-12X-0.0
Zinc	100	300	20/21	3380.00	YES	COC	RHS-94-12X-0.0D
PESTICIDES							
4,4'-DDE	N/A	N/A	1/2	0.01	No	BRSLs	SHS-93-02X-0.0

Notes:
MDL - Method Detection Limit
COC - Contaminant of Concern
N/A - Not applicable

BRSLs- Concentration below USEPA Regional Screening Levels (RSLs) for residential soil.
Chrysene not identified as a COC in the 2001 RA.
Cobalt, iron and magnesium have limited toxicology data. Although they are considered COCs limited toxicological data resulted in minimal risks associated with exposure.

ATTACHMENT A

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	12/17/2014 2:41:59 PM
From File	Railroad Roundhouse ProUCL Soil Sediment Data_V2.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Antimony

General Statistics

Total Number of Observations	35	Number of Distinct Observations	23
Number of Detects	24	Number of Non-Detects	11
Number of Distinct Detects	23	Number of Distinct Non-Detects	1
Minimum Detect	1.09	Minimum Non-Detect	1.09
Maximum Detect	38	Maximum Non-Detect	1.09
Variance Detects	112.8	Percent Non-Detects	31.43%
Mean Detects	11.88	SD Detects	10.62
Median Detects	6.7	CV Detects	0.894
Skewness Detects	1.279	Kurtosis Detects	0.58
Mean of Logged Detects	2.101	SD of Logged Detects	0.904

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.82	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.916	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.258	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.181	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

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

Mean	8.486	Standard Error of Mean	1.72
SD	9.961	95% KM (BCA) UCL	11.64
95% KM (t) UCL	11.39	95% KM (Percentile Bootstrap) UCL	11.36
95% KM (z) UCL	11.31	95% KM Bootstrap t UCL	12.22
90% KM Chebyshev UCL	13.65	95% KM Chebyshev UCL	15.98
97.5% KM Chebyshev UCL	19.23	99% KM Chebyshev UCL	25.6

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.658	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.762	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.199	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.181	Detected Data Not Gamma Distributed at 5% Significance Level

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

Gamma Statistics on Detected Data Only

k hat (MLE)	1.482	k star (bias corrected MLE)	1.325
Theta hat (MLE)	8.011	Theta star (bias corrected MLE)	8.964
nu hat (MLE)	71.16	nu star (bias corrected)	63.59
MLE Mean (bias corrected)	11.88	MLE Sd (bias corrected)	10.32

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.726	nu hat (KM)	50.81
Approximate Chi Square Value (50.81, α)	35.44	Adjusted Chi Square Value (50.81, β)	34.83
95% Gamma Approximate KM-UCL (use when n>=50)	12.17	95% Gamma Adjusted KM-UCL (use when n<50)	12.38

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	8.147
Maximum	38	Median	5.25
SD	10.37	CV	1.273
k hat (MLE)	0.324	k star (bias corrected MLE)	0.315
Theta hat (MLE)	25.17	Theta star (bias corrected MLE)	25.87
nu hat (MLE)	22.65	nu star (bias corrected)	22.05
MLE Mean (bias corrected)	8.147	MLE Sd (bias corrected)	14.52
		Adjusted Level of Significance (β)	0.0425
Approximate Chi Square Value (22.05, α)	12.37	Adjusted Chi Square Value (22.05, β)	12.03
95% Gamma Approximate UCL (use when n>=50)	14.52	95% Gamma Adjusted UCL (use when n<50)	14.93

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.965	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.916	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.146	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.181	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	8.476	Mean in Log Scale	1.414
SD in Original Scale	10.12	SD in Log Scale	1.311
95% t UCL (assumes normality of ROS data)	11.37	95% Percentile Bootstrap UCL	11.31
95% BCA Bootstrap UCL	11.98	95% Bootstrap t UCL	12.36
95% H-UCL (Log ROS)	18.49		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	1.468	95% H-UCL (KM -Log)	15.23
KM SD (logged)	1.188	95% Critical H Value (KM-Log)	2.696
KM Standard Error of Mean (logged)	0.205		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	8.315	Mean in Log Scale	1.25
SD in Original Scale	10.24	SD in Log Scale	1.476
95% t UCL (Assumes normality)	11.24	95% H-Stat UCL	22.74

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

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Gamma Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (Percentile Bootstrap) UCL	11.36	95% GROS Adjusted Gamma UCL	14.93
95% Adjusted Gamma KM-UCL	12.38		

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	35	Number of Distinct Observations	15
		Number of Missing Observations	0
Minimum	7.19	Mean	14.67
Maximum	26	Median	13
SD	4.675	Std. Error of Mean	0.79
Coefficient of Variation	0.319	Skewness	0.786

Normal GOF Test

Shapiro Wilk Test Statistic	0.923	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.934	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.183	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.15	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	16.01	95% Adjusted-CLT UCL (Chen-1995)	16.08
		95% Modified-t UCL (Johnson-1978)	16.03

Gamma GOF Test

A-D Test Statistic	0.679	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.748	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.156	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.149	Data Not Gamma Distributed at 5% Significance Level

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

Gamma Statistics

k hat (MLE)	10.81	k star (bias corrected MLE)	9.901
Theta hat (MLE)	1.358	Theta star (bias corrected MLE)	1.482
nu hat (MLE)	756.6	nu star (bias corrected)	693.1
MLE Mean (bias corrected)	14.67	MLE Sd (bias corrected)	4.663
		Approximate Chi Square Value (0.05)	633
Adjusted Level of Significance	0.0425	Adjusted Chi Square Value	630.3

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	16.07	95% Adjusted Gamma UCL (use when n<50)	16.13

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.966	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.934	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.138	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.15	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.973	Mean of logged Data	2.639
Maximum of Logged Data	3.258	SD of logged Data	0.309

Assuming Lognormal Distribution

95% H-UCL	16.16	90% Chebyshev (MVUE) UCL	17
95% Chebyshev (MVUE) UCL	18.06	97.5% Chebyshev (MVUE) UCL	19.53
99% Chebyshev (MVUE) UCL	22.42		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	15.97	95% Jackknife UCL	16.01
95% Standard Bootstrap UCL	15.94	95% Bootstrap-t UCL	16.15
95% Hall's Bootstrap UCL	16.17	95% Percentile Bootstrap UCL	15.94
95% BCA Bootstrap UCL	16.07		
90% Chebyshev(Mean, Sd) UCL	17.04	95% Chebyshev(Mean, Sd) UCL	18.12
97.5% Chebyshev(Mean, Sd) UCL	19.61	99% Chebyshev(Mean, Sd) UCL	22.54

Suggested UCL to Use

95% Adjusted Gamma UCL	16.13

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

Benzo(a)anthracene

General Statistics

Total Number of Observations	21	Number of Distinct Observations	7
		Number of Missing Observations	14
Number of Detects	11	Number of Non-Detects	10
Number of Distinct Detects	6	Number of Distinct Non-Detects	1
Minimum Detect	0.19	Minimum Non-Detect	0.17
Maximum Detect	20	Maximum Non-Detect	0.17
Variance Detects	36	Percent Non-Detects	47.62%
Mean Detects	3.808	SD Detects	6
Median Detects	2	CV Detects	1.576
Skewness Detects	2.442	Kurtosis Detects	5.834
Mean of Logged Detects	0.55	SD of Logged Detects	1.255

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.593	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.437	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.267	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

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

Mean	2.076	Standard Error of Mean	1.035
SD	4.522	95% KM (BCA) UCL	3.971
95% KM (t) UCL	3.861	95% KM (Percentile Bootstrap) UCL	3.939
95% KM (z) UCL	3.778	95% KM Bootstrap t UCL	11.07
90% KM Chebyshev UCL	5.18	95% KM Chebyshev UCL	6.586
97.5% KM Chebyshev UCL	8.538	99% KM Chebyshev UCL	12.37

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.027	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.762	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.36	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.265	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.76	k star (bias corrected MLE)	0.613
Theta hat (MLE)	5.014	Theta star (bias corrected MLE)	6.213
nu hat (MLE)	16.71	nu star (bias corrected)	13.49
MLE Mean (bias corrected)	3.808	MLE Sd (bias corrected)	4.864

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.211	nu hat (KM)	8.851
Approximate Chi Square Value (8.85, α)	3.237	Adjusted Chi Square Value (8.85, β)	2.981
95% Gamma Approximate KM-UCL (use when n>=50)	5.675	95% Gamma Adjusted KM-UCL (use when n<50)	6.163

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	2
Maximum	20	Median	0.19
SD	4.667	CV	2.334
k hat (MLE)	0.27	k star (bias corrected MLE)	0.263
Theta hat (MLE)	7.404	Theta star (bias corrected MLE)	7.596
nu hat (MLE)	11.34	nu star (bias corrected)	11.06
MLE Mean (bias corrected)	2	MLE Sd (bias corrected)	3.897
		Adjusted Level of Significance (β)	0.0383
Approximate Chi Square Value (11.06, α)	4.611	Adjusted Chi Square Value (11.06, β)	4.295
95% Gamma Approximate UCL (use when n>=50)	4.793	95% Gamma Adjusted UCL (use when n<50)	5.147

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.914	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.273	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.267	Detected Data Not Lognormal at 5% Significance Level

Detected Data appear Approximate Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	2.037	Mean in Log Scale	-1.079
SD in Original Scale	4.65	SD in Log Scale	2.102
95% t UCL (assumes normality of ROS data)	3.787	95% Percentile Bootstrap UCL	3.879
95% BCA Bootstrap UCL	4.543	95% Bootstrap t UCL	10.95
95% H-UCL (Log ROS)	23.57		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-0.556	95% H-UCL (KM -Log)	4.649
KM SD (logged)	1.448	95% Critical H Value (KM-Log)	3.227
KM Standard Error of Mean (logged)	0.331		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	2.035	Mean in Log Scale	-0.886
SD in Original Scale	4.651	SD in Log Scale	1.78
95% t UCL (Assumes normality)	3.786	95% H-Stat UCL	9.019

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

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Lognormal Distributed at 5% Significance Level

Suggested UCL to Use

97.5% KM (Chebyshev) UCL	8.538

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.

Benzo(a)pyrene

General Statistics

Total Number of Observations	21	Number of Distinct Observations	6
		Number of Missing Observations	14
Number of Detects	6	Number of Non-Detects	15
Number of Distinct Detects	4	Number of Distinct Non-Detects	3
Minimum Detect	1	Minimum Non-Detect	0.25
Maximum Detect	30	Maximum Non-Detect	1
Variance Detects	131.5	Percent Non-Detects	71.43%
Mean Detects	7.667	SD Detects	11.47
Median Detects	2	CV Detects	1.496
Skewness Detects	2.029	Kurtosis Detects	4.071
Mean of Logged Detects	1.182	SD of Logged Detects	1.375

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.682	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.788	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.356	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.362	Detected Data appear Normal at 5% Significance Level

Detected Data appear Approximate Normal at 5% Significance Level

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

Mean	2.369	Standard Error of Mean	1.559
SD	6.521	95% KM (BCA) UCL	N/A
95% KM (t) UCL	5.058	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	4.933	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	7.046	95% KM Chebyshev UCL	9.164
97.5% KM Chebyshev UCL	12.1	99% KM Chebyshev UCL	17.88

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.656	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.724	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.358	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.344	Detected Data Not Gamma Distributed at 5% Significance Level

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

Gamma Statistics on Detected Data Only

k hat (MLE)	0.706	k star (bias corrected MLE)	0.464
Theta hat (MLE)	10.86	Theta star (bias corrected MLE)	16.52
nu hat (MLE)	8.47	nu star (bias corrected)	5.568
MLE Mean (bias corrected)	7.667	MLE Sd (bias corrected)	11.25

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.132	nu hat (KM)	5.543
Approximate Chi Square Value (5.54, α)	1.411	Adjusted Chi Square Value (5.54, β)	1.258
95% Gamma Approximate KM-UCL (use when n>=50)	9.307	95% Gamma Adjusted KM-UCL (use when n<50)	10.43

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	2.198
Maximum	30	Median	0.01
SD	6.74	CV	3.067
k hat (MLE)	0.197	k star (bias corrected MLE)	0.201
Theta hat (MLE)	11.14	Theta star (bias corrected MLE)	10.94
nu hat (MLE)	8.284	nu star (bias corrected)	8.434
MLE Mean (bias corrected)	2.198	MLE Sd (bias corrected)	4.904
		Adjusted Level of Significance (β)	0.0383
Approximate Chi Square Value (8.43, α)	2.989	Adjusted Chi Square Value (8.43, β)	2.745
95% Gamma Approximate UCL (use when n>=50)	6.201	95% Gamma Adjusted UCL (use when n<50)	6.753

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.849	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.788	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.305	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.362	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	2.226	Mean in Log Scale	-2.649
SD in Original Scale	6.731	SD in Log Scale	3.028
95% t UCL (assumes normality of ROS data)	4.76	95% Percentile Bootstrap UCL	4.933
95% BCA Bootstrap UCL	6.564	95% Bootstrap t UCL	23.6
95% H-UCL (Log ROS)	392.2		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-0.653	95% H-UCL (KM -Log)	3.197
KM SD (logged)	1.34	95% Critical H Value (KM-Log)	3.06
KM Standard Error of Mean (logged)	0.32		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	2.339	Mean in Log Scale	-0.917
SD in Original Scale	6.694	SD in Log Scale	1.599
95% t UCL (Assumes normality)	4.858	95% H-Stat UCL	4.96

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

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	5.058	95% KM (Percentile Bootstrap) UCL	N/A

Warning: One or more Recommended UCL(s) not available!

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.

Benzo(b)fluoranthene

General Statistics

Total Number of Observations	21	Number of Distinct Observations	6
		Number of Missing Observations	14
Number of Detects	9	Number of Non-Detects	12
Number of Distinct Detects	4	Number of Distinct Non-Detects	3
Minimum Detect	1	Minimum Non-Detect	0.21
Maximum Detect	10	Maximum Non-Detect	1
Variance Detects	11.61	Percent Non-Detects	57.14%
Mean Detects	4.111	SD Detects	3.408
Median Detects	3	CV Detects	0.829
Skewness Detects	1.438	Kurtosis Detects	0.485
Mean of Logged Detects	1.154	SD of Logged Detects	0.742

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.705	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.829	Detected Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.406	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.295	Detected Data Not Normal at 5% Significance Level	

Detected Data Not Normal at 5% Significance Level

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

Mean	1.882	Standard Error of Mean	0.661
SD	2.855	95% KM (BCA) UCL	N/A
95% KM (t) UCL	3.022	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	2.969	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	3.864	95% KM Chebyshev UCL	4.762
97.5% KM Chebyshev UCL	6.008	99% KM Chebyshev UCL	8.457

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.896	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.73	Detected Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.354	**Kolmogrov-Smirnoff GOF**	
5% K-S Critical Value	0.282	Detected Data Not Gamma Distributed at 5% Significance Level	

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	2.077	k star (bias corrected MLE)	1.458
Theta hat (MLE)	1.98	Theta star (bias corrected MLE)	2.819
nu hat (MLE)	37.38	nu star (bias corrected)	26.25
MLE Mean (bias corrected)	4.111	MLE Sd (bias corrected)	3.404

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.435	nu hat (KM)	18.25
Approximate Chi Square Value (18.25, α)	9.572	Adjusted Chi Square Value (18.25, β)	9.091
95% Gamma Approximate KM-UCL (use when n>=50)	3.588	95% Gamma Adjusted KM-UCL (use when n<50)	3.778

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	1.768
Maximum	10	Median	0.01
SD	2.995	CV	1.694
k hat (MLE)	0.261	k star (bias corrected MLE)	0.255
Theta hat (MLE)	6.781	Theta star (bias corrected MLE)	6.927
nu hat (MLE)	10.95	nu star (bias corrected)	10.72
MLE Mean (bias corrected)	1.768	MLE Sd (bias corrected)	3.499
		Adjusted Level of Significance (β)	0.0383
Approximate Chi Square Value (10.72, α)	4.395	Adjusted Chi Square Value (10.72, β)	4.087
95% Gamma Approximate UCL (use when n>=50)	4.31	95% Gamma Adjusted UCL (use when n<50)	4.635

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.87	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.829	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.308	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.295	Detected Data Not Lognormal at 5% Significance Level	

Detected Data appear Approximate Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	2.008	Mean in Log Scale	-0.101
SD in Original Scale	2.857	SD in Log Scale	1.319
95% t UCL (assumes normality of ROS data)	3.084	95% Percentile Bootstrap UCL	3.082
95% BCA Bootstrap UCL	3.424	95% Bootstrap t UCL	4.325
95% H-UCL (Log ROS)	5.267		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-0.397	95% H-UCL (KM -Log)	5.054
KM SD (logged)	1.419	95% Critical H Value (KM-Log)	3.183
KM Standard Error of Mean (logged)	0.329		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	1.842	Mean in Log Scale	-0.711
SD in Original Scale	2.951	SD in Log Scale	1.752
95% t UCL (Assumes normality)	2.952	95% H-Stat UCL	9.797

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

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Lognormal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	3.022	95% KM (% Bootstrap) UCL	N/A

Warning: One or more Recommended UCL(s) not available!

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.

Benzo(k)fluoranthene

General Statistics

Total Number of Observations	21	Number of Distinct Observations	10
		Number of Missing Observations	14
Number of Detects	10	Number of Non-Detects	11
Number of Distinct Detects	8	Number of Distinct Non-Detects	2
Minimum Detect	0.2	Minimum Non-Detect	0.066
Maximum Detect	10	Maximum Non-Detect	0.66
Variance Detects	8.599	Percent Non-Detects	52.38%
Mean Detects	1.99	SD Detects	2.932
Median Detects	0.95	CV Detects	1.474
Skewness Detects	2.741	Kurtosis Detects	7.89
Mean of Logged Detects	0.075	SD of Logged Detects	1.087

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.597	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.842	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.332	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.28	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

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

Mean	0.984	Standard Error of Mean	0.494
SD	2.146	95% KM (BCA) UCL	1.928
95% KM (t) UCL	1.835	95% KM (Percentile Bootstrap) UCL	1.822
95% KM (z) UCL	1.796	95% KM Bootstrap t UCL	3.889
90% KM Chebyshev UCL	2.465	95% KM Chebyshev UCL	3.136
97.5% KM Chebyshev UCL	4.067	99% KM Chebyshev UCL	5.896

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.703	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.75	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.295	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.274	Detected Data Not Gamma Distributed at 5% Significance Level

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

Gamma Statistics on Detected Data Only

k hat (MLE)	0.947	k star (bias corrected MLE)	0.73
Theta hat (MLE)	2.1	Theta star (bias corrected MLE)	2.726
nu hat (MLE)	18.95	nu star (bias corrected)	14.6
MLE Mean (bias corrected)	1.99	MLE Sd (bias corrected)	2.329

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.21	nu hat (KM)	8.831
Approximate Chi Square Value (8.83, α)	3.225	Adjusted Chi Square Value (8.83, β)	2.969
95% Gamma Approximate KM-UCL (use when n>=50)	2.695	95% Gamma Adjusted KM-UCL (use when n<50)	2.927

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	0.953
Maximum	10	Median	0.01
SD	2.213	CV	2.322
k hat (MLE)	0.297	k star (bias corrected MLE)	0.286
Theta hat (MLE)	3.211	Theta star (bias corrected MLE)	3.331
nu hat (MLE)	12.46	nu star (bias corrected)	12.01
MLE Mean (bias corrected)	0.953	MLE Sd (bias corrected)	1.782
		Adjusted Level of Significance (β)	0.0383
Approximate Chi Square Value (12.01, α)	5.237	Adjusted Chi Square Value (12.01, β)	4.896
95% Gamma Approximate UCL (use when n>=50)	2.186	95% Gamma Adjusted UCL (use when n<50)	2.338

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.952	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.842	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.228	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.28	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.984	Mean in Log Scale	-1.55
SD in Original Scale	2.199	SD in Log Scale	1.889
95% t UCL (assumes normality of ROS data)	1.812	95% Percentile Bootstrap UCL	1.795
95% BCA Bootstrap UCL	2.377	95% Bootstrap t UCL	3.942
95% H-UCL (Log ROS)	6.699		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-1.377	95% H-UCL (KM -Log)	2.811
KM SD (logged)	1.562	95% Critical H Value (KM-Log)	3.41
KM Standard Error of Mean (logged)	0.36		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	0.979	Mean in Log Scale	-1.641
SD in Original Scale	2.202	SD in Log Scale	1.893
95% t UCL (Assumes normality)	1.808	95% H-Stat UCL	6.216

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

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Gamma Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	1.835	95% GROS Adjusted Gamma UCL	2.338
95% Adjusted Gamma KM-UCL	2.927		

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	19	Number of Distinct Observations	8
Number of Detects	7	Number of Non-Detects	12
Number of Distinct Detects	7	Number of Distinct Non-Detects	1
Minimum Detect	0.953	Minimum Non-Detect	0.7
Maximum Detect	424	Maximum Non-Detect	0.7
Variance Detects	41648	Percent Non-Detects	63.16%
Mean Detects	215.1	SD Detects	204.1
Median Detects	265	CV Detects	0.949
Skewness Detects	-0.152	Kurtosis Detects	-2.604
Mean of Logged Detects	3.873	SD of Logged Detects	2.611

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.782	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.803	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.275	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.335	Detected Data appear Normal at 5% Significance Level

Detected Data appear Approximate Normal at 5% Significance Level

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

Mean	79.69	Standard Error of Mean	38.27
SD	154.4	95% KM (BCA) UCL	142.3
95% KM (t) UCL	146.1	95% KM (Percentile Bootstrap) UCL	141.7
95% KM (z) UCL	142.6	95% KM Bootstrap t UCL	169.3
90% KM Chebyshev UCL	194.5	95% KM Chebyshev UCL	246.5
97.5% KM Chebyshev UCL	318.7	99% KM Chebyshev UCL	460.5

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.849	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.762	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.312	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.33	Detected data appear Gamma Distributed at 5% Significance Level

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

Gamma Statistics on Detected Data Only

k hat (MLE)	0.434	k star (bias corrected MLE)	0.343
Theta hat (MLE)	496.1	Theta star (bias corrected MLE)	627.1
nu hat (MLE)	6.071	nu star (bias corrected)	4.802
MLE Mean (bias corrected)	215.1	MLE Sd (bias corrected)	367.3

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.266	nu hat (KM)	10.12
Approximate Chi Square Value (10.12, α)	4.016	Adjusted Chi Square Value (10.12, β)	3.686
95% Gamma Approximate KM-UCL (use when n>=50)	200.8	95% Gamma Adjusted KM-UCL (use when n<50)	218.8

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	79.26
Maximum	424	Median	0.01
SD	158.9	CV	2.005
k hat (MLE)	0.133	k star (bias corrected MLE)	0.147
Theta hat (MLE)	593.7	Theta star (bias corrected MLE)	537.3
nu hat (MLE)	5.073	nu star (bias corrected)	5.605
MLE Mean (bias corrected)	79.26	MLE Sd (bias corrected)	206.4
		Adjusted Level of Significance (β)	0.0369
Approximate Chi Square Value (5.60, α)	1.441	Adjusted Chi Square Value (5.60, β)	1.267
95% Gamma Approximate UCL (use when n>=50)	308.2	95% Gamma Adjusted UCL (use when n<50)	350.7

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.794	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.803	Detected Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.315	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.335	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Approximate Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	79.36	Mean in Log Scale	-1.121
SD in Original Scale	158.8	SD in Log Scale	4.801
95% t UCL (assumes normality of ROS data)	142.5	95% Percentile Bootstrap UCL	143
95% BCA Bootstrap UCL	154.1	95% Bootstrap t UCL	173.5
95% H-UCL (Log ROS)	1.581E+9		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	1.202	95% H-UCL (KM -Log)	1680
KM SD (logged)	2.513	95% Critical H Value (KM-Log)	5.177
KM Standard Error of Mean (logged)	0.623		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	79.47	Mean in Log Scale	0.764
SD in Original Scale	158.8	SD in Log Scale	2.868
95% t UCL (Assumes normality)	142.6	95% H-Stat UCL	6760

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

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	146.1	95% KM (Percentile Bootstrap) UCL	141.7

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Chrysene

General Statistics

Total Number of Observations	21	Number of Distinct Observations	9
		Number of Missing Observations	14
Number of Detects	12	Number of Non-Detects	9
Number of Distinct Detects	8	Number of Distinct Non-Detects	1
Minimum Detect	0.24	Minimum Non-Detect	0.12
Maximum Detect	30	Maximum Non-Detect	0.12
Variance Detects	69.29	Percent Non-Detects	42.86%
Mean Detects	4.958	SD Detects	8.324
Median Detects	2	CV Detects	1.679
Skewness Detects	2.914	Kurtosis Detects	8.953
Mean of Logged Detects	0.731	SD of Logged Detects	1.377

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.572	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.859	Detected Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.343	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.256	Detected Data Not Normal at 5% Significance Level	

Detected Data Not Normal at 5% Significance Level

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

Mean	2.884	Standard Error of Mean	1.478
SD	6.483	95% KM (BCA) UCL	5.562
95% KM (t) UCL	5.433	95% KM (Percentile Bootstrap) UCL	5.474
95% KM (z) UCL	5.315	95% KM Bootstrap t UCL	12.44
90% KM Chebyshev UCL	7.317	95% KM Chebyshev UCL	9.325
97.5% KM Chebyshev UCL	12.11	99% KM Chebyshev UCL	17.59

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.613	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.77	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.238	**Kolmogrov-Smirnoff GOF**	
5% K-S Critical Value	0.256	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.696	k star (bias corrected MLE)	0.577
Theta hat (MLE)	7.127	Theta star (bias corrected MLE)	8.588
nu hat (MLE)	16.7	nu star (bias corrected)	13.85
MLE Mean (bias corrected)	4.958	MLE Sd (bias corrected)	6.525

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.198	nu hat (KM)	8.314
Approximate Chi Square Value (8.31, α)	2.918	Adjusted Chi Square Value (8.31, β)	2.677
95% Gamma Approximate KM-UCL (use when n>=50)	8.218	95% Gamma Adjusted KM-UCL (use when n<50)	8.956

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	2.837
Maximum	30	Median	0.25
SD	6.664	CV	2.349
k hat (MLE)	0.27	k star (bias corrected MLE)	0.263
Theta hat (MLE)	10.51	Theta star (bias corrected MLE)	10.78
nu hat (MLE)	11.34	nu star (bias corrected)	11.05
MLE Mean (bias corrected)	2.837	MLE Sd (bias corrected)	5.531
		Adjusted Level of Significance (β)	0.0383
Approximate Chi Square Value (11.05, α)	4.61	Adjusted Chi Square Value (11.05, β)	4.293
95% Gamma Approximate UCL (use when n>=50)	6.803	95% Gamma Adjusted UCL (use when n<50)	7.304

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.954	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.859	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.156	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.256	Detected Data appear Lognormal at 5% Significance Level	

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	2.868	Mean in Log Scale	-0.843
SD in Original Scale	6.65	SD in Log Scale	2.243
95% t UCL (assumes normality of ROS data)	5.371	95% Percentile Bootstrap UCL	5.393
95% BCA Bootstrap UCL	7.165	95% Bootstrap t UCL	12.34
95% H-UCL (Log ROS)	52.46		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-0.491	95% H-UCL (KM -Log)	11.29
KM SD (logged)	1.728	95% Critical H Value (KM-Log)	3.682
KM Standard Error of Mean (logged)	0.394		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	2.859	Mean in Log Scale	-0.788
SD in Original Scale	6.654	SD in Log Scale	2.067
95% t UCL (Assumes normality)	5.363	95% H-Stat UCL	27.57

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

Nonparametric Distribution Free UCL Statistics

Detected Data appear Gamma Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (BCA) UCL	5.562	95% GROS Adjusted Gamma UCL	7.304
95% Adjusted Gamma KM-UCL	8.956		

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.

Dibenzo(a,h)anthracene

General Statistics

Total Number of Observations	19	Number of Distinct Observations	4
Number of Detects	2	Number of Non-Detects	17
Number of Distinct Detects	2	Number of Distinct Non-Detects	3
Minimum Detect	1	Minimum Non-Detect	0.21
Maximum Detect	3	Maximum Non-Detect	1
Variance Detects	2	Percent Non-Detects	89.47%
Mean Detects	2	SD Detects	1.414
Median Detects	2	CV Detects	0.707
Skewness Detects	N/A	Kurtosis Detects	N/A
Mean of Logged Detects	0.549	SD of Logged Detects	0.777

Warning: Data set has only 2 Detected Values.
This is not enough to compute meaningful or reliable statistics and estimates.

Normal GOF Test on Detects Only
Not Enough Data to Perform GOF Test

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

Mean	0.398	Standard Error of Mean	0.207
SD	0.638	95% KM (BCA) UCL	N/A
95% KM (t) UCL	0.757	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	0.739	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	1.019	95% KM Chebyshev UCL	1.301
97.5% KM Chebyshev UCL	1.691	99% KM Chebyshev UCL	2.458

Gamma GOF Tests on Detected Observations Only
Not Enough Data to Perform GOF Test

Gamma Statistics on Detected Data Only

k hat (MLE)	3.634	k star (bias corrected MLE)	N/A
Theta hat (MLE)	0.55	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	14.54	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.39	nu hat (KM)	14.82
		Adjusted Level of Significance (β)	0.0369
Approximate Chi Square Value (14.82, α)	7.136	Adjusted Chi Square Value (14.82, β)	6.674
95% Gamma Approximate KM-UCL (use when n>=50)	0.827	95% Gamma Adjusted KM-UCL (use when n<50)	0.885

Lognormal GOF Test on Detected Observations Only
Not Enough Data to Perform GOF Test

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.23	Mean in Log Scale	-4.732
SD in Original Scale	0.708	SD in Log Scale	2.729
95% t UCL (assumes normality of ROS data)	0.512	95% Percentile Bootstrap UCL	0.539
95% BCA Bootstrap UCL	0.708	95% Bootstrap t UCL	4.454
95% H-UCL (Log ROS)	13.14		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	0.387	Mean in Log Scale	-1.577
SD in Original Scale	0.674	SD in Log Scale	0.96
95% t UCL (Assumes normality)	0.655	95% H-Stat UCL	0.584

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

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

Suggested UCL to Use

95% KM (t) UCL	0.757	95% KM (% Bootstrap) UCL	N/A

Warning: One or more Recommended UCL(s) not available!

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.

Indeno(1,2,3-cd)pyrene

General Statistics

Total Number of Observations	19	Number of Distinct Observations	5
Number of Detects	6	Number of Non-Detects	13
Number of Distinct Detects	4	Number of Distinct Non-Detects	2
Minimum Detect	0.9	Minimum Non-Detect	0.29
Maximum Detect	9	Maximum Non-Detect	1
Variance Detects	12.34	Percent Non-Detects	68.42%
Mean Detects	3.133	SD Detects	3.513
Median Detects	1	CV Detects	1.121
Skewness Detects	1.271	Kurtosis Detects	-0.0776
Mean of Logged Detects	0.63	SD of Logged Detects	1.066

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.714	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.788	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.395	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.362	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

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

Mean	1.204	Standard Error of Mean	0.561
SD	2.231	95% KM (BCA) UCL	N/A
95% KM (t) UCL	2.177	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	2.127	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	2.887	95% KM Chebyshev UCL	3.65
97.5% KM Chebyshev UCL	4.708	99% KM Chebyshev UCL	6.787

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.991	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.713	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.417	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.34	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.113	k star (bias corrected MLE)	0.668
Theta hat (MLE)	2.815	Theta star (bias corrected MLE)	4.694
nu hat (MLE)	13.35	nu star (bias corrected)	8.011
MLE Mean (bias corrected)	3.133	MLE Sd (bias corrected)	3.835

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.291	nu hat (KM)	11.07
Approximate Chi Square Value (11.07, α)	4.621	Adjusted Chi Square Value (11.07, β)	4.262
95% Gamma Approximate KM-UCL (use when n>=50)	2.884	95% Gamma Adjusted KM-UCL (use when n<50)	3.127

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	0.996
Maximum	9	Median	0.01
SD	2.378	CV	2.386
k hat (MLE)	0.242	k star (bias corrected MLE)	0.239
Theta hat (MLE)	4.114	Theta star (bias corrected MLE)	4.169
nu hat (MLE)	9.202	nu star (bias corrected)	9.082
MLE Mean (bias corrected)	0.996	MLE Sd (bias corrected)	2.038
		Adjusted Level of Significance (β)	0.0369
Approximate Chi Square Value (9.08, α)	3.377	Adjusted Chi Square Value (9.08, β)	3.079
95% Gamma Approximate UCL (use when n>=50)	2.68	95% Gamma Adjusted UCL (use when n<50)	2.939

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.713	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.788	Detected Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.389	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.362	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	1.075	Mean in Log Scale	-1.572
SD in Original Scale	2.346	SD in Log Scale	1.894
95% t UCL (assumes normality of ROS data)	2.008	95% Percentile Bootstrap UCL	2.067
95% BCA Bootstrap UCL	2.386	95% Bootstrap t UCL	6.099
95% H-UCL (Log ROS)	7.662		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	1.145	Mean in Log Scale	-0.927
SD in Original Scale	2.318	SD in Log Scale	1.301
95% t UCL (Assumes normality)	2.067	95% H-Stat UCL	2.361

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

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

95% KM (BCA) UCL	N/A

Warning: One or more Recommended UCL(s) not available!

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	35	Number of Distinct Observations	34
		Number of Missing Observations	0
Minimum	4.05	Mean	202.5
Maximum	660	Median	140
SD	207.2	Std. Error of Mean	35.02
Coefficient of Variation	1.023	Skewness	0.904

Normal GOF Test

Shapiro Wilk Test Statistic	0.843	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.934	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.169	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.15	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	261.7	95% Adjusted-CLT UCL (Chen-1995)	265.8
		95% Modified-t UCL (Johnson-1978)	262.6

Gamma GOF Test

A-D Test Statistic	0.898	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.797	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.136	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.156	Detected data appear Gamma Distributed at 5% Significance Level

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

Gamma Statistics

k hat (MLE)	0.652	k star (bias corrected MLE)	0.615
Theta hat (MLE)	310.5	Theta star (bias corrected MLE)	329.1
nu hat (MLE)	45.65	nu star (bias corrected)	43.07
MLE Mean (bias corrected)	202.5	MLE Sd (bias corrected)	258.1
		Approximate Chi Square Value (0.05)	29.02
Adjusted Level of Significance	0.0425	Adjusted Chi Square Value	28.48

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	300.5	95% Adjusted Gamma UCL (use when n<50)	306.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.867	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.934	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.175	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.15	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.399	Mean of logged Data	4.375
Maximum of Logged Data	6.492	SD of logged Data	1.726

Assuming Lognormal Distribution

95% H-UCL	983.8	90% Chebyshev (MVUE) UCL	694.2
95% Chebyshev (MVUE) UCL	863.6	97.5% Chebyshev (MVUE) UCL	1099
99% Chebyshev (MVUE) UCL	1560		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	260.1	95% Jackknife UCL	261.7
95% Standard Bootstrap UCL	261.9	95% Bootstrap-t UCL	268.3
95% Hall's Bootstrap UCL	267.2	95% Percentile Bootstrap UCL	262
95% BCA Bootstrap UCL	266.3		
90% Chebyshev(Mean, Sd) UCL	307.5	95% Chebyshev(Mean, Sd) UCL	355.1
97.5% Chebyshev(Mean, Sd) UCL	421.2	99% Chebyshev(Mean, Sd) UCL	550.9

Suggested UCL to Use

95% Adjusted Gamma UCL	306.3

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

Naphthalene

General Statistics

Total Number of Observations	21	Number of Distinct Observations	11
		Number of Missing Observations	14
Number of Detects	11	Number of Non-Detects	10
Number of Distinct Detects	9	Number of Distinct Non-Detects	2
Minimum Detect	0.063	Minimum Non-Detect	0.037
Maximum Detect	10	Maximum Non-Detect	0.29
Variance Detects	12.72	Percent Non-Detects	47.62%
Mean Detects	2.651	SD Detects	3.567
Median Detects	1	CV Detects	1.345
Skewness Detects	1.549	Kurtosis Detects	1.189
Mean of Logged Detects	-0.177	SD of Logged Detects	1.834

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.734	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.279	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.267	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

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

Mean	1.407	Standard Error of Mean	0.638
SD	2.786	95% KM (BCA) UCL	2.452
95% KM (t) UCL	2.507	95% KM (Percentile Bootstrap) UCL	2.506
95% KM (z) UCL	2.456	95% KM Bootstrap t UCL	4.149
90% KM Chebyshev UCL	3.32	95% KM Chebyshev UCL	4.187
97.5% KM Chebyshev UCL	5.389	99% KM Chebyshev UCL	7.751

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.383	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.778	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.168	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.268	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.544	k star (bias corrected MLE)	0.456
Theta hat (MLE)	4.871	Theta star (bias corrected MLE)	5.808
nu hat (MLE)	11.97	nu star (bias corrected)	10.04
MLE Mean (bias corrected)	2.651	MLE Sd (bias corrected)	3.924

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.255	nu hat (KM)	10.72
Approximate Chi Square Value (10.72, α)	4.397	Adjusted Chi Square Value (10.72, β)	4.09
95% Gamma Approximate KM-UCL (use when n>=50)	3.432	95% Gamma Adjusted KM-UCL (use when n<50)	3.69

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	1.393
Maximum	10	Median	0.063
SD	2.862	CV	2.054
k hat (MLE)	0.268	k star (bias corrected MLE)	0.262
Theta hat (MLE)	5.194	Theta star (bias corrected MLE)	5.325
nu hat (MLE)	11.27	nu star (bias corrected)	10.99
MLE Mean (bias corrected)	1.393	MLE Sd (bias corrected)	2.724
		Adjusted Level of Significance (β)	0.0383
Approximate Chi Square Value (10.99, α)	4.571	Adjusted Chi Square Value (10.99, β)	4.256
95% Gamma Approximate UCL (use when n>=50)	3.351	95% Gamma Adjusted UCL (use when n<50)	3.599

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.918	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.149	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.267	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	1.395	Mean in Log Scale	-2.478
SD in Original Scale	2.861	SD in Log Scale	2.974
95% t UCL (assumes normality of ROS data)	2.472	95% Percentile Bootstrap UCL	2.502
95% BCA Bootstrap UCL	2.885	95% Bootstrap t UCL	4
95% H-UCL (Log ROS)	343.5		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-1.647	95% H-UCL (KM -Log)	9.053
KM SD (logged)	2	95% Critical H Value (KM-Log)	4.14
KM Standard Error of Mean (logged)	0.458		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	1.404	Mean in Log Scale	-1.895
SD in Original Scale	2.857	SD in Log Scale	2.298
95% t UCL (Assumes normality)	2.479	95% H-Stat UCL	23.07

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

Nonparametric Distribution Free UCL Statistics

Detected Data appear Gamma Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (BCA) UCL	2.452	95% GROS Adjusted Gamma UCL	3.599
95% Adjusted Gamma KM-UCL	3.69		

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	21	Number of Distinct Observations	21
		Number of Missing Observations	14
Minimum	8.03	Mean	369.5
Maximum	3380	Median	35.9
SD	969.4	Std. Error of Mean	211.5
Coefficient of Variation	2.624	Skewness	2.95

Normal GOF Test

Shapiro Wilk Test Statistic	0.398	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.908	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.433	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.193	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	734.3	95% Adjusted-CLT UCL (Chen-1995)	862.9
		95% Modified-t UCL (Johnson-1978)	757

Gamma GOF Test

A-D Test Statistic	2.875	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.835	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.312	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.204	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.354	k star (bias corrected MLE)	0.335
Theta hat (MLE)	1044	Theta star (bias corrected MLE)	1103
nu hat (MLE)	14.86	nu star (bias corrected)	14.07
MLE Mean (bias corrected)	369.5	MLE Sd (bias corrected)	638.3
		Approximate Chi Square Value (0.05)	6.62
Adjusted Level of Significance	0.0383	Adjusted Chi Square Value	6.229

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	785.3	95% Adjusted Gamma UCL (use when n<50)	834.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.864	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.908	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.166	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.193	Data appear Lognormal at 5% Significance Level

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.083	Mean of logged Data	4.015
Maximum of Logged Data	8.126	SD of logged Data	1.694

Assuming Lognormal Distribution

95% H-UCL	918.9	90% Chebyshev (MVUE) UCL	476.3
95% Chebyshev (MVUE) UCL	600.6	97.5% Chebyshev (MVUE) UCL	773.2
99% Chebyshev (MVUE) UCL	1112		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	717.4	95% Jackknife UCL	734.3
95% Standard Bootstrap UCL	707.2	95% Bootstrap-t UCL	4785
95% Hall's Bootstrap UCL	3710	95% Percentile Bootstrap UCL	698.9
95% BCA Bootstrap UCL	851.6		
90% Chebyshev(Mean, Sd) UCL	1004	95% Chebyshev(Mean, Sd) UCL	1291
97.5% Chebyshev(Mean, Sd) UCL	1690	99% Chebyshev(Mean, Sd) UCL	2474

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	1291

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

ATTACHMENT B

Resident Equation Inputs for Soil

Variable	Value
TR (target cancer risk) unitless	0.000001
ED_{ress} (exposure duration - resident) year	26
ED_{ressc} (exposure duration - child) year	6
ED_{ressa} (exposure duration - adult) year	20
ET_{ress} (exposure time - resident) hour	24
ET_{ressc} (exposure time - child) hour	24
ET_{ressa} (exposure time - adult) hour	24
BW_{ressa} (body weight - adult) kg	80
BW_{ressc} (body weight - child) kg	15
SA_{ressa} (skin surface area - adult) cm^2/day	6032
SA_{ressc} (skin surface area - child) cm^2/day	2690
THQ (target hazard quotient) unitless	1
LT (lifetime - resident) year	70
EF_{ress} (exposure frequency - resident) day/year	350
EF_{ressc} (exposure frequency - child) day/year	350
EF_{ressa} (exposure frequency - adult) day/year	350
IRS_{ressa} (soil intake rate - adult) mg/day	100
IRS_{ressc} (soil intake rate - child) mg/day	200
AF_{ressa} (skin adherence factor - adult) mg/cm^2	0.07
AF_{ressc} (skin adherence factor - child) mg/cm^2	0.2
$IFS_{res\text{-}adj}$ (age-adjusted soil ingestion factor) mg/kg	36750
$DFS_{res\text{-}adj}$ (age-adjusted soil dermal factor) mg/kg	112266
$IFSM_{res\text{-}adj}$ (mutagenic age-adjusted soil ingestion factor) mg/kg	166833.3
$DFSM_{res\text{-}adj}$ (mutagenic age-adjusted soil dermal factor) mg/kg	475598.7
$AF_{0\text{-}2}$ (skin adherence factor) mg/cm^2	0.2
$AF_{2\text{-}6}$ (skin adherence factor) mg/cm^2	0.2
$AF_{6\text{-}16}$ (skin adherence factor) mg/cm^2	0.07
$AF_{16\text{-}30}$ (skin adherence factor) mg/cm^2	0.07
$BW_{0\text{-}2}$ (body weight) kg	15
$BW_{2\text{-}6}$ (body weight) kg	15
$BW_{6\text{-}16}$ (body weight) kg	80
$BW_{16\text{-}30}$ (body weight) kg	80
$ED_{0\text{-}2}$ (exposure duration) year	2
$ED_{2\text{-}6}$ (exposure duration) year	4
$ED_{6\text{-}16}$ (exposure duration) year	10
$ED_{16\text{-}30}$ (exposure duration) year	10
$EF_{0\text{-}2}$ (exposure frequency) day/year	350
$EF_{2\text{-}6}$ (exposure frequency) day/year	350
$EF_{6\text{-}16}$ (exposure frequency) day/year	350
$EF_{16\text{-}30}$ (exposure frequency) day/year	350
$ET_{0\text{-}2}$ (exposure time) hour/day	24
$ET_{2\text{-}6}$ (exposure time) hour/day	24
$ET_{6\text{-}16}$ (exposure time) hour/day	24
$ET_{16\text{-}30}$ (exposure time) hour/day	24
$IRS_{0\text{-}2}$ (soil intake rate) mg/day	200
$IRS_{2\text{-}6}$ (soil intake rate) mg/day	200
$IRS_{6\text{-}16}$ (soil intake rate) mg/day	100
$IRS_{16\text{-}30}$ (soil intake rate) mg/day	100
$SA_{0\text{-}2}$ (skin surface area) cm^2/day	2690
$SA_{2\text{-}6}$ (skin surface area) cm^2/day	2690
$SA_{6\text{-}16}$ (skin surface area) cm^2/day	6032
$SA_{16\text{-}30}$ (skin surface area) cm^2/day	6032
City (Climate Zone) PEF Selection	Default
A_s (acres) PEF Selection	0.5
Q/C_{wp} (g/m^2-s per kg/m^3) PEF Selection	93.77
PEF (particulate emission factor) m^3/kg	1359344438
A (PEF Dispersion Constant)	16.2302
B (PEF Dispersion Constant)	18.7762
C (PEF Dispersion Constant)	216.108
V (fraction of vegetative cover) unitless	0.5
U_m (mean annual wind speed) m/s	4.69
U_t (equivalent threshold value)	11.32
F(x) (function dependant on U_m/U_t) unitless	0.194
City (Climate Zone) VF Selection	Default
A_s (acres) VF Selection	0.5
A (VF Dispersion Constant)	11.911
B (VF Dispersion Constant)	18.4385
C (VF Dispersion Constant)	209.7845
Q/C_{wp} (g/m^2-s per kg/m^3) VF Selection	68.18
foc (fraction organic carbon in soil) g/g	0.006
ρ_b (dry soil bulk density) g/cm^3	1.5
ρ_s (soil particle density) g/cm^3	2.65
θ_w (water-filled soil porosity) L_{water}/L_{soil}	0.15
T (exposure interval) s	819936000
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Recreator Equation Inputs for Soil/Sediment

Variable	Value
TR (target cancer risk) unitless	0.000001
ED_r (exposure duration - recreator) years	26
ET_r (exposure time - recreator) hours	1
ED_c (exposure duration - child) years	6
BW_a (body weight - adult) kg	80
BW_c (body weight - child) kg	15
SA_a (skin surface area - adult) cm^2/day	6032
SA_c (skin surface area - child) cm^2/day	2690
THQ (target hazard quotient) unitless	1
LT (lifetime - recreator) yr	70
EF_r (exposure frequency) d/yr	75
IRS_a (soil intake rate - adult) mg/day	100
IRS_c (soil intake rate - child) mg/day	200
AF_a (skin adherence factor - adult) mg/cm^2	0.07
AF_c (skin adherence factor - child) mg/cm^2	0.2
IFS_{adj} (age-adjusted soil ingestion factor) mg/kg	7875
DFS_{adj} (age-adjusted soil dermal factor) mg/kg	24057
$IFSM_{adj}$ (mutagenic age-adjusted soil ingestion factor) mg/kg	35750
$DFSM_{adj}$ (mutagenic age-adjusted soil dermal factor) mg/kg	101914
AF_{0-2} (skin adherence factor) mg/cm^2	0.2
AF_{2-6} (skin adherence factor) mg/cm^2	0.2
AF_{6-16} (skin adherence factor) mg/cm^2	0.07
AF_{16-30} (skin adherence factor) mg/cm^2	0.07
BW_{0-2} (body weight) kg	15
BW_{2-6} (body weight) kg	15
BW_{6-16} (body weight) kg	80
BW_{16-30} (body weight) kg	80
ED_{0-2} (exposure duration) year	2
ED_{2-6} (exposure duration) year	4
ED_{6-16} (exposure duration) year	10
ED_{16-30} (exposure duration) year	10
EF_{0-2} (exposure frequency) day/year	75
EF_{2-6} (exposure frequency) day/year	75
EF_{6-16} (exposure frequency) day/year	75
EF_{16-30} (exposure frequency) day/year	75
ET_{0-2} (exposure time) hour/day	1
ET_{2-6} (exposure time) hour/day	1
ET_{6-16} (exposure time) hour/day	1
ET_{16-30} (exposure time) hour/day	1
IRS_{0-2} (soil intake rate) mg/day	200
IRS_{2-6} (soil intake rate) mg/day	200
IRS_{6-16} (soil intake rate) mg/day	100
IRS_{16-30} (soil intake rate) mg/day	100
SA_{0-2} (skin surface area) cm^2/day	2690
SA_{2-6} (skin surface area) cm^2/day	2690
SA_{6-16} (skin surface area) cm^2/day	6032
SA_{16-30} (skin surface area) cm^2/day	6032
City (Climate Zone) PEF Selection	Default
A_s (acres) PEF Selection	0.5
Q/C_{wp} (g/m^2-s per kg/m^3) PEF Selection	93.77
PEF (particulate emission factor) m^3/kg	1359344438
A (PEF Dispersion Constant)	16.2302
B (PEF Dispersion Constant)	18.7762
C (PEF Dispersion Constant)	216.108
V (fraction of vegetative cover) unitless	0.5
U_m (mean annual wind speed) m/s	4.69
U_t (equivalent threshold value)	11.32
F(x) (function dependant on U_m/U_t) unitless	0.194
City (Climate Zone) VF Selection	Default
A_s (acres) VF Selection	0.5
A (VF Dispersion Constant)	11.911
B (VF Dispersion Constant)	18.4385
C (VF Dispersion Constant)	209.7845
Q/C_{wp} (g/m^2-s per kg/m^3) VF Selection	68.18
foc (fraction organic carbon in soil) g/g	0.006
ρ_b (dry soil bulk density) g/cm^3	1.5
ρ_s (soil particle density) g/cm^3	2.65
θ_w (water-filled soil porosity) L_{water}/L_{soil}	0.15
T (exposure interval) s	819936000
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Resident RISK for Soil

Chemical	Mutagen?	VOC ?	Chronic RfD (mg/kg-day)	RfD Reference	Chronic RfC (mg/m^3)	RfC Reference	Ingestion SF $(mg/kg\text{-}day)^{-1}$	SFO Reference	Inhalation Unit Risk $(ug/m^3)^{-1}$	IUR Reference	ABS_{gi}	ABS_{derm}
Antimony (metallic)	No	No	0.0004	IRIS	-		-		-		1.50E-01	-
Chrysene	Yes	No	-		-		0.0073	Surroga	1.10E-05	CALEPA	1.00E+00	1.30E-01
Naphthalene	No	Yes	0.02	IRIS	0.003	IRIS	-		3.40E-05	CALEPA	1.00E+00	1.30E-01
Zinc and Compounds	No	No	0.3	IRIS	-		-		-		1.00E+00	-
**Total Risk/HI*			-		-		-		-		-	-

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D_{ia}	D_{iw}	H`	K_d	Volatilization Factor (m^3/kg)	Particulate Emission Factor (m^3/kg)	Soil Saturation Concentration (mg/kg)	Concentration (mg/kg)	Child Ingestion Noncarcinogenic CDI	Child Inhalation Noncarcinogenic CDI
-	-	-	4.50E+01	-	1.36E+09	-	1.49E+01	1.91E-04	1.05E-08
2.61E-02	6.75E-06	2.14E-04	-	-	1.36E+09	-	8.96E+00	1.15E-04	6.32E-09
6.05E-02	8.38E-06	1.80E-02	9.26E+00	4.63E+04	1.36E+09	-	3.69E+00	4.72E-05	7.64E-05
-	-	-	6.20E+01	-	1.36E+09	-	1.29E+03	1.65E-02	9.11E-07
-	-	-	-	-	-	-	-	-	-

Child Dermal Noncarcinogenic CDI	Adult Ingestion Noncarcinogenic CDI	Adult Inhalation Noncarcinogenic CDI	Adult Dermal Noncarcinogenic CDI	Adjusted Ingestion Noncarcinogenic CDI	Adjusted Inhalation Noncarcinogenic CDI	Adjusted Dermal Noncarcinogenic CDI	Ingestion Carcinogenic CDI	Inhalation Carcinogenic CDI	Dermal Carcinogenic CDI
-	1.79E-05	1.05E-08	-	5.78E-05	1.05E-08	-	2.15E-05	3.91E-06	-
4.00E-05	1.07E-05	6.32E-09	5.89E-06	3.47E-05	6.32E-09	1.38E-05	5.85E-05	6.50E-06	2.17E-05
1.65E-05	4.42E-06	7.64E-05	2.43E-06	1.43E-05	7.64E-05	5.67E-06	5.31E-06	2.84E-02	2.11E-06
-	1.55E-03	9.11E-07	-	5.00E-03	9.11E-07	-	1.86E-03	3.38E-04	-
-	-	-	-	-	-	-	-	-	-

Child Ingestion HQ	Child Inhalation HQ	Child Dermal HQ	Child Total HI	Adult Ingestion HQ	Adult Inhalation HQ	Adult Dermal HQ	Adult Total HI	Adjusted Ingestion HQ	Adjusted Inhalation HQ
4.77E-01	-	-	4.77E-01	4.47E-02	-	-	4.47E-02	1.45E-01	-
-	-	-	-	-	-	-	-	-	-
2.36E-03	2.55E-02	8.25E-04	2.86E-02	2.21E-04	2.55E-02	1.21E-04	2.58E-02	7.14E-04	2.55E-02
5.50E-02	-	-	5.50E-02	5.16E-03	-	-	5.16E-03	1.67E-02	-
5.35E-01	*2.55E-02*	*8.25E-04*	*5.61E-01*	*5.01E-02*	*2.55E-02*	*1.21E-04*	*7.57E-02*	*1.62E-01*	*2.55E-02*

Adjusted Dermal HQ	Adjusted Total HI	Ingestion Risk	Inhalation Risk	Dermal Risk	Total Risk
-	1.45E-01	-	-	-	-
-	-	4.27E-07	7.15E-11	1.58E-07	5.85E-07
2.84E-04	2.65E-02	-	9.65E-07	-	9.65E-07
-	1.67E-02	-	-	-	-
2.84E-04	*1.88E-01*	*4.27E-07*	*9.65E-07*	*1.58E-07*	***1.55E-06***

Recreator RISK for Soil/Sediment

Chemical	Mutagen?	VOC ?	Chronic RfD (mg/kg-day)	RfD Reference	Chronic RfC (mg/m^3)	RfC Reference	Ingestion SF $(mg/kg\text{-}day)^{-1}$	SFO Reference	Inhalation Unit Risk $(ug/m^3)^{-1}$	IUR Reference	ABS_{gi}	ABS_{derm}
Antimony (metallic)	No	No	0.0004	IRIS	-		-		-		0.15	-
Chrysene	Yes	No	-		-		0.0073	Surroga	0.000011	CALEPA	1	0.13
Naphthalene	No	Yes	0.02	IRIS	0.003	IRIS	-		0.000034	CALEPA	1	0.13
Zinc and Compounds	No	No	0.3	IRIS	-		-		-		1	-
Total Risk/HI			-		-		-		-		-	-

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D_{ia}	D_{iw}	H`	K_d	Volatilization Factor (m^3/kg)	Particulate Emission Factor (m^3/kg)	Soil Saturation Concentration (mg/kg)	Concentration (mg/kg)	Child Ingestion Noncarcinogenic CDI	Child Inhalation Noncarcinogenic CDI
-	-	-	4.50E+01	-	1.36E+09	-	1.49E+01	4.09E-05	9.40E-11
2.61E-02	6.75E-06	2.14E-04	-	-	1.36E+09	-	8.96E+00	2.45E-05	5.64E-11
6.05E-02	8.38E-06	1.80E-02	9.26E+00	4.63E+04	1.36E+09	-	3.69E+00	1.01E-05	6.82E-07
-	-	-	6.20E+01	-	1.36E+09	-	1.29E+03	3.54E-03	8.13E-09
-	-	-	-	-	-	-	-	-	-

Child Dermal Noncarcinogenic CDI	Adult Ingestion Noncarcinogenic CDI	Adult Inhalation Noncarcinogenic CDI	Adult Dermal Noncarcinogenic CDI	Adjusted Ingestion Noncarcinogenic CDI	Adjusted Inhalation Noncarcinogenic CDI	Adjusted Dermal Noncarcinogenic CDI	Ingestion Carcinogenic CDI	Inhalation Carcinogenic CDI	Dermal Carcinogenic CDI
-	3.83E-06	9.40E-11	-	1.24E-05	9.40E-11	-	4.60E-06	3.49E-08	-
8.58E-06	2.30E-06	5.64E-11	1.26E-06	7.43E-06	5.64E-11	2.95E-06	1.25E-05	5.80E-08	4.64E-06
3.54E-06	9.48E-07	6.82E-07	5.20E-07	3.06E-06	6.82E-07	1.22E-06	1.14E-06	2.53E-04	4.52E-07
-	3.32E-04	8.13E-09	-	1.07E-03	8.13E-09	-	3.98E-04	3.02E-06	-
-	-	-	-	-	-	-	-	-	-

Child Ingestion HQ	Child Inhalation HQ	Child Dermal HQ	Child Total HI	Adult Ingestion HQ	Adult Inhalation HQ	Adult Dermal HQ	Adult Total HI	Adjusted Ingestion HQ	Adjusted Inhalation HQ
1.02E-01	-	-	1.02E-01	9.59E-03	-	-	9.59E-03	3.10E-02	-
-	-	-	-	-	-	-	-	-	-
5.05E-04	2.27E-04	1.77E-04	9.10E-04	4.74E-05	2.27E-04	2.60E-05	3.01E-04	1.53E-04	2.27E-04
1.18E-02	-	-	1.18E-02	1.11E-03	-	-	1.11E-03	3.57E-03	-
1.15E-01	*2.27E-04*	*1.77E-04*	*1.15E-01*	*1.07E-02*	*2.27E-04*	*2.60E-05*	*1.10E-02*	*3.47E-02*	*2.27E-04*

Adjusted Dermal HQ	Adjusted Total HI	Ingestion Risk	Inhalation Risk	Dermal Risk	Total Risk
-	3.10E-02	-	-	-	-
-	-	9.15E-08	6.38E-13	3.39E-08	1.25E-07
6.08E-05	4.41E-04	-	8.61E-09	-	8.61E-09
-	3.57E-03	-	-	-	-
6.08E-05	*3.50E-02*	*9.15E-08*	*8.61E-09*	*3.39E-08*	*1.34E-07*