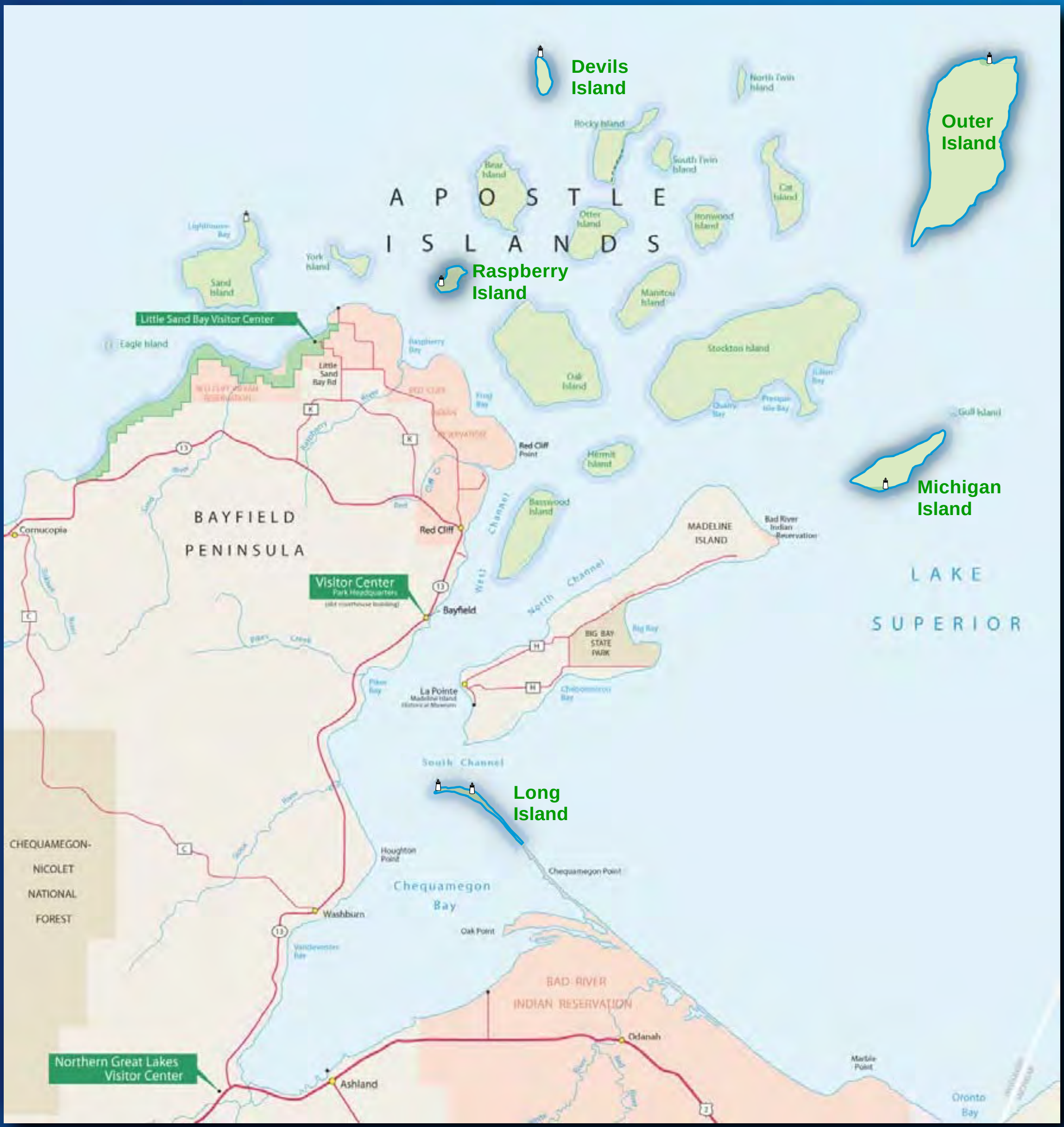
Apostle Islands National Lakeshore

Draft Final Engineering Evaluation/Cost Analysis for Lead-Impacted Soils at Light Stations on Michigan, Outer, Raspberry, Devils, and Long Islands



Prepared for:

National Park Service
415 Washington Avenue
Bayfield, WI 54814

Prepared by:

Weston Solutions, Inc.
P.O. Box 577
Houghton, MI 49931

and

PRIZIM, Inc.
4740 White Bear Parkway, Suite 102
White Bear Lake, MN 55110

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DRAFT FINAL

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PRIZIM, Inc.
4740 White Bear Parkway, Suite 102
White Bear Lake, MN 55110

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LIST OF ACRONYMS

µg/dL	Microgram per deciliter
ACHP	Advisory Council on Historic Preservation
AHA	Anderson Hallas Architects
ALM	Adult Lead Model
APIS	Apostle Islands National Lakeshore
ARAR	Applicable or Relevant and Appropriate Requirements
bgs	Below Ground Surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CET	Clean Earth Technologies, Inc.
CFR	Code of Federal Regulations
CLR	Cultural Landscape Report
CWA	Clean Water Act
CY	Cubic Yards
DC	Direct Contact
ECC	Environmental Chemical Corporation
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
FSP	Field Sampling Plan
ft	Feet
FWS	U.S. Fish and Wildlife Service
H	Horizontal
HHRA	Human Health Risk Assessment Model
HSR	Historic Structure Report
IC	Institutional Controls
IEUBK	Integrated Exposure-Uptake Biokinetic
LOAEL	Lowest Observed Adverse Effect Level
mg/kg	Milligram per kilogram
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	Commerce Department’s National Marine Fisheries Service
NPS	National Park Service

LIST OF ACRONYMS (CONTINUED)

PA	Preliminary Assessment
PRG	Preliminary Remedial Goals
PPE	Personal Protective Equipment
PRIZIM	PRIZIM, Inc.
RA	Risk Assessment
RAO	Remedial Action Objective
RCL	Soil Residual Contaminant Level
RCRA	Resource Conservation and Recovery Act
SAIC	Science Applications International Corporation, Inc.
SARA	Superfund Amendments and Reauthorization Act
SESC	Soil Erosion and Sedimentation Controls
SHPO	State Historic Preservation Office
SI	Site investigation
SLERA	Screening Level Ecological Risk Assessment
SOW	Statement of Work
SSA	Site-Specific Attachment
SY	Square Yards
TBC	To-Be-Considered Materials
THPO	Tribal Historic Preservation Office
UCL	Upper Confidence Limit
USACE	United States Army Corps of Engineers
U.S.C	United States Code
V	Vertical
WDNR	Wisconsin Department of Natural Resources
WESTON	Weston Solutions, Inc.
Wis. Admin. Code	Wisconsin Administrative Code
WPDES	Wisconsin Pollutant Discharge Elimination System
XRF	X-Ray Fluorescence

EXECUTIVE SUMMARY

Weston Solutions, Inc. (WESTON®) has prepared this Engineering Evaluation/Cost Analysis (EE/CA) to assist the National Park Service (NPS) in undertaking response activities at the Apostle Islands National Lakeshore (APIS). This EE/CA was prepared by WESTON in accordance with the NPS document, *Statement of Work Engineering Evaluation/Cost Analysis (EE/CA) for Apostle Islands National Lakeshore* dated July 2013 (**Appendix A**). The EE/CA is based on the findings presented in the November 2012 *National Park Service Great Lakes Restoration Initiative Apostle Islands National Lakeshore Letter Report*. The EE/CA has been prepared under the PRIZIM, Inc. (PRIZIM) a wholly owned subsidiary of Hitachi Consulting Contract No. B2420090003 with NPS Midwest Region and WESTON's *Proposal for Engineering Evaluation/Cost Analysis, Apostle Islands National Lakeshore, Bayfield, Wisconsin* dated August 2013.

This EE/CA has been prepared to:

- Summarize results from previous sampling efforts;
- Assess human and ecological risk;
- Identify applicable or relevant and appropriate requirements (ARARs);
- Establish target risk levels;
- Develop site-specific preliminary remedial goals (PRGs); and,
- Analyze an appropriate array of response alternatives consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

Proposed response activities were conceptualized based on the findings of remedial investigation activities completed at each of the following five islands (project sites) within APIS.

- Michigan Island;
- Outer Island;
- Raspberry Island;
- Devils Island; and,
- Long Island.

Due to heavy traffic in the shipping lanes, multiple lighthouses were constructed in the mid-1800s to the early 1900s. These lighthouses required constant maintenance. The light station complexes range in size from a few buildings to large multi-building complexes that housed multiple keepers and their families. Lead-based paint was used on numerous structures on the islands. During the 1960s and 1970s, these lighthouses became automated and no longer required the constant care the onsite keepers provided.

Today these complexes have been added the National Register of Historic Places. The grounds are open to the public for hiking and recreational use. Some of the buildings have been restored and are open for guided tours. For additional site history information, refer to the APIS Site Specific Attachment (SSA) Field Sampling Plan (FSP) and its Addendum (NPS 2011a and NPS 2012).

The results of previous investigations at the project sites determined that lead concentrations exceeding human health action levels were present at each light station making them subject to processes and rules promulgated under the CERCLA and the NCP. As such, a Draft Risk Assessment (RA) Report (**Appendix B**) was prepared to develop site-specific human health PRGs and determine whether available data indicate the potential for ecological impacts from lead in soil for use in evaluating the removal alternatives

PRGs were developed for each receptor group using the Adult Lead Model. Exposure frequencies of five days per week and an averaging time of mid-April through mid-October (183 days) were used for the Maintenance Worker. An exposure frequency of one and five days per week for an Interpretive Park Ranger and seven days per week for a Volunteer Lighthouse Keeper were used for an averaging time of mid-June through September (107 days). Continuous exposure for three months was also considered for a Volunteer Lighthouse Keeper. PRGs were calculated as follows:

- Maintenance Worker – Mid-April through Mid-October: 939 milligrams per kilogram (mg/kg);
- Interpretive Park Ranger (one day/week) – Mid-April through Mid-October: 9,458 mg/kg;
- Interpretive Park Ranger (five days/week) – Mid-June through End September: 1,881 mg/kg;
- Volunteer Lighthouse Keeper – Mid-June through End September - Adult: 1,344 mg/kg; and,
- Volunteer Lighthouse Keeper – Mid-June through End September - Adolescent: 768 mg/kg.

Based on the infrequent use of the project sites by young children, this receptor group is not evaluated in the Human Health Risk Assessment (HHRA). Utilizing the most conservative of the calculated PRGs, lead concentrations greater than 768 mg/kg were determined to present unacceptable exposures to human and ecological receptors at each light station. If a young child would be in residence in the keeper's quarters at the light stations EPA (1994) and WDNR (2013) have established a residential cleanup level of 400 mg/kg. Use of the 768 mg/kg PRG will require an institutional control that young children not be allowed in residence at the light stations.

As part of the EE/CA, removal action objectives (RAOs) were developed for each of the project sites to mitigate exposure risks associated with lead contamination present in shallow surface and near-surface soils in the vicinity of structures and trash pile locations at the light stations at each of the project sites.

The RAOs include the mitigation of unacceptable exposures to contaminated soils from the impacted areas of each light station.

Implementation of these actions require that ARARs are attained while ensuring that the fundamental purpose of the NPS remains the principle factor in determining the applicability of the proposed actions at each of the project sites. Specific goals for the proposed removal actions include:

- Elimination of the potential migration of contaminated soil through erosion and disturbance;
- Elimination of the exposure pathways to human and ecological receptors; and,
- Preservation of the historical and cultural landscape and conservation of the scenery and natural surroundings at APIS.

It is anticipated that completion of the removal action at each of the project sites will be a final action necessary to address soil contamination related to deterioration of lead-based paint and trash piles at the subject facilities. Further, achievement of the RAOs at each of the project sites will reduce threats to human health and the environment while eliminating the need for long-term management of the impacted areas and preserving the mission of the NPS.

The overall goal of a potential removal action at the project sites is to minimize the risk that lead poses to human health and/or the environment. The removal action scope considers soil removal, and/or controlled exposure via engineering and institutional controls, protective of human health and the environment based on the project site's current and anticipated future land use. These uses include continued recreational use as part of APIS.

The removal action scope involves mitigating soil exposures in areas where lead concentrations exceed proposed cleanup action levels. The estimated volume of material exceeding the PRG is 859.1 in-place cubic yards (CY). Note, that at Devils Island and Long Island several of the structures could not be characterized during previous investigations. Since there was the potential for lead-based paint associated with the uncharacterized structures, estimates were generated of the volumes of impacted soils associated with the subject structures based on comparisons to similar structures that were assessed. In addition, because the limits and consequently the volume of affected soil at the trash pile locations were not determined, an estimated volume was included for each location exceeding the PRG. None of the trash pile and disposal area samples were known to be within wilderness areas. Therefore, in the summary below, an additional 5.9 CY was added for Devils Island, 140.8 CY for Long Island, and 5.6 CY for each of four trash pile locations (one on Michigan Island, one on Raspberry Island, and two on Devils Island).

The contaminated soil removal would encompass the following estimated areas, volumes, and on-island timeframes (excluding timeframes for vegetation establishment and regrowth):

- Michigan Island - 316.3 square yards (SY), 111.2 in-place CY, 5 weeks;
- Outer Island - 78.7 SY, 32.5 in-place CY, 3 weeks;
- Raspberry Island - 197.1 SY, 75.4 in-place CY, 3 weeks;
- Devils Island - 918.2 SY, 322.1 in-place CY, 4 weeks; and,
- Long Island - 569.5 SY, 317.9 in-place CY, 3 weeks.

The non-time critical removal action should proceed as expediently as reasonably possible. Weather will be a significant consideration applicable to on-island implementation of remedies as will peak visitation timeframes to limit the impact to users. The logistics of material handling with also be a schedule driver for any on-island work. In general, the removal action should begin as soon as possible in the spring, conceptually the spring of 2016 for an initial project site or group of project sites with the remaining project sites to follow in 2017 or beyond, so that maximum time is available during the construction season to complete the remedy. Given the volume of materials and logistics involved, work may carry through more than one construction season dependent upon the final remedy selected for each of the project sites.

In support of determining a final remedy, remedial alternatives were developed based on the findings of the Site Investigation (SI), the observed conditions at the Site, including limitations posed by topography, structural integrity, and accessibility. The alternatives do not represent the findings of a comprehensive feasibility study, but rather were chosen as potential remedial options for addressing the lead-contaminated soil around the buildings and structures and at trash pile locations at each of the project sites under a non-time-critical removal action. The potential remedial alternatives were evaluated under the following nine NCP evaluation criteria pursuant to CERCLA and as summarized in applicable EPA (1993) guidance:

- Overall protection of human health and the environment – This criterion provides an assessment of how well the proposed alternative protects the public health and the environment. This criterion is further supported by the findings of the criteria that follows;

- Compliance with ARARs – This criterion focuses on how each alternative will attain identified ARARs established under Federal and State statutes and local regulations with regard to the urgency of the situation and the scope of the removal;

- Long-term effectiveness and permanence - The long-term effectiveness and permanence criterion evaluates the magnitude of the risks posed by treatment residuals or untreated wastes remaining at the project sites following implementation of the proposed alternative;

- Reduction of toxicity, mobility, or volume of contaminants through treatment - This criterion evaluates the ability of the proposed treatment technology to reduce the principal threats posed by contaminants of concern, specifically as it relates to the reduction of toxicity, mobility, or volume of the contaminants;

- Short-term effectiveness - The short-term effectiveness criterion evaluates the effects of the alternative during implementation and prior to achievement of the RAOs;

- Implementability – The implementability criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation;

- State acceptance – This criterion provides a summary of the State's position as it relates to the technical and administrative components of the proposed alternative. The State's concerns and comments will be considered during the final selection of the alternative in the Action Memorandum;

- Community acceptance – This criterion summarizes considerations related to the public's input on a given alternative. As with State acceptance, community acceptance of an alternative will be considered when making a recommendation in the EE/CA and in the final selection of the alternative in the Action Memorandum; and,

- Cost – This criterion includes an evaluation of the projected costs for the given alternative, including direct capital costs, such as construction costs, equipment costs, material costs, and transportation and disposal costs. Indirect capital costs (engineering and design costs and legal/licensing fees) and annual post-removal site controls (operation and maintenance costs and monitoring costs) are also included in the evaluation as applicable.

The alternatives evaluated for potential removal actions at the Sites included:

- Alternative 1: No Action;
- Alternative 2: Land Use Restrictions; and,
- Alternative 3: Excavation and Off-Site Disposal.

Following the detailed analysis, the removal action alternatives were compared to one another. The comparative analysis evaluated the relative performance of each alternative in relation to the respective evaluation criteria outlined above. The results of the comparative analysis identified key advantages and disadvantages of implementing one alternative over another. Ultimately, the analysis highlighted which proposed alternative provided the greatest overall benefit while achieving the RAOs for each project site at APIS. Advantages and disadvantages derived from the analysis of each alternative are summarized on **Table ES-1**.

Table ES-1
Summary of Alternative Advantages and Disadvantages

Alternative	Advantages	Disadvantages
Alternative No.1 No Action	▪ Relatively low cost ▪ Relatively low effort ▪ Relatively simple logistical issues related to implementation ▪ Technically feasible ▪ Administratively feasible ▪ Does not use services and materials for implementation	▪ No treatment technology utilized in remedial approach ▪ Not protective of human health and the environment ▪ Continuing Obligations under Wisconsin statutes ▪ Will not attain chemical-specific ARARs ▪ Does not reduce the toxicity, mobility, and volume of contaminants at the project sites ▪ Unlikely to be an acceptable remedial option by the State and community stakeholders
Alternative No.2 Institutional Controls	▪ Relatively low cost ▪ Relatively low effort ▪ Relatively simple logistical issues related to implementation ▪ Technically feasible ▪ Administratively feasible ▪ Services and materials are locally/regionally available.	▪ No treatment technology utilized in remedial approach ▪ Not protective of human health and the environment ▪ Long-term operation and maintenance obligations ▪ Continuing Obligations under Wisconsin statutes ▪ Unlikely to attain chemical specific ARARs ▪ Poses short term risks to the environment and workers during implementation ▪ Does not reduce the toxicity, mobility, and volume of contaminants at the project sites ▪ Unlikely to be an acceptable remedial option by the State and community stakeholders
Alternative No. 3 Excavation and Disposal	▪ Protective of human health and the environment ▪ No long-term maintenance requirements ▪ No Continuing obligations under Wisconsin statutes ▪ Attainment of ARARs is achievable ▪ Provides a sustainable, long-term solution ▪ Effectively reduces the toxicity, mobility, and volume of contaminants at the project sites ▪ Technically feasible ▪ Administratively feasible ▪ Services and materials are locally/regionally available. ▪ Likely to be an acceptable remedial option by the State and possibly community stakeholders	▪ Relatively high cost ▪ Relatively high level of effort ▪ Relatively complex logistical issues related to implementation ▪ Some continuing obligations under Wisconsin statutes related to children in-residence ▪ Poses short term risks to the environment and workers during implementation ▪ May require mitigation plans for the project sites to comply with the NHPA and the SHPO/THPO ▪ May not be acceptable to community stakeholders since temporary light station closures will be needed

The outcome of the EE/CA determined that Alternatives No. 1 and No. 2, while relatively easy to implement with fairly low costs, do not meet the RAOs. Alternative No. 1 does not mitigate exposures to human health and the environment. Alternative No. 2 does not meet cultural landscape and historical preservation objectives. Alternative No. 3, excavation and off-site disposal, while expensive and requiring an institutional control preventing young children from living in residence at the light stations, was determined to provide the most long-term effectiveness and reduction in the risk to human and ecological receptors with only short term impacts to the cultural landscape. Excavation and off-site disposal is the recommended removal alternative.

The estimated costs for implementation of each of the evaluated alternatives at all of the project sites are summarized as follows:

- Alternative 1: No Action - $88,187
- Alternative 2:Institutional Controls – Total $552,414
  - Michigan Island - $100,328
  - Outer Island - $95,021
  - Raspberry Island - $108,928
  - Devils Island - $128,408
  - Long Island - $119,731
- Alternative 3: Excavation and Off-Site Disposal – Total $2,336,674
  - Michigan Island - $460,284
  - Outer Island - $320,364
  - Raspberry Island - $354,624
  - Devils Island - $633,630
  - Long Island - $567,772

SECTION 1

SITE CHARACTERIZATION

Weston Solutions, Inc. (WESTON®) has prepared this Engineering Evaluation/Cost Analysis (EE/CA) to assist the National Park Service (NPS) in undertaking response activities at the Apostle Islands National Lakeshore (APIS). This EE/CA was prepared by WESTON in accordance with the NPS document, *Statement of Work Engineering Evaluation/Cost Analysis (EE/CA) for Apostle Islands National Lakeshore* dated July 2013 (**Appendix A**). The EE/CA is based on the findings presented in the November 2012 *National Park Service Great Lakes Restoration Initiative Apostle Islands National Lakeshore Letter Report*. The EE/CA has been prepared under the PRIZIM Inc. (PRIZIM) a wholly owned subsidiary of Hitachi Consulting Contract No. B2420090003 with NPS Midwest Region and WESTON's *Proposal for Engineering Evaluation/Cost Analysis, Apostle Islands National Lakeshore, Bayfield, Wisconsin* dated August 2013.

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Proposed response activities were conceptualized based on the findings of remedial investigation activities completed at each of the following five islands (project sites) within APIS.

- Michigan Island;
- Outer Island;
- Raspberry Island;
- Devils Island; and,
- Long Island.

The results of the investigations determined that lead concentrations exceeding site-specific action levels are present at each light station making them subject to processes and rules promulgated under CERCLA and the NCP. The response activities have been developed to address exposure to lead impacted soils at the light stations.

The following sections summarize the site description and background for each of the project sites identified in the Statement of Work (SOW).

1.1 SITE DESCRIPTION AND BACKGROUND

Located in Lake Superior, the Apostle Island archipelago consists of 22 islands in northwestern Wisconsin off of the Bayfield Peninsula. The location of APIS and the locations of the five island sites included in this EE/CA are shown in **Figure 1-1**. All five of the APIS project sites are accessible by boat on a seasonal basis (generally April through October). All project sites are located on NPS property. The site characterization activities summarized in this EE/CA are excerpted from the November 2012 *National Park Service Great Lakes Restoration Initiative Apostle Islands National Lakeshore Letter Report* and are focused on the light station complexes at each of the five islands.

"The Apostle Islands were formed by glacial activity. The dominant bedrock in the entire Apostle Islands region includes the members of the Bayfield Group. The common bedrock for all the islands is the Chequamegon Sandstone, described as a red, brown, and white feldspathic sandstone, generally thick bedded and commonly cross-bedded. Rare inter-beds of red shale and conglomerate are found (Cannon et al. 1996). The light station complex soil profiles consist predominantly of red clay, silts, and sands.

The surficial landscape is sandstone and glacial till that have been weathered by lake processes to produce beaches, spits, and caves. The islands, with the exception of Long Island, are heavily vegetated by predominantly northern mesic forest. Long Island vegetation is sandscape, which is characterized by beach grass, beach pea, trees, and shrubs that help stabilize the sand dunes.

Groundwater flow and water table elevation are assumed to be controlled by the level of Lake Superior. Surface water drainage is assumed to be directed to the lake" (ECC/SAIC, 2012).

Due to heavy traffic in the shipping lanes, multiple lighthouses were constructed in the mid-1800s to the early 1900s. These lighthouses required constant maintenance. The light station complexes range in size from a few buildings to large multi-building complexes that housed multiple keepers and their families. Lead-based paint was used on numerous structures. During the 1960s and 1970s, these lighthouses became automated and no longer required the constant care the onsite keepers provided.

Today these complexes have been added to the National Register of Historic Places. The grounds are open to the public for hiking and recreational use. Some of the buildings have been restored and are open for guided tours. For additional site history information, refer to the APIS Site Specific Attachment (SSA) Field Sampling Plan (FSP) and its Addendum (NPS 2011a and NPS 2012).

The following subsections provide a brief description of each of the five project sites being evaluated under this EE/CA.

1.1.1 Michigan Island

The lighthouse on Michigan Island was constructed in 1856 and entered service in the spring of 1857, but was closed after only one year of operation. "For more than a decade, the Michigan Island tower sat vacant, and in the harsh Lake Superior climate, it quickly began to deteriorate." In 1869, the light was refurbished and equipped with a three-and-a-half order Fresnel lens and returned to service (NPS, 2014).

"The light station grounds on Michigan Island are located on a bluff, rising approximately 60 feet (ft) above Lake Superior. The overall island topography consists of a landscape of gently rolling, forested hills ending in steep banks that slope down to rocky or sandy beaches. The light station grounds are primarily flat with several small drainages leading from the interior of the island to the bluff edge and shoreline. The embankment slope is highly erodible but stable. The shoreline adjacent to the light station is primarily a narrow rocky cobble beach east of the boat dock with sand beaches to the west fluctuating in width. The topography of the light station and reservation is in good condition.

The light station grounds are arranged in a fairly formal, rectangular shape. The forest/encroaching vegetation creates an outer perimeter, the buildings and tram tracks form an inner perimeter, with the open lawn in the central portion of the site. Within the grounds the structures and tram tracks reinforce this outdoor common space. Centered in the grounds is the dominant element, the tall, steel Light Tower." (Anderson Hallas Architects [AHA], 2011).

The Michigan Island Light Station buildings include:

- The Old Michigan Island Lighthouse (LH1);
- Lighthouse (LH2);
- Fog Signal Building (FS1);
- Keepers Quarters (KQ1);
- Assistant Keepers Quarters (KQ2);
- Outhouse (OH1); and,
- Utility Building/Shed (SH1).

Structures on Michigan Island include the boat dock, tramway, tram turntable and tram tracks.

"The concrete boat dock extends from the shore in an 'L' shape to the south (140 ft) and west (70 ft) of the shore. The existing dock was constructed in 1987 and was modified in 1993. It is a steel sheet pile structure infilled with stone rubble and capped with a concrete deck. The top of the boat dock has tram rails set into the surface, which are connected to the inclined tramway. The inclined tramway is 158 ft long and connects the boat dock to the top of the bluff, rising approximately 60 ft above the shoreline." (AHA, 2011).

The Michigan Island project site is presented on **Figure 1-2**.

1.1.2 Outer Island

"Standing on a high bluff at the most remote point of the Apostle Islands chain, the Outer Island lighthouse was built in 1874 to guide ships past the archipelago to the rapidly growing ports of Duluth and Superior.

The brick tower stands 90 ft high and was sited to cast its beam far across the open lake. The Outer Island light had a large, "third-order" Fresnel lens with a central band of six glass prism bull's-eye panels. These bull's-eyes concentrated the light into six brilliant beams. Rotation of the lens on a clockwork mechanism powered by weights caused the beams to sweep the horizon, making the light appear to flash.

The light station on Outer Island is exposed to the full force of Lake Superior. In its first year of operation, the station dock washed away. Waves eroded the clay banks until they collapsed, destroying the fog signal building at their base. The original fog signal building was replaced by a structure at the top of the cliff in 1875. In 1878, a third fog signal building, virtually identical to the second, was built at cliff top, adjacent to its twin. These two buildings were renovated and combined into a single structure in 1900, assuming the form that we see today" (NPS, 2014).

"The light station grounds on Outer Island are located on a bluff, rising approximately 50 ft above Lake Superior. The overall island topography consists of a landscape of gently rolling, forested hills ending in steep banks that slope down to rocky or sandy beaches. The light station grounds are primarily flat with the Outer Island Tower, Keepers Quarters, and Fog Signal Building occupying the highest points of the site. The remainder of the site slopes gently south, east, and west towards the bordering forest. A drainage swale, constructed in 2005, runs the length of the light station grounds along the northern perimeter. At the north edge of the grounds, steep banks slope down to Lake Superior. The embankment slope is highly erodible but currently stable. The shoreline adjacent to the light station features a stone revetment approximately 50 ft wide at the bottom of the bank.

Extensive erosion control measures were implemented on the northern island banks in the early 1980s and again in 2005 to reduce erosion of the banks and potential impacts to the light station grounds and structures. The work included installation of a stone revetment covering the shoreline zone (which was once a sandy beach), bioengineering along the shoreline banks primarily with log cribs and planting of native shrubs and forbs, a drainage swale along the northern edge of the light station grounds, and terracing portions of the banks. The drainage swale has created a subtle change to the landscape while the slope terracing has a more apparent impact to the topography. Overall, the condition of the light station's topography is good, with the exception of the shoreline bank, which is fair with high erosion potential.

The Outer Island Light Station buildings include:

- The Outer Island Tower/Keeper's Quarters (LH1);
- Fog Signal Building (FS1);
- Oil Storage Building (OS1); and,
- Outhouse (OH1).

The structures on Outer Island include the boat dock, tramway, and tram tracks.

The concrete boat dock is 14 ft wide and extends from the shore in an 'L' shape to the north (100 ft) and then jogs west (200 ft), to form the breakwater. The existing dock was constructed in 1958. It is a steel sheet pile structure in-filled with stone rubble, capped and sided with concrete. The top of the boat dock has approximately 80 ft of tram rails set into the surface, which are connected to the inclined tramway.

The inclined concrete tramway is 105 ft long and connects the boat dock to the top of the bluff, rising approximately 50 ft above the shoreline. The tramway consists of: concrete structural support footings, cast iron tram rails with formed concrete steps between the rails, a tram hoist at the top of the tramway, and a steel pipe railing located on the east side of the structure. The upper portion of the tramway structure (approximately 40 ft) is constructed at a slope of approximately 19 degrees. The lower portion (approximately 65 ft) is constructed at a steeper slope of approximately 28 degrees.

The tramway is in good condition and retains all of its original elements including: concrete structural supports with footings and stairs, steel handrail, and cast iron tram rails" (AHA, 2011).

The Outer Island project site is presented on **Figure 1-3**.

1.1.3 Raspberry Island

Construction of the lighthouse began in 1861, and in mid-July of 1863 the lens was installed and the light station officially began operation. "As originally built, the Raspberry lighthouse was a boxy, two-bedroom house with a shed at one side containing the kitchen. Rising from the center of the roof was a short tower that supported the lantern" (NPS, 2014).

"With continuing expansion in shipping traffic on Lake Superior, demand rose for a fog signal at Raspberry Island. State-of-the-art technology called for a coal-fired steam whistle, and such equipment demanded extra personnel to share the workload. In 1903, the current fog signal building was constructed, and a second assistant authorized.

In 1906, the Lighthouse Service remodeled the building from the ground up. Portions of the old structure were incorporated into the new building, but final result was a lighthouse that was much larger and more imposing than the original. The new lighthouse was occupied until 1947, when the light was converted to automatic operation. The lens remained in the tower until 1957, when the Coast Guard replaced it with a battery-operated beacon mounted on a pole in front of the lighthouse.

While the lighthouse we see on Raspberry Island appears much the same as it did in 1906, the surrounding setting has changed substantially. When the lighthouse was built, the surrounding area was cleared of trees so that ships would have a clear view of the beacon. Photos taken as recently as the 1940s show an open area of several acres around the station. Today, forest has encroached upon the site, and only a portion of the original clearing remains" (NPS, 2014).

"The topography of Raspberry Island played a major role in the selection of the island as the site for a lighthouse. The level, elevated bluff that rises forty feet above the water's edge at the west end of the island – directly adjacent to the navigation channel, offered an ideal site for a lighthouse and the associated infrastructure needed to support the lighthouse keepers. Historic maps from 1877 and 1910 indicate that the topography of the island has experienced little change since establishment of the station, with the exception of erosion of the bluff immediately west of the lighthouse as a result of wave action. The highest point of the island is centrally located between the lighthouse yard and the sand point, well within the forest canopy.

Within the station clearing the land slopes from east to west (from the historic edge of the clearing towards the bluff) at an approximate rate of 1 Horizontal (H):10 Vertical (V).

Natural erosion and human efforts to stem this erosion have significantly altered the bluff. Erosion of the bluff has altered spatial relationships in the lighthouse yard by eliminating a strip of level ground between twenty and forty feet in width from the area immediately west of the lighthouse and fog signal building.

The existing condition of the bluff reflects a major stabilization project, completed in 2003, which added nearly forty feet of material to the base of the bluff. This engineered revetment consists of a French drain installed at the top of the bluff to aid drainage, stone riprap placed along the bottom third of the bluff, and replanted native species on the upper two-thirds of the slope. This planting design is intended to encourage revegetation of native species while protecting the bluff face and allowing the view from the top of the bluff to the west to remain unimpaired.

The other principal topographic feature at the site is a small ditch, created by the NPS, dug around the perimeter of the lighthouse yard. This ditch aids in the drainage of the heavy clay soil. It is visually hidden by unmown grass.

All the buildings and structures associated with the Raspberry Island Light Station are located in a single cluster within the light station clearing at the southwest end of the island. The dates of construction of these resources range from 1862 (original portions of the lighthouse) to the 1940s. Previous preservation and planning efforts have focused on the lighthouse, which forms the focal point of the building cluster. The Lakeshore personnel conduct routine maintenance at the buildings. Several of the ancillary buildings are in need of stabilization to arrest ongoing deterioration" (NPS, 2004).

The Raspberry Island Light Station buildings include:

- The Raspberry Island Lighthouse/Keeper's Quarters (LH1);
- Fog Signal Building (FS1);
- Oil Storage Building (OS1);
- Shed (SH1);
- Cabin (SH2);
- Barn/Warehouse (SH3); and,
- Outhouse (OH1);
- Head Keeper's Outhouse (OH2).

The Raspberry Island project site is presented on **Figure 1-4**.

1.1.4 Devils Island

"The beacon on Devils Islands was lit in 1891. A two-story, red brick, Queen Anne- style keeper's dwelling and a building for the steam fog signal were completed at this time, but the light was placed in a temporary tower. The tower, made of wooden timbers, held a fourth order, non-flashing red light.

A two-story, brick and shingle house similar in design to the keeper's dwelling was built for the assistant keepers in 1897. Work began on the permanent tower, an 82- foot tall steel cylinder, that same year. Although the tower was ready in the fall of 1898, there was a three year delay in supplying it with a lens. A third order lens…arrived in April 1901. The permanent tower was placed in service shortly afterward, and the temporary tower torn down the same year.

The lighthouse was originally designed as a plain, self-supporting cylinder, but the high winds of its exposed location caused the tower to shake so badly that lightkeepers complained that the motion sometimes extinguished the lamp. In 1914, the Lighthouse Service reinforced the structure with external braces, alleviating the problem and giving the tower the appearance we see today.

The lighthouse at Devils Island is the only one among the Apostles group to retain its original Fresnel lens, though there was a three-year period when the lantern room was empty. The U. S. Coast Guard removed the third order Fresnel lens from the tower in 1989 and replaced it with a smaller, plastic beacon. The National Park Service repaired the lens and returned it to the tower as a display in 1992" (NPS, 2014).

"The topography of Devils Island consists of low, undulating landscape that rises approximately 58 ft above Lake Superior at its highest point. Bedrock under the northern two thirds of the island is the Devils Island brownstone formation. The outcrop along the island's shoreline forms the island's characteristic sandstone cliffs and sea caves. The topography at the light station grounds is generally level and elevated approximately 20 ft above Lake Superior. A shallow depression exists east of the Keepers Quarters, marking the location of the non-extant Assistant Keepers Quarters.

The Devils Island Light Station buildings include:

- The Devils Island Lighthouse (LH1);
- Keeper's Quarters (KQ1);
- Assistant Keeper's Quarters (KQ2)
- Fog Signal Building (FS1);
- Oil Storage Building (OS1); and,
- Oil Storage Building (OS2);

The structures on Devils Island include the tram tracks, pump house, boat dock, radio antenna tower, and NPS Vault Toilet.

The tram tracks on the light station connect the Fog Signal Building to the Tramway Engine House, running the length of the grounds (approximately 1,600 ft) following a straight line that parallels the shoreline of the island. The tracks remain in place but are nonfunctional as a system. The condition of the tram tracks is poor as the timbers beneath are rotted, the area between the tracks has become filled with soil and vegetation, and portions of the rails have been damaged and bent.

The pump house is located northeast of the Keepers Quarters, and is built into the edge of the shoreline cliff, overhanging open water below. It is a board formed, cast-in-place, concrete structure, approximately 10 ft x10 ft with a concrete stairway leading down to an access door on its north facade. The pump house is in poor condition and is nonfunctional" (AHA, 2011). The Devils Island project site is presented on **Figure 1-5**.

1.1.5 Long Island

"The first LaPointe light was constructed about one-quarter mile east of the island's western tip. This small, wooden structure was hastily erected in 1858, when authorities found that in the previous year, the lighthouse intended for Long Island had been placed on Michigan Island " (NPS, 2014).

"Over the years, the focus of shipping in the area shifted from venerable LaPointe to the bustling industrial port of Ashland. To accommodate this change, authorities installed a steam-powered fog signal and replaced the old lighthouse with two newer towers, spaced nearly a mile apart.

The fog signal came first, built in 1891, several thousand feet east of the original light. In 1897, it was joined by the "New" LaPointe light, a 67-foot cylindrical tower constructed alongside. The old lighthouse had its lantern room removed, and continued to serve as housing for keepers and their families until it was finally abandoned in 1940, replaced by a triplex apartment block. Only ruins remain today, hidden in thick vegetation.

By 1924, a radio beacon was added to the LaPointe light station. Generators supplied power for the radio beacon and keepers' quarters. Eventually, a cable was installed across the channel to Madeline Island, making the LaPointe station the only one among the Apostle Island lights with consistent access to electrical power.

The Chequamegon Point light, a 42-foot tower at the western tip of the island, was also erected in 1897.

LaPointe light station and the Chequamegon Point light were fully automated in 1964. The fog signal building was demolished in 1986.

Of the three historic lighthouses of Long Island, only the New LaPointe tower remains in use. In 1987, concerned about erosion, the U.S. Coast Guard moved the Chequamegon Point tower, lifting it with a helicopter and transporting it about one hundred feet back from the shoreline. The beacon was placed on a modern cylindrical structure, and the old tower stands empty, surrounded by trees" (NPS, 2014).

"In contrast to the other islands at APIS, Long Island is a barrier spit that is primarily composed of low ridge and swale topography, typical of sandy dunes and beaches. The interior of the island rises to approximately 10 ft above the edge of Lake Superior and consists of dune vegetation, scrub forest and areas of low wetlands. All three of the Long Island Light Station sites are located on or near dynamic sandy landscapes. The Lake Superior shoreline of the island is constantly reshaped by the natural forces of weather and water. Historic photographs and maps indicate the shoreline has changed significantly since the initial light station development on the island.

"The dynamic nature of the island has changed the Original LaPointe Lighthouse site from a shoreline location to pine barren, rolling dune character that is now over 400 ft from the water. This change from natural forces has affected the character and visibility of the site. The topography of the LaPointe site has changed in the same manner but to a lesser degree. The area between the grounds and shoreline has decreased and the shoreline is closer to the buildings and structures than during the period of significance. At Chequamegon Point, the shifting sandscape at the tip of the island has changed significantly enough to necessitate the relocation of the original light tower approximately 170 ft further inland (northeast).

The Long Island Light Station buildings include:

- The LaPointe Lighthouse (LH1);
- Keeper's Quarters/Triplex Resident (KQ1);
- The Old Chequamegon Point Lighthouse (LH2); and,
- The New Chequamegon Point Lighthouse (LH3).

Structures at the LaPointe site include a boat dock, Fog Signal Building foundation, utility unit (fiberglass generator hut) and shed.

The boat dock is located on the Lake Superior shoreline directly north the LaPointe Light Tower. The dock is approximately 80 ft long and 8 ft wide and is built of steel pipe framing with a concrete deck. In 2009, the south end of the dock was approximately 15 ft from the shoreline. Due to the nature and location of the boat dock, this dock and its predecessors have frequently been damaged or destroyed by the harsh wave and ice action of Lake Superior. The dock is used for landing small boats by visitors and park staff. The current boat dock was built in 2000 on the structural framing of the previous dock" (AHA, 2011).

The Long Island project sites for the LaPointe Lighthouse and the Original LaPointe Lighthouse are depicted on **Figure 1-6** and **Figure 1-7**, respectively. The Chequamegon Point project site is depicted on **Figure 1-8**.

1.2 PREVIOUS INVESTIGATIONS

All five islands were part of an NPS Preliminary Assessment/Site Investigation (PA/SI) conducted in 2008. During the 2008 study, soil samples were collected from areas adjacent to light station structures on each island. Lead contamination was identified as a concern in the shallow soil surrounding the light station structures. In addition, trash piles and battery disposal areas were identified as potential contamination sources but were not fully characterized.

The findings of the PA/SI postulated that a potential release of lead to the soil, surface water, and possibly to groundwater has occurred. Based on the results of the PA/SI, it was recommended that a site investigation (SI) be performed to further characterize the project sites.

Environmental Chemical Corporation (ECC) and Science Applications International Corporation (SAIC), Inc., under contract with the United States Army Corps of Engineers (USACE) completed a SI in two mobilizations, the first in 2011 and the second in 2012. The SI focused on lead-based paint contamination in soil, debris piles, former battery disposal areas, and collection of background samples. The results of the investigation are summarized in a November 2012 report prepared by ECC/SAIC entitled *National Park Service, Great Lakes Restoration Initiative, Apostle Islands National Lakeshore Letter Report*.

1.3 SOURCE, NATURE, AND EXTENT OF CONTAMINATION

Site characterization data was gathered during the SI to determine the source, nature, and extent of contamination at each of the project sites. As reported by ECC/SAIC (2012), site characterization activities were completed over two mobilizations; the first was conducted in September and October 2011 at Michigan Island, Outer Island, Raspberry Island, and Long Island. The second site characterization mobilization was completed in June 2012 at Devils Island. In addition to characterizing the Devils Island light station, ECC/SAIC also characterized additional structures at Michigan, Outer, and Long Islands and collected analytical samples from the garden on Raspberry Island.

In general, characterization of the project sites included the screening and collection of surface and near-surface soil samples from areas adjacent to buildings and structures at each light station. Soil sample locations were oriented in transects perpendicular to the building wall/structure. Soil sample transects generally were located at the approximate midpoint along each wall for larger structures and along two opposite walls for smaller structures, although some transect locations were biased to specific features. In general, soil samples were collected along transects at 1 ft, 3 ft, 7 ft, and 15 ft intervals progressing away from the building/structure.

Characterization activities were completed in accordance with approved planning documents, but were generally conducted as follows:

1. Using a steel slotted soil probe, two samples were collected from each location: one surface soil sample from 0 – 0.5 ft below ground surface (bgs) and one shallow soil sample from 0.5 – 1 ft bgs. A third sample was collected from the 1 – 1.5 ft interval if screening data exceeded the field screening level of 250 parts per million (ppm).

2. Collected samples were then screened using a portable Innov-X Delta "Classic" X-ray Fluorescence (XRF) analyzer.

3. Each sample was screened with the XRF using a single 30 second count time.

4. Soil samples identified for laboratory analysis were transferred to the appropriate sample container after completion of XRF analysis.

Characterization activities completed by ECC/SAIC resulted in the collection and screening of 893 soil samples. Of those samples, 23 were submitted for laboratory analysis for lead. Additional details related to the site investigation activities are detailed in the aforementioned letter report. The following subsections summarize the sampling rationale and findings related to the presence of lead-contaminated soil at each of the project sites.

1.3.1 Michigan Island

The Michigan Island site characterization was conducted from September 15 – 18, 2011, and on June 22, 2012. Site characterization activities at the Michigan Island project site were completed to evaluate the presence of lead in surface and near surface soils. As part of the assessment, background samples were collected from Michigan Island for comparison to the residual contaminant concentrations measured in the vicinity of the light station structures. **Table 1-1** presents the sampling rationale that was implemented during investigative activities at the Michigan Island project site.

Table 1-1
Michigan Island SI Sampling Rationale

Building Identifier	Building Name	Building Construction	Sample Location Rationale
FS1	Fog Signal Building	▪ Brick ▪ Shingle roof	▪ North elevation: painted window frame ▪ East elevation: painted pipe ▪ South Elevation: painted window frame ▪ West Elevation: painted window frame/midpoint
KQ1	Keeper's Quarters	▪ Brick ▪ Shingle roof ▪ Painted wood frame attachment	▪ North Elevation: corner between painted frame entryway and brick building ▪ East Elevation: adjacent to painted doorway/midpoint • South Elevation: midpoint/ porch floor drain ▪ West elevation: painted window frame
KQ2	Assistant Keeper's Quarters	▪ Painted wood frame ▪ Shingle roof	▪ North elevation: midpoint ▪ East elevation: doorway/midpoint ▪ South elevation: doorway ▪ West elevation: midpoint
LH1	Lighthouse/Keeper's Quarters	▪ Painted stucco-covered stone/wood frame roof ▪ Shingled roof	▪ North elevation: midpoint of lighthouse/intersection of lighthouse with quarters (2) ▪ East elevation: painted wood framed windows ▪ South elevation: adjacent to painted doorway ▪ West elevation: painted wood framed windows/corner of intersection
LH2	Lighthouse	▪ Painted Steel Tower ▪ Painted brick and wood frame entryway/painted roof	▪ North elevation: midpoint of entryway/ intercardinal of concrete footers/2 ft bgs between entryway and concrete footer ▪ East elevation: midpoint of entryway/ intercardinal of concrete footers • South elevation: entryway adjacent to sidewalk/ intercardinal of concrete footers ▪ West elevation: midpoint of entryway/ intercardinal of concrete footers
OH1	Outhouse	▪ Painted wood frame ▪ Shingle Roof	▪ North elevation: midpoint ▪ East elevation: midpoint ▪ South elevation: midpoint ▪ West elevation: midpoint
OS1	Oil Storage Building	▪ No visible evidence of former structure	▪ North/east/south elevation: midpoint of structure
SH1	Shed	▪ Painted wood frame ▪ Shingle roof	▪ North elevation: midpoint ▪ East elevation: midpoint ▪ South elevation: midpoint ▪ West elevation: midpoint

1.3.1.1 Lead Contamination in Soil

A total of 103 soil samples were collected and screened for lead using the portable XRF analyzer. Six of the samples were submitted for laboratory analysis for lead using U.S. Environmental Protection Agency (EPA) Method SW-846 6010B/3050B. Of the screened soil samples, numerous locations exceeded the Wisconsin Department of Natural Resources (WDNR) soil cleanup standard of 400 milligrams per kilogram (mg/kg). Sampling results were also compared to the site-specific PRG as discussed further in **Section 1.5**.

The characterization activities concluded that soil directly beneath painted doorways and/or window sills showed evidence of elevated lead concentrations. Seven soil samples collected from the vicinity of the original lighthouse and the attached keeper's quarters (LH1), which is constructed of brick and painted white, did not contain elevated lead concentrations. The most significant impacts were identified at the lighthouse in the center of the complex (LH2). In addition, detected lead results at the Trash Pile 3 (TP3) location exceeded the PRG.

In general, the screening and laboratory analytical results indicate that deteriorating painted surfaces on select buildings and structures at the Michigan Island light station are contributing to lead contamination in soil around the buildings/structures. The soil screening and analytical results were used to evaluate the horizontal and vertical extent of contamination around each building/structure that exceeds the PRG. As a result, buildings/structures where lead contamination was present typically have a "halo" of contamination present in the shallow soil around the structure. The depth of contamination at the Michigan Island project site did not exceed 1.5 ft.

The locations and depths of XRF and laboratory soil samples collected during the SI and the estimated extent of lead contaminated soil on Michigan Island exceeding the site-specific PRG are depicted on **Figure 1-9**.

1.3.2 Outer Island

The Outer Island site characterization was conducted from September 19 – 23, 2011, and on June 22, 2012. Site characterization activities at the Outer Island project site were completed to evaluate the presence of lead in surface and near surface soils. As part of the assessment, background samples were collected from Outer Island for comparison to the residual contaminant concentrations measured in the vicinity of the light station structures. The following sampling rationale was implemented during investigative activities at the Outer Island project site:

Table 1-2
Outer Island SI Sampling Rationale

Building Identifier	Building Name	Building Construction	Sample Location Rationale
AS1	Above Ground Storage Tank	▪ Painted steel tank on concrete saddles	▪ Painted tank and piping/valves
FS1	Fog Signal Building	▪ Painted wood frame ▪ Shingle Roof	▪ North elevation: painted frame wall/piping ▪ East elevation: painted frame wall/concrete steps ▪ South elevation: painted wall/doorway/concrete steps ▪ West elevation: painted wall/doorway/concrete steps ▪ Former AST stand (west of building): concrete stand footers (3 sides)
LH1	Lighthouse/Keeper's Quarters	▪ Brick/wood frame roof (Keeper's Quarters) ▪ Painted frame entries (2) (Keeper's Quarters) ▪ Painted brick (Lighthouse) ▪ Shingle Roof	▪ North elevation (Lighthouse): painted brick wall midpoint; corners at painted brick/frame wall intersection (2) ▪ East elevation: brick wall midpoint (2) ▪ South elevation: painted window frame ▪ West elevation: painted frame entries (2); painted window frame
OH1	Outhouse	▪ Painted brick ▪ Metal roof	▪ Painted brick wall midpoint (2) ▪ Opposite walls per roof runoff
OS1	Oil Storage Building	▪ Painted brick ▪ Metal roof	▪ Painted brick walls (west and south)
SH1	Well	▪ Wood planks	▪ Two samples located adjacent to planks on northwest and southeast

1.3.2.1 Lead Contamination in Soil

A total of 109 soil samples were collected and screened for lead using the portable XRF analyzer. Four of the samples were submitted for laboratory analysis for lead using EPA Method SW-846 6010B/3050B. Of the screened soil samples, numerous locations exceeded the screening level of 400 ppm. Sampling results were also compared to the site-specific PRG as discussed further in **Section 1.5**.

The Outer Island light station complex contains five buildings and one former structure (SH1). All five buildings were determined to have lead impacts in the shallow surface and near-surface soils adjacent to the buildings. The lighthouse tower (painted white) did not exhibit any soil lead concentrations above 400 ppm except on one side where it connects to the keeper's quarters.

In general, the screening and laboratory analytical results indicate that deteriorating painted surfaces on the majority of the buildings and structures at the Outer Island light station are contributing to lead contamination in soil around the buildings/structures. The soil screening and analytical results were used to evaluate the horizontal and vertical extent of contamination around each building/structure that exceeds the WDNR's Soil Cleanup Standard. The buildings/structures where lead contamination was present in shallow soils typically extended less than 10 ft from the structure. The depth of contamination at the Outer Island project site did not exceed 1.5 ft.

The locations and depths of XRF and laboratory soil samples collected during the SI and the estimated extent of lead contaminated soil on Outer Island exceeding the PRG are depicted on **Figure 1-10**.

1.3.3 Raspberry Island

The Raspberry Island site characterization was conducted from September 23 – 27, 2011, and on June 22, 2012. Site characterization activities at the Raspberry Island project site were completed to evaluate the presence of lead in surface and near surface soils. As part of the assessment, background samples were collected from Raspberry Island for comparison to the residual contaminant concentrations measured in the vicinity of the light station structures. The following sampling rationale was implemented during investigative activities at the Raspberry Island project site:

Table 1-3
Raspberry Island SI Sampling Rationale

Building Identifier	Building Name	Building Construction	Sample Location Rationale
BH1	Boathouse	▪ Painted wood frame exterior ▪ Unpainted interior ▪ Shingle roof	▪ South elevation: painted frame wall midpoint ▪ Interior: soil floor adjacent to east wall
LH1	Lighthouse/Keeper's Quarters	▪ Painted wood frame, brick footers ▪ Metal roof	▪ North elevation: painted frame wall midpoint (2); corner (2); steps ▪ East elevation: painted frame wall midpoint and corner ▪ South elevation: painted frame wall midpoint and corner ▪ West elevation: painted frame wall midpoint (2) and corner

Building Identifier	Building Name	Building Construction	Sample Location Rationale
FS1	Fog Signal Building	▪ Brick ▪ Metal roof	▪ North elevation: painted frame door ▪ East elevation: brick wall midpoint ▪ South elevation: painted frame door ▪ West elevation: painted frame door
OH1	Outhouse	▪ Painted wood frame ▪ Shingle roof	▪ East/west elevation: painted frame wall midpoint ▪ Opposite walls per roof runoff
OH2	Outhouse	▪ Painted wood frame ▪ Metal roof	▪ North/south elevation: painted frame wall midpoint ▪ Opposite walls per roof runoff
OS1	Oil Storage Building	▪ Brick ▪ Metal roof ▪ Four concrete tank saddles	▪ North/south elevation: brick walls/concrete tank saddles
SH1	Shed	▪ Painted wood frame ▪ Shingle roof	▪ Painted frame wall midpoint (all four walls)
SH2	Shed	▪ Painted wood frame, metal roof	▪ North elevation: painted frame wall midpoint ▪ East elevation: painted frame wall midpoint ▪ South elevation: painted frame wall midpoint ▪ West elevation: painted frame wall
SH3	Shed	▪ Painted wood frame ▪ Metal roof	▪ Painted frame wall midpoint (all four walls)
SW1	Drainage Swale	▪ Open vegetated swale	▪ Five locations within swale
Garden	Garden	▪ Vegetable garden in open grass area	▪ Two locations within the garden fence

1.3.3.1 Lead Contamination in Soil

A total of 178 soil samples were collected and screened for lead using the portable XRF analyzer. Soil samples were collected from the soil adjacent to the buildings, from soil in the garden, and from soil in a drainage swale behind the lighthouse and fog signal buildings. Six of the samples were submitted for laboratory analysis for lead using EPA Method SW-846 6010B/3050B. Of the screened soil samples, numerous locations exceeded the screening level of 400 ppm. Sampling results were also compared to the site-specific PRG as discussed further in **Section 1.5**.

The Raspberry Island light station complex features nine buildings; eight of which have measurable lead impacts. The soil adjacent to the boathouse did not contain elevated concentrations of lead. Four samples were collected from the drainage swale, and only the northernmost sample from the swale exceeded the soil cleanup standard. The two soil samples collected from the garden were also below the WDNR soil cleanup standard. Detected lead results at the Trash Pile 1 (TP1) location exceeded the PRG.

The screening and laboratory analytical results indicate that deteriorating painted surfaces on the majority of the buildings and structures at the Raspberry Island light station have contributed to lead contamination in soil around the buildings/structures. The soil screening and analytical results were used to evaluate the horizontal and vertical extent of contamination around each building/structure that exceeds the WDNR's Soil Cleanup Standard and the site-specific PRG. As a result, buildings/structures where lead contamination was present in shallow soils typically extended 5 ft to130 ft from the structure. The depth of contamination at the Raspberry Island project site did not exceed 1.5 ft.

The locations and depths of XRF and laboratory soil samples collected during the SI and the estimated extent of lead contaminated soil on Raspberry Island exceeding the PRG are depicted on **Figure 1-11**.

1.3.4 Devils Island

The Devils Island site characterization was conducted from June 16 – 25, 2012. Site characterization activities at the Devils Island project site were completed to evaluate the presence of lead in surface and near surface soils. As part of the assessment, background samples were collected from Devils Island for comparison to the residual contaminant concentrations measured in the vicinity of the light station structures. The following sampling rationale was implemented during investigative activities at the Devils Island project site:

Table 1-4
Devils Island SI Sampling Rationale

Building Identifier	Building Name	Building Construction	Sample Location Rationale
AS1	AST Saddles	▪ Concrete	▪ Included in OS1 samples (see below)
BH1	Boathouse	▪ Painted wood frame	▪ Not characterized to date
FS1	Fog Signal Building	▪ Main building frame with shingle roof ▪ Garage: Painted corrugated metal	▪ North elevation: western transect center of window; eastern transect center of window and painted stand ▪ East elevation: northern transect adjacent to door; southern transect midpoint of garage ▪ South elevation: midpoint of wall and window ▪ West elevation: (1) corner of wood frame structure and adjacent to garage door; (1) under window; (1)adjacent to door; (1) below window

Building Identifier	Building Name	Building Construction	Sample Location Rationale
KQ1	E Keeper's Quarters	▪ Brick ▪ Wood frame roof with shingles ▪ Entryway: cinderblock and wood frame	▪ North elevation: (1) midpoint of window; (1) adjacent to porch/wooden steps ▪ East elevation: (1) north transect adjacent of front porch; (2) under windows ▪ South elevation: (2) adjacent to entry way and under window; (1) adjacent to doorway ▪ West elevation: (1) under painted wood basement vent; (1) basement entrance and window; (1) under window
KQ2	W Keeper's Quarters	▪ Brick first floor; wood frame second floor ▪ Wood frame roof with shingles	▪ North elevation: (1) under window; (1) adjacent to porch/wooden steps ▪ East elevation: (1) adjacent to porch; (1) adjacent to door; (1) under window ▪ South elevation: (1) under window; (1) adjacent to former entry way; (1) downspout gutter ▪ West elevation: (1) under window; (1) under painted metal vent cover
KQ3	Assistant Keeper's Quarters	▪ No evidence of former structure	▪ North elevation: midpoint of assumed center of wall ▪ East elevation: midpoint of assumed center of wall ▪ South elevation: midpoint of assumed center of wall ▪ West elevation: midpoint of assumed center of wall ▪ Assumed center of former foundation
LH1	Lighthouse	▪ Painted steel on concrete pad	▪ Transects (4) from midpoint of the concrete pad ▪ Transects (4) 45 degrees off of the corners ▪ Soil stressed in this area no grass growing
LH2	Lighthouse	▪ No evidence of former structure	▪ Field located with GPS ▪ Assumed building corners and center of assumed building foundation
OH1	E Outhouse	▪ No evidence of former structure	▪ North elevation: midpoint of assumed center of wall ▪ East elevation: midpoint of assumed center of wall ▪ South elevation: midpoint of assumed center of wall ▪ West elevation: midpoint of assumed center of wall
OH2	W Outhouse	▪ No evidence of former structure	▪ North elevation: midpoint of assumed center of wall ▪ East elevation: midpoint of assumed center of wall ▪ South elevation: midpoint of assumed center of wall ▪ West elevation: midpoint of assumed center of wall
OS1	E Oil Storage Building	▪ Brick ▪ Wood shingle roof	▪ North elevation: door and painted sidewalk ▪ East elevation: midpoint of wall ▪ South elevation: from wall and extends through AS1 ▪ West elevation: midpoint

Building Identifier	Building Name	Building Construction	Sample Location Rationale
OS2	W Oil Storage Building	▪ Brick ▪ Wood shingle roof	▪ North elevation: adjacent to door and painted sidewalk ▪ East elevation: midpoint of wall ▪ South elevation: midpoint of wall ▪ West elevation: midpoint
PH1	Pump House	▪ Painted concrete	▪ Not characterized to date
SH1	Barn	▪ No evidence of former structure	▪ North elevation: midpoint of assumed center of wall ▪ East elevation: midpoint of assumed center of wall ▪ South elevation: midpoint of assumed center of wall ▪ West elevation: midpoint of assumed center of wall ▪ Assumed center of former foundation
SH2	Storehouse	▪ No evidence of former structure ▪ Located to north of current propane tank in trees	▪ Assumed building corners and center of assumed building foundations
SH3	Shed	▪ Located north of the current propane tank in the trees	▪ Assumed building corners and center of assumed building foundations
SH4	Tramway Engine Building	▪ Stone construction ▪ Painted metal roof ▪ Brick chimney	▪ North elevation: below window ▪ East elevation: midpoint of center of wall below bordered hatchway ▪ South elevation: below window ▪ West elevation: midpoint of wall
TW1	Metal Truss Tower	▪ 3 concrete footers ▪ Painted steel truss tower	▪ Midpoint between each footers 2 ft from the centerline
TW2	Wood Post	▪ Wood	▪ Not characterized to date

1.3.4.1 Lead Contamination in Soil

A total of 236 soil samples were collected and screened for lead using the portable XRF analyzer. Soil samples were collected from the soil adjacent to the buildings. Of the screened soil samples, numerous locations exceeded the screening level of 400 ppm. Sampling results were also compared to the site-specific PRG as discussed further in **Section 1.5**.

The Devils Island light station complex contains 10 buildings. The fog signal building (FS1), lighthouse (LH1), and the tramway building (SH4) had significant lead impacts in the adjacent soil. The keeper's quarters (KQ1 and 2) had minimal impacts. Devils Island soil adjacent to former structures also had apparent impacts from lead-based paint. In addition, detected lead results at the Trash Pile 1 (TP1) and Trash Pile 4 (TP4) locations exceeded the PRG.

The screening results indicate that deteriorating painted surfaces on the buildings and former structures at the Devils Island light station have contributed to lead contamination in soil around the buildings/structures. The soil screening results were used to evaluate the horizontal and vertical extent of contamination around each building/structure that exceeds the WDNR's Soil Cleanup Standard and site-specific PRG. As a result, buildings/structures where lead contamination was present in shallow soils typically extended 20 ft to 50 ft from the structure. The depth of contamination at the Devils Island project site did not exceed 1.5 ft.

The locations and depths of XRF and laboratory soil samples collected during the SI and the estimated extent of lead contaminated soil on Devils Island exceeding the PRG are depicted on **Figure 1-12**.

1.3.5 Long Island

The initial Long Island site characterization was conducted from September 27 – October 1, 2011. A second mobilization to complete characterization activities was conducted from June 13-15 and 26, 2012. Site characterization activities at the Long Island project site were completed to evaluate the presence of lead in surface and near surface soils at three light station complexes on the island, including the "Original" LaPointe, the LaPointe, and Chequamegon light stations. As part of the assessment, background samples were collected from Long Island for comparison to the residual contaminant concentrations measured in the vicinity of the light station structures. The following sampling rationale was implemented during investigative activities at the Long Island project site:

Table 1-5
Long Island SI Sampling Rationale

Building Identifier	Building Name	Building Construction	Sample Location Rationale
AS1	Above ground storage tank	▪ Painted (formerly) Steel	▪ North elevation: midpoint ▪ East elevation: midpoint ▪ South elevation: midpoint ▪ West elevation: midpoint
CS1	LaPointe Cistern	▪ Brick sidewall and concrete top ▪ Painted steel hatch in center	▪ Adjacent to cylinder base (3)

Building Identifier	Building Name	Building Construction	Sample Location Rationale
BH1	Original LaPointe Boathouse	▪ No longer visible	▪ Not able to be characterized due to changes in shoreline
FS1	Fog Signal Building	▪ Brick foundation remnants (formally painted corrugated metal walls and roof)	▪ North elevation: midpoint ▪ East elevation: biased toward former doorway ▪ South elevation: biased toward former doorway ▪ West elevation: midpoint
FT1	Former Radio Tower Footers	▪ Concrete Footers	▪ North elevation: bisected footers ▪ East elevation: bisected footers ▪ South elevation: bisected footers ▪ West elevation: bisected footers
FT2	LaPointe Radio Beacon	▪ Concrete Footers	▪ North elevation: bisected footers ▪ East elevation: bisected footers ▪ South elevation: bisected footers ▪ West elevation: bisected footers
KQ1	Keeper’s Quarters	▪ Painted wood frame ▪ Shingle Roof	▪ North elevation: midpoint ▪ East elevation: adjacent to door near midpoint ▪ South elevation: adjacent to door near midpoint ▪ West elevation: adjacent to door near midpoint
KQ2	Original LaPointe Keeper's Quarters	▪ Brick and wood frame; only portions of first floor brick walls/foundation remain	▪ North elevation: (2) adjacent to corners; (1) midpoint at former porch ▪ East elevation: (2) Centered under windows ▪ South elevation: (4) midpoint of walls where access could be achieved past brick wall debris and felled trees ▪ West elevation: (2) Centered under windows
LH1	LaPointe Lighthouse	▪ Steel, concrete base and footers	▪ Adjacent to cylinder base (3) ▪ Midpoint of concrete footers at intercardinal
LH2	Old Chequamegon Lighthouse (2 locations)	▪ Steel footers/Painted wood frame ▪ Original location concrete footers	▪ Old LH2: North and South elevation: midpoint ▪ LH2: East/West transect under the painted structure (5)/intercardinal of southwest and northeast footers
LH3	Chequamegon Lighthouse	▪ Steel	▪ Northwest footer ▪ Southwest footer ▪ East midpoint
OH1	Original LaPointe E Outhouse	▪ No visible evidence of structures	▪ Not characterized to date
OH2	Original LaPointe W Outhouse	▪ No visible evidence of structures	▪ Not characterized to date

Building Identifier	Building Name	Building Construction	Sample Location Rationale
OS1	Oil Storage Shed	▪ Painted Steel ▪ Metal Roof	▪ North elevation: midpoint ▪ East elevation: midpoint ▪ South elevation: midpoint ▪ West elevation: midpoint
OS2	Original LaPointe Oil Storage Building	▪ Brick construction ▪ Metal roof	▪ Not characterized to date
SH1	LaPointe E Shed	▪ No visible evidence of former framed structures	▪ No evidence of structures; 20 ft center regular grid; area identified with field GPS and SSA maps
SH2	LaPointe Center Shed		
SH3	LaPointe W Shed		
SH4	Original LaPointe W Shed	▪ Unknown; not inspected	▪ Not characterized to date
SH5	Original LaPointe Center Shed	▪ No visible evidence of structures	▪ Not characterized to date
SH6	Original LaPointe Kitchen	▪ No visible evidence of structures	▪ Not characterized to date
SH7	Original LaPointe Root Cellar	▪ Unknown; not inspected	▪ Not characterized to date
SH8	Original LaPointe E Shed	▪ Unknown; not inspected	▪ Not characterized to date
SH9	Original LaPointe Coal Shed	▪ Metal Roof	▪ Not characterized to date

1.3.5.1 Lead Contamination in Soil

A total of 267 soil samples were collected and screened for lead using the portable XRF analyzer. Six of the samples were submitted for laboratory analysis for lead using EPA Method SW-846 6010B/3050B. Of the screened soil samples, numerous locations exceeded the screening level of 400 ppm. Sampling results were also compared to the site-specific PRG as discussed further in **Section 1.5**.

The Chequamegon light station complex consists of three structures. A total of 28 soil samples were field screened in the vicinity of the Chequamegon light station. Lead was not detected in 20 of the screened samples and the remaining eight samples were below the WDNR’s Soil Cleanup Standard.

The LaPointe light station complex includes eight structures and three former structures. Lead contamination was measured in the soil samples collected from around the structures with the exception of the concrete footers (FT1) northeast and to the southeast (FT2) of the lighthouse. The Original LaPointe light station complex includes two structures (KQ2 and OS1) and eight former structures. Lead contamination was measured in the soil around the former keeper's quarters. The other structures (OS1 and all former structures) were not able to be characterized due to schedule constraints.

The screening results indicate that deteriorating painted surfaces on the buildings and former structures at the Original LaPointe and LaPointe light stations on Long Island have contributed to lead contamination in soil around the buildings/structures. The soil screening results were used to evaluate the horizontal and vertical extent of contamination around each building/structure that exceeds the WDNR's Soil Cleanup Standard and site-specific PRG. As a result, buildings/structures where lead contamination was present in shallow soils typically extended 5 ft to 20 ft from the structures. The depth of contamination at the Long Island project sites did not exceed 1.5 ft.

The locations and depths of XRF and laboratory soil samples collected during the SI and the estimated extent of lead contaminated soil on Long Island exceeding the PRG are depicted on **Figure 1-13**.

1.4 ANALYTICAL DATA

WESTON prepared this EE/CA using existing site data and information compiled during previous activities at the project sites. No new analytical data was generated in support of the EE/CA development. The basis for the EE/CA is the data collected by ECC and SAIC, Inc. **Table 1-6** outlines the resources and data reviewed by WESTON to develop the EE/CA.

Table 1-6
Resources and Data Used for EE/CA

Type of Document	Title	Author	Date
Guidance Document	Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA	EPA - Office of Emergency and Remedial Response Washington D.C.	1993
Manual	CERCLA Compliance with Other Laws Manual – Interim Final	EPA - Office of Emergency and Remedial Response Washington D.C.	1988
Guidance Document	A Guide to Developing and Documenting Cost Estimates During the Feasibility Study	USACE – Hazardous Toxic, and Radioactive Waste Center of Expertise, Omaha, Nebraska and EPA Office of Emergency and Remedial Response Washington D.C.	2000

Type of Document	Title	Author	Date
Letter Report	Apostle Islands National Lakeshore Letter Report	ECC and SAIC, Inc.	2011
Report	Cultural Landscape Report and Environmental Assessment, Raspberry Island Light Station, Apostle Islands National Lakeshore, Bayfield County,	NPS, HRA Gray & Pape, LLC, and Woopert LLP. *Wisconsin*	2004
Report	Cultural Landscape Report, Historic Structure Report (HSR), and Environmental Assessment, Volume II, Light Stations of Michigan Island, Outer Island, Devils Island, Long Island, and Sand Island. Volume I of VI: Introduction and Overall Development History	Anderson Hallas Architects	2011
Report	Cultural Landscape Report (CLR), Historic Structure Report, and Environmental Assessment, Volume II of VI: Michigan Island CLR/HSR	Anderson Hallas Architects	2011
Report	Cultural Landscape Report, Historic Structure Report, and Environmental Assessment, Volume III of VI: Outer Island CLR/HSR	Anderson Hallas Architects	2011
Report	Cultural Landscape Report, Historic Structure Report, and Environmental Assessment, Volume IV of VI: Devils Island HSR/CLR	Anderson Hallas Architects	2011
Report	Cultural Landscape Report, Historic Structure Report, and Environmental Assessment, Volume V of VI: Long Island HSR/CLR	Anderson Hallas Architects	2011

1.5 STREAMLINED RISK EVALUATION

The results of the previous investigations summarized in the preceding subsections determined that contaminant concentrations exceeding human health action levels were present at each light station making them subject to processes and rules promulgated under the CERCLA and the NCP. As such, a Risk Assessment (RA) was conducted to develop site-specific human health PRGs and determine whether available data indicate the potential for ecological impacts from lead in soil for use in evaluating the removal alternatives described herein.

The Adult Lead Model (ALM) was used to evaluate lead exposure by calculating a blood lead concentration of a Maintenance Worker, Interpretive Park Ranger, and Volunteer Lighthouse Keeper (adult [>16 years old] and adolescent [7 to 16 years old]) and estimating the probability of fetal blood lead concentration of a pregnant female worker exceeding 10 micrograms per deciliter (µg/dL). Both

95th percentile upper confidence limit (95UCL) on the arithmetic mean and maximum soil concentrations were used in the evaluation of risk so that potential hotspots of contamination were not overlooked.

PRGs were developed for each receptor group using the ALM. Exposure frequencies of five days per week and an averaging time of mid-April through mid-October (183 days) were used for the Maintenance Worker. An exposure frequency of one and five days per week for an Interpretive Park Ranger and seven days per week for a Volunteer Lighthouse Keeper were used for an averaging time of mid-June through September (107 days). Continuous exposure for three months was also considered for a Volunteer Lighthouse Keeper. PRGs were calculated as follows:

- Maintenance Worker – Mid-April through Mid-October: 939 mg/kg;
- Interpretive Park Ranger (one day/week) – Mid-April through Mid-October: 9,458 mg/kg;
- Interpretive Park Ranger (five days/week) – Mid-June through End September: 1,881 mg/kg;
- Volunteer Lighthouse Keeper – Mid-June through End September - Adult: 1,344 mg/kg; and,
- Volunteer Lighthouse Keeper – Mid-June through End September - Adolescent: 768 mg/kg.

Based on the infrequent use of the project sites by young children, this receptor group was not evaluated in the Human Health Risk Assessment (HHRA). The EPA's Integrated Exposure-Uptake Biokinetic Model (IEUBK) predicts plausible distributions of blood lead levels in children zero to seven years of age. Based on this model, EPA (1994) and WDNR (2013) have established a residential cleanup level of 400 mg/kg. This cleanup level is recommended for the light stations if a young child would be in residence in the keeper's quarters. Use of the 768 mg/kg PRG will require an institutional control that young children not be allowed in residence at the light stations.

The garden soil lead concentrations on Raspberry Island ranged from 36 mg/kg to 65.9 mg/kg. EPA (2013d) guidance on gardening states that soil concentrations less than 100 mg/kg present low risk. No specific remediation is needed and there are no restrictions on crop type. Good gardening and housekeeping practices (i.e., wash hands, clothes, and produce) are recommended.

In accordance with EPA ecological risk guidelines, the Screening Level Ecological Risk Assessment (SLERA) included conservative assumptions to ensure ecological receptors and risks are not prematurely eliminated from consideration. The SLERA found that there is potential risk to plants, soil invertebrates, small mammals, passerine birds, carnivorous birds, and mammals from exposure to lead in soil at all light stations. Under more realistic project site use conditions (e.g., 95UCL concentrations and species common to APIS), the risk to site-specific individual organisms would be reduced. Risk estimates were also refined using the lowest observed adverse effect level (LOAEL)-based alternative toxicity reference values to evaluate a dose which is expected to produce adverse population effects. At the 95UCL soil concentrations on Michigan Island, Devils Island, and Long Island, the LOAEL-based hazard quotient (HQ) exceeded one for the American woodcock, indicating potential risk to upper trophic level populations of avian insectivores. However, the risk evaluation assumes that woodcock feeds entirely within the light stations, which encompass 1.6 to 3 acres, while the home range of a woodcock is from 7 to 98 acres (EPA, 1993).

There is lead in soil at the project sites at concentrations above natural background and conservative ecological screening levels. These concentrations have been delineated to 250 mg/kg (ECC/SAIC, 2012) and were found to be localized around the buildings/structures. At 250 mg/kg lead, the LOAEL-based HQ for all receptor groups does not exceed the threshold of one. The light stations are not included in the adjacent Gaylord Nelson National Wilderness area; the habitat near the building/structures consists of maintained lawns. Some of the buildings are open for guided tours and the grounds are also open to the public for hiking and recreational use (ECC/SAIC, 2012). Human use of the area will limit use by wildlife. Lead does not biomagnify in the food chain or significantly bioaccumulate. Therefore, remediation of lead in project site soils for human use is anticipated to result in protection of ecological receptors that may inhabit the developed areas around the light stations.

Achievement of the Remedial Action Objectives (RAOs) at each of the project sites will eliminate threats to human health and the environment while eliminating the need for long-term management of the impacted areas and preserving the mission of the NPS.

1.6 REGULATORY REQUIREMENTS

In accordance with Section 300.415(j) of the NCP, ARARs were reviewed and considered in the development of removal action alternatives at each of the project sites at APIS. The following subsections provide a summary of the anticipated agency roles and the identified ARARs and their applicability to the implementation of each removal alternative.

1.6.1 Agency Roles

The NPS, as the lead agency under CERCLA, will be required to prepare letters requesting ARARs from the appropriate agencies. The following is summary of the identified agencies with potential regulatory authority over all or aspects of the proposed removal action:

- Wisconsin Historical Society;
- WDNR; and
- EPA, Region 5.

Subsequently, the NPS and their delegates will also be responsible for ensuring that removal actions are completed in accordance with the applicable ARARs and agency review procedures for each project site.

1.6.2 Identification of Applicable or Relevant and Appropriate Requirements

In accordance with CERCLA statutes and applicable guidance, the applicability of identified ARARS was weighed against three factors related to the practicable attainment of the ARARs for each project site including the following:

- *Exigencies of the situation* - The proposed removal actions for the project sites are not constrained by urgent conditions. As a result, it is anticipated that obtaining ARARs prior to design and implementation of selected remedial alternative would not compromise the overall objectives of the removal actions for each project site.
- *Scope of the removal action* - Removal actions generally focus on the stabilization of a release or threat of release and mitigation of near-term threats. ARARs that are within the scope of such removal actions, therefore, are only those ARARs that must be attained in order to eliminate the near-term threats. Analytical results from the project sites indicate that any proposed remedial action would be limited in scope, and as such it is anticipated that identified ARARs would be limited to those associated with the excavation, transportation, and disposal of contaminated soil.
- *Statutory limits* - CERCLA sets time and money limitations on a removal action. The limited scope and nature of the proposed remedial alternatives do not present a timeline that is anticipated to conflict with obtaining and attaining all identified ARARs. In the event that removal actions are expedited to account for seasonal access restrictions to the project sites, it is expected that any identified ARARs will be still be obtained and attainable prior to the implementation of the proposed remedial alternative.

In addition to the three factors for determining whether it is practicable to identify and attain ARARs for removal actions, the statutory waivers in CERCLA §121(d)(4) would apply to removal as well as to remedial actions. For example, State ARARs do not have to be attained where the State standard, requirement, criterion, or limitation has not been consistently applied in circumstances similar to the response in question. If a State standard is identified as an ARAR for a removal action, attainment of that ARAR may be waived if the State has inconsistently applied it in similar circumstances.

"CERCLA requires selection of a remedial action that is protective of human health and the environment. EPA's approach to determining protectiveness involves assessment, considering both ARARs and to-be-considered materials (TBCs)" (EPA, 1988). In accordance with CERCLA statutes and the NCP, identified ARARS were divided into the following three categories:

- *Chemical-specific ARARs* – Typically these are "health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical…in the ambient environment. If a chemical has more than one such requirement that is ARAR, the most stringent generally should be complied with. There are, at present, only a limited number of chemical-specific requirements" (EPA, 1988).

- *Location-specific ARARs* – These are requirements that provide guidance and establish operational protocols that are specifically identified due the project site's location. These requirements may be applicable due to the presence of sensitive habitats and ecosystems such as wetlands, floodplains or dune environments. The cultural and historical significance of the project sites may also incorporate processes and limitations as they relate to the disturbance or impacts to these resources.

- *Action-specific ARARs* – Typically, these are "technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. These action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved" (EPA, 1988).

- *TBCs* – Generally these "are non-promulgated advisories or guidance issued by Federal or State government that are not legally binding and do not have the status of potential ARARs" (EPA, 1988). It is appropriate, however, to include TBCs as part of the risk assessment completed at the project sites as well as during the final design and implementation phases of the work as they may include additional guidance and limitations on the performance of the removal activities.

The following subsections summarize the ARARs identified for the APIS project sites.

1.6.2.1 Chemical-Specific ARARs

In accordance with *Wisconsin Administrative Code (Wis. Admin. Code), Natural Resources, Chapter 720 Soil Cleanup Standards*, remedial actions conducted by responsible parties to address soil contamination shall be designed and implemented to restore the contaminated soil to levels that, at a minimum, meet the residual contaminant levels or performance standards for the site or facility determined in accordance with this chapter. If all soil contaminant concentrations meet applicable residual contaminant levels or performance standards after a remedial action is completed, the department may not require further remedial action for soils.

A Non-Industrial Direct Contact (DC) Soil Residual Contaminant Level (RCL) of 400 mg/kg was established for the project sites in accordance with January 2014 WDNR regulatory criteria.

Chemical-specific ARARs are summarized on **Table C-1** in **Appendix C**.

1.6.2.2 Location-Specific ARARs

The following is a summary of the significant location-specific ARARs that are anticipated to apply to the proposed removal activities at each of the APIS project sites.

- ***Resource Conservation and Recovery Act (RCRA)*** *- U.S. Code (U.S.C.), Title 42 – The Public Health and Welfare, Chapter 82 – Solid Waste Disposal* and its amendments grant EPA the authority to control hazardous waste from the "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also sets forth a framework for the management of non-hazardous solid wastes.

  This ARAR is applicable to the APIS project sites. The proposed removal actions at the APIS project sites will be required to comply with the rules and regulations established under RCRA, particularly as it relates to the treatment, storage, and disposal of hazardous and non-hazardous waste generated as a result of the proposed remedial activities.

- ***National Historic Preservation Act (NHPA) -*** Section 106 of the NHPA requires Federal agencies to take into account the effects of their undertakings on historic properties, and afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment. The agency must identify the appropriate State Historic Preservation Officer/Tribal Historic Preservation Officer (SHPO/THPO) to consult with during the process. It should also plan to involve the public, and identify other potential consulting parties. If it determines that it has no undertaking, or that its undertaking is a type of activity that has no potential to affect historic properties, the agency has no further Section 106 obligations. The agency, in consultation with the SHPO/THPO, makes an assessment of adverse effects on the identified historic properties based on criteria found in ACHP's regulations. If the consulting parties agree that there will be no adverse effects**,** the agency proceeds with the undertaking and any agreed-upon conditions. Conversely, if the consulting parties determine that there are adverse effects, or if the parties cannot agree and ACHP determines within 15 days that there is an adverse effect, the agency begins consultation to seek ways to avoid, minimize, or mitigate the adverse effects.

  This ARAR is applicable to the APIS project sites as the light station complexes are listed on the National Registry of Historic Places. The Wisconsin Historical Society is the SHPO and has an established review process for "undertakings" by federal agencies whose actions are subject to review under the NHPA. In addition, both the Red Cliff Band of Lake Superior Chippewa Indians and the Bad River Band of Lake Superior Chippewa Indians have THPO designations, and therefore NHPA submittals should also be provided to the tribal agencies as applicable.

  Compliance with this statute has been rolled up into a submittal process for determining adverse effects associated with the proposed work at the project sites. Discussions with the SHPO indicate that the NPS should complete a "Request for SHPO Comment and Consultation on a Federal Undertaking" which will initiate the appropriate review process. http://www.wisconsinhistory.org/Content.aspx?dsNav=N:4294963828-4294963805&dsRecordDetails=R:CS3993

- ***NPS Organic Act –*** *U.S.C., Title 16 – Conservation, Chapter 1 National Parks, Military Parks, Monuments, and Seashores, Subchapter I – National Park Service*, establishes the NPS and grants the service the authority to "…regulate the use of the Federal areas known as national parks, monuments, and reservations…by such means and measures as conform to the fundamental purposes of the said parks…which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment for future generations"

This ARAR is applicable to the performance of any removal activities completed at the project sites, specifically as it relates to the conservation of the unique historical and natural characteristics of the project sites.

- ***APIS Enabling Legislation*** *– U.S.C., Title 16 – Conservation, Chapter 1 National Parks, Military Parks, Monuments, and Seashores, Subchapter LXXXI – Apostle Island National Lakeshore, Section 460w* establishes "the Apostle Islands National Lakeshore in Ashland and Bayfield Counties in Wisconsin". The legislation states that "In the administration, protection, and development of the lakeshore, the Secretary shall adopt and implement…a land and water use management plan which shall include specific provision for" the following:

  - Protection of scenic, scientific, historic, geological, and archeological features contributing to public education, inspiration, and enjoyment;

  - Development of facilities to provide the benefits of public recreation together with such access roads as he deems appropriate; and

  - Preservation of the unique flora and fauna and the physiographic and geologic conditions now prevailing on the Apostle Islands within the lakeshore: Provided, that the Secretary may provide for the public enjoyment and understanding of the unique natural, historical, scientific, and archeological features of the Apostle Islands through the establishment of such trails, observation points, exhibits, and services as he may deem desirable."

  This ARAR is applicable to the performance of any removal activities completed at the project sites and will provide an overarching context for the development of the remedial designs and implementation of any proposed removal action.

- ***Endangered Species Act –*** *U.S.C., Title 16 – Conservation, Chapter 35- Endangered Species* was established "to protect and recover imperiled species and the ecosystems upon which they depend. It is administered by the U.S. Fish and Wildlife Service (FWS) and the Commerce Department's National Marine Fisheries Service (NMFS). The FWS has primary responsibility for terrestrial and freshwater organisms, while the responsibilities of NMFS are mainly marine wildlife such as whales and anadromons fish such as salmon" (FWS, 2014).

  "APIS is home to two animals protected under the Endangered Species Act— bald eagle (*Haliaeetus leucocephalus*) and piping plover (*Charadrius melodus*)—as well as several species listed by the state of Wisconsin as threatened or endangered. These include the red-shouldered hawk (*Buteo lineatus*), osprey (*Pandion haliaetus*), peregrine falcon (*Falco peregrinus*), Henslow's sparrow (*Ammodramus henslowii*), loggerhead shrike (*Lanius ludovicianus*),- Caspian tern (*Hydroprogne caspia*), Forster's tern (*Sterna forsteri*), common tern (*Sterna hirundo*), and red-necked grebe (*Podiceps grisegena*), which all may migrate through the park. Long Island is the only location in Wisconsin where piping plovers have recently nested successfully. Long Island and the Michigan Island sandscapes are designated critical habitats for piping plover. In addition to protected animals, Apostle Islands provides important habitat for many rare plants. The park harbors five species listed by the state of Wisconsin as endangered, 13 listed as threatened, and 26 designated as species of concern" (NPCA, 2007).

  This ARAR is applicable to the performance of any removal activities completed at the project sites. Site-specific details related to plants and habitats for each island environment will be required to ensure that endangered or threatened species, their habitats, and sensitive ecosystems, including dunes and wetlands are protected. Compliance with this statute has been streamlined utilizing a web-based tool for determining adverse effects associated with the proposed work at the project sites. Discussions with FWS indicate that the NPS should complete a Section 7 determination related to adverse effects caused by the work. http://www.fws.gov/midwest/endangered/section7/s7process/index.html

- ***Clean Water Act (CWA)** - U.S.C., Title 33 – Navigation and Navigable Waters, Chapter 26 – Water Pollution Prevention and Control* establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. In addition, the Act ensures that dredged or fill material is not discharged into wetlands and other waters of the United States except as authorized by a permit issued by the United States Army Corps of Engineers. EPA investigates and inspects those discharging dredge and fill material into wetlands and other waters of the United States without a permit and pursues appropriate enforcement to ensure compliance.

  This ARAR is applicable to the performance of any removal activities completed at the project sites. The proposed removal alternatives will be completed in terrestrial areas; however, , it may be feasible to use dredged sand for backfill on Long Island and logistically Lake Superior provides the primary means of access for materials being transported to and from the project sites making this ARAR important to the performance of the removal action.

- ***Tribal Interests and Concurrent Jurisdiction*** – APIS lies within and adjacent to the Red Cliff Band of Lake Superior Chippewa Indian and the Bad River Band of the Lake Superior Chippewa Indian Reservations. "The Lakeshore is managed under what is known as Concurrent Jurisdiction. This basically means that the State of Wisconsin (Police, Conservation, Fish and Game departments, etc.), County Sheriff's, Township constables, and other non-Federal agencies share jurisdiction on park lands and waters. In addition to Federal officers from numerous agencies (including the U.S. Coast Guard, Border Patrol, US Customs, FBI, US Fish and Wildlife Service, etc.), officers of the non-Federal agencies actively enforce their rules and regulations at various times and places within the park. This is also true of Tribal officers since all of the park is either a part of the local Indian Reservations or within an area defined as ceded Indian territory" (NPS, 2014).

  The conditions outlined above are considered TBCs. Consultation and coordination with the aforementioned agencies should be incorporated into the design and planning phases of the proposed removal alternatives.

- **Superintendents Compendium –** "The Superintendent's Compendium is the summary of park specific rules implemented under 36 Code of Federal Regulations (36 CFR). It serves as public notice, identifies areas closed for public use, provides a list of activities requiring either a special use permit or reservation, and elaborates on public use and resource protection regulations pertaining specifically to the administration of the park. The Superintendent's Compendium does not repeat regulations found in 36 CFR and other United States Code and CFR Titles, which are enforced without further elaboration at the park level" (NPS, 2014).

  The content of the Superintendent's Compendium is considered a TBC. Although the rules outlined in the document may not be specific to the implementation of removal activities at each of the project sites, it may have bearing on actions of personnel accessing APIS to perform the work. In addition, the document is subject to change and should be reviewed during subsequent phases of the design and removal operations.

A site's location is a fundamental determinant of its impact on human health and the environment. Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations. Some examples of special locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats. Location-specific ARARs are summarized on **Table C-2** in **Appendix C.**

1.6.2.3 Action-Specific ARARs

The following is a summary of the significant action-specific ARARs that are anticipated to apply to the proposed removal activities at each of the APIS project sites.

- *Wis. Admin. Code, Natural Resources, Chapter 216 Storm Water Discharge Permits* defines storm water discharges needing Wisconsin Pollutant Discharge Elimination System (WPDES) storm water permits. The goal of these statutes is to minimize the discharge of pollutants carried by storm water runoff from certain industrial facilities, construction sites, and municipal separate storm sewer systems as identified in this chapter.

  "Under Subchapter III of NR 216, Wis. Adm. Code, a notice of intent must be filed with the WDNR by any landowner who disturbs one or more acres of land. This disturbance can create a point source discharge of storm water from the construction site to waters of the state.

  In addition, all construction projects involving wetlands should be reviewed to ensure local, state, and federal wetland regulations are met prior to construction. USACE, under Section 404 of the Clean Water Act, is responsible for permitting activities in wetlands in nonagricultural situations, such as urban development or road construction. The WDNR has water quality certification over wetlands governed by the USACE" (WDNR, 2014).

Based on the requirements outlined above, permits would not be required for the individual project sites; however, the proposed removal activities should be completed in accordance with "Best Management Practices" and controls common to earthwork. Soil erosion and sedimentation controls (SESCs) will be implemented at each of the APIS project sites in accordance with WDNR Storm Water Construction Technical Standards.

For the purposes of this EE/CA it is assumed that one or more of the following SESCs will be incorporated into the final design for each of the project sites:

- Dust Control – Standard 1068;
- Seeding – Standard 1059;
- Grading Practices for Erosion Control – Temporary – Standard 1067;
- Vegetative Buffer for Construction Sites – Standard 1054;
- Sediment Bale Barrier – Standard 1056; and,
- Silt Fence – Standard 1055.

Action-specific ARARs are summarized on **Table C-3** in **Appendix C**.

SECTION 2

IDENTIFICATION OF REMOVAL ACTION GOALS, SCOPE, AND OBJECTIVES

This Section evaluates each of the APIS project sites on a case by case basis, describing the specific RAOs, remedial goals and anticipated implementation schedule for each of the project sites described in **Section 1**.

2.1 REMOVAL ACTION OBJECTIVES

RAOs for each of the project sites were developed to mitigate exposure risks associated with lead contamination present in shallow surface and near-surface soils in the vicinity of structures at the light stations at the following islands:

- Michigan Island;
- Outer Island;
- Raspberry Island;
- Devils Island; and,
- Long Island.

The RAOs include the mitigation of risks to human and ecological receptors from exposure to lead impacted areas at each light station. Implementation of these actions require that ARARs are attained while ensuring that the fundamental purpose of the NPS remains the principle factor in determining the applicability of the proposed actions at each of the project sites. Specific goals for the proposed removal actions include:

- Elimination of the potential migration of contaminated soil through erosion, and disturbance;
- Elimination of the exposure pathways to human and ecological receptors; and,
- Preservation of the historical and cultural landscape and conservation of the scenery and natural surroundings at APIS.

It is anticipated that completion of the removal action at each of the project sites will be a final action necessary to remediate soil contamination related to deterioration of lead-based paint at the subject facilities. Further, achievement of the RAOs at each of the project sites will eliminate threats to human health and the environment while eliminating the need for long-term management of the impacted areas and preserving the mission of the NPS.

2.2 REMOVAL ACTION SCOPE

The overall goal of a potential removal action at the project sites is to minimize the risk that lead poses to human health and/or the environment. The removal action scope considers soil removal, and/or controlled exposure via engineering and institutional controls, protective of human health and the environment based on the project sites' current and anticipated future land use. These uses include continued recreational use as part of APIS.

The removal action scope involves mitigating soil exposures in areas where lead concentrations exceed proposed cleanup action levels. The estimated volume of material is 859.1 in-place cubic yards (CY). A summary of SI screening results, by structure and by island is included in **Appendix D**. Note that at Devils Island and Long Island several of the structures could not be characterized during previous investigations. Since there was the potential for lead-based paint associated with the uncharacterized structures, estimates were generated of the volumes of impacted soils associated with the subject structures based on comparisons to similar structures that were assessed. In addition, because the limits and consequently the volume of affected soil at the trash pile locations were not determined, an estimated volume was included for each location exceeding the PRG. None of the trash pile and disposal area samples were known to be within wilderness areas. Therefore, in the summary below, an additional 5.9 CY was added for Devils Island, 140.8 CY for Long Island, and 5.6 CY for each of four trash pile locations (one on Michigan Island, one on Raspberry Island, and two on Devils Island) compared to the estimated volumes exceeding the XRF screening results.

- Michigan Island, 111.2 in-place CY;
- Outer Island, 32.5 in-place CY;
- Raspberry Island, 75.4 in-place CY;
- Devils Island, 322.1 in-place CY; and,
- Long Island, 317.9 in-place CY.

2.3 REMOVAL ACTION SCHEDULE

The non-time critical removal action should proceed as expediently as reasonably possible. Weather will be a significant consideration applicable to on-island implementation of remedies as will peak visitation timeframes to limit the impact to users. The logistics of material handling with also be a schedule driver for any on-island work. In general, the removal action should begin as soon as possible in the spring, conceptually the spring of 2016 for an initial project site or group of project sites with the remaining project sites to follow in 2017 or beyond, so that maximum time is available during the construction season to complete the remedy. Given the volume of materials and logistics involved, work may carry through more than one construction season dependent upon the final remedy selected for each of the project sites. For CERCLA purposes each of the light stations may be considered its own project.

SECTION 3

IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section considers potential remedial alternatives for the project sites, including potential action and management alternatives. The remedial alternatives were developed based on the findings of the PA/SI, the observed conditions at the project sites, including limitations posed by topography, structural integrity, and accessibility. The alternatives do not represent the findings of a comprehensive feasibility study, but rather were chosen as potential remedial options for addressing the lead-contaminated soil around the buildings and structures at each of the project sites and trash pile locations under a non-time-critical removal action. The potential remedial alternatives were evaluated under the following nine NCP evaluation criteria pursuant to CERCLA and as summarized in applicable EPA (1993) guidance:

- *Overall protection of human health and the environment* – This criterion provides an assessment of how well the proposed alternative protects the public health and the environment. This criterion is further supported by the findings of the criteria that follows;

- *Compliance with ARARs* – This criterion focuses on how each alternative will attain identified ARARs established under Federal and State statutes and local regulations with regard to the urgency of the situation and the scope of the removal;

- *Long-term effectiveness and permanence* - The long-term effectiveness and permanence criterion evaluates the magnitude of the risks posed by treatment residuals or untreated wastes remaining at the project sites following implementation of the proposed alternative;

- *Reduction of toxicity, mobility, or volume of contaminants through treatment* - This criterion evaluates the ability of the proposed treatment technology to reduce the principal threats posed by contaminants of concern, specifically as it relates to the reduction of toxicity, mobility, or volume of the contaminants;

- *Short-term effectiveness* - The short-term effectiveness criterion evaluates the effects of the alternative during implementation and prior to achievement of the RAOs;

- *Implementability* – The implementability criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation;

- *State acceptance* – This criterion provides a summary of the State's position as it relates to the technical and administrative components of the proposed alternative. The State's concerns and comments will be considered during the final selection of the alternative in the Action Memorandum;

- *Community acceptance* – This criterion summarizes considerations related to the public's input on a given alternative. As with State acceptance, community acceptance of an alternative will be considered when making a recommendation in the EE/CA and in the final selection of the alternative in the Action Memorandum; and,
- *Cost* – This criterion includes an evaluation of the projected costs for the given alternative, including direct capital costs, such as construction costs, equipment costs, material costs, and transportation and disposal costs. Indirect capital costs (engineering and design costs and legal/licensing fees) and annual post-removal site controls (operation and maintenance costs and monitoring costs) are also included in the evaluation as applicable.

3.1 PRELIMINARY ALTERNATIVE SCREENING

In accordance with applicable guidance, "the preference for treatment over conventional containment or land disposal approaches" (EPA, 1993) was considered during preparation of the EE/CA. During the evaluation of potential remedial alternatives, several treatment technologies and remedial options were considered, but dismissed generally due to conflicts with the RAOs, logistical considerations, or the long-term maintenance requirements for the alternatives. The following provides a brief summary of other remedial alternatives that were considered as part of the evaluation.

3.1.1 Phytoremediation

The use of plants and biota in remedial projects has had limited success at lead-contaminated sites across the country. Similarly, ferns have been shown to effectively remediate inorganic contaminants, specifically arsenic, at other contaminated sites. Generally, phytoremediation requires multiple growing seasons, gradually reducing the concentrations of inorganic contaminants over time.

In general, the use of phytoremediation was screened out as a viable alternative for implementation at the project sites based on the following:

- Areas requiring remediation are located in close proximity to buildings and structures and would likely have a negative impact on the cultural and historical characteristics of the project sites;
- The soil and natural setting in the areas to be remediated are likely not conducive to the growth of plants, such as ferns, which have demonstrated phytoremediation success; and,
- The plants would require maintenance and monitoring to ensure sufficient plant growth. In addition, the long-term remediation would require annual harvesting and disposal of the lead-laden plant biomass.

3.1.2 In-Situ Treatment – Soil Washing

In 2008, Clean Earth Technologies™ (CET) of Nova Scotia, Canada implemented a soil washing remedial alternative at the Swallowtail light station located on Grand Manan Island in New Brunswick, Canada. The light station was contaminated with inorganic constituents from the historic use of lead-based paint. The remote location of the light station posed logistical limitations that made traditional remediation options, such as the excavation and off-site disposal of soil, logistically and financially unfeasible.

A proprietary soil washing process was tested at the site to treat the contaminated soil and resulted in reducing lead concentrations to 400 mg/kg or less (non-detect) with an average lead concentration of 119 mg/kg. Using physical separation techniques, the process separated these fine, contaminated particles from the larger uncontaminated particles. The unit used on the site was a scaled-down version of a mobile soil washing unit, allowing it to be airlifted to the site using a helicopter.

Approximately, 1,875 tons of soil were processed using the mobile soil washing system. Approximately 1,780 tons of treated soil were deemed to have low enough concentrations to be returned to the excavated areas at the site. Approximately 95 tons of soil were placed in woven sacks and airlifted off the island for further treatment and disposal.

In general, the use of the soil washing alternative was screened out as a viable alternative for implementation at the project sites based on the following:

- CET is a Canadian company and is not currently licensed to use the soil washing technology in the United States;
- Preliminary conversations with CET indicate that it may be cost prohibitive to mobilize equipment from Nova Scotia; and,
- Additional design considerations would be required to fully evaluate the use of the soil washing alternative. Equipment staging, air lifting/barging equipment, and weather considerations are several of the limiting factors that would require additional research to fully understand the feasibility of implementing the alternative.

3.1.3 In-Situ Treatment and Disposal

Based on the findings of the SI and pending waste characterization analytical results, it is likely that select areas of the project sites will require handling and disposal as characteristically hazardous waste, due to leachable lead concentrations in the waste deposit. A potential alternative to the management and disposal of the material as a hazardous waste could be the in-situ treatment, or delisting, of the material so that it could be handled and disposed of as a non-hazardous waste.

The in-situ treatment process converts hazardous inorganic wastes into non-hazardous, delisted residuals. Once the waste is effectively treated, it is rendered non-hazardous, making it suitable for disposal at a non-hazardous disposal facility. The treatment process involves using the waste material and reagents to neutralize the waste, precipitate the metals and create insoluble metal compounds. Due to the proximity of the nearest hazardous waste disposal facility, it is likely that in-situ treatment of characteristically hazardous lead-contaminated soil is a cost-effective alternative to hazardous waste transport and disposal of contaminated soil.

- Although in-situ treatment of the soil would reduce the leachable concentrations of lead from the soil, it would not effectively treat the soil to eliminate exposure pathways to human and ecological receptors; and,
- Additional design considerations would be required to fully evaluate the use of the soil treatment technology in effectively delisting characteristically hazardous soils excavated from the project sites.

3.1.4 Soil Capping

The removal of contaminated soil from the project sites would be limited to approximately 1.5 ft to 2 ft bgs. An excavation and disposal remedial alternative will require backfill to restore the Site to existing grade. If the excavation requires backfill, a soil cap alternative could effectively eliminate the need to transport and dispose of as much contaminated soil. A soil cap over the area of proposed soil removal constructed of clay or a similar, low permeability material would also minimize the infiltration of water into the subsurface, potentially reducing the mobility and/or leaching of the contaminants.

- Areas requiring remediation are located in close proximity to buildings and structures and capping would likely have a negative impact on the cultural and historical characteristics of the project sites and negatively impact drainage away from the structures;
- Soil capping would likely require the use of institutional controls (IC) to protect the integrity of the soil caps and to prohibit disturbance of the contaminated media underlying the soil cap; and,
- The soil cap would require long-term maintenance and monitoring to ensure that the integrity of the remedy remains protective of human health and the environment.

3.1.5 Polymer Stabilization

Soil stabilization using a polymer application has been successfully implemented as a soil stabilizer and dust control agent. The contaminated areas of the project sites would make this a possible remedial alternative that would essentially solidify the near surface soils at the Site, limiting the mobility of contaminants. The liquid polymer used in the application forms bonds between the soil or aggregate particles making a durable and water resistant matrix of flexible solid-mass. Although it is unlikely that polymer stabilization alone could remedy the Site, it could be implemented in conjunction with the remedial alternatives.

In general, the use of polymer stabilization at the Site was screened out as a viable alternative for implementation at the Site based on the following:

- The polymer is biodegradable, requiring reapplication after a period of time, making the option a more temporary solution rather than a long term remedy.
- The polymer application would require long term maintenance and monitoring and likely would require the use of ICs to minimize the potential for disturbance of the contaminated media.

The aforementioned "screened out" alternatives are not all-inclusive of available remedial technologies potentially suitable for remediating contaminated soils at the project sites. These alternatives were evaluated in part, to determine if they could be used in conjunction with the three alternatives evaluated further in the EE/CA. These alternatives were evaluated with respect to the RAOs, current and anticipated future land use, sensitivity to cultural landscapes, and the historical relevance of the affected areas. As summarized above, these alternatives were not considered for further evaluation.

The alternatives do not represent the findings of a comprehensive feasibility study, but rather were chosen as potential remedial options for addressing the lead-contaminated soil around the buildings and structures at each of the project sites under a non-time-critical removal action. The following sections summarize the select remedial alternatives that were carried forward for detailed evaluation at each of the project sites:

3.2 ALTERNATIVE NO. 1 – NO ACTION

The remedial approach outlined under this section is applicable to all of the project sites at APIS. Specifically, this section evaluates the effectiveness of Alternative No. 1 – No Action in achieving the RAOs established for the project sites at APIS. The following subsections summarize the findings of the evaluation of Alternative No. 1 as it relates to its effectiveness in mitigating threats to the public health, welfare, and the environment under the CERCLA evaluation criteria.

3.2.1 Treatment Technologies

The implementation of Alternative No. 1 – No Action results in no changes to the existing conditions at each of the project sites. As such, no treatment technologies would be implemented under this alternative.

3.2.2 Effectiveness

The following subsections discuss the alternative's ability to adequately provide protection and comply with laws and regulatory statues having precedence over the implementation of the action.

3.2.2.1 Overall Protection of Human Health and the Environment

Under Alternative No. 1 – No Action, no remedy is implemented at the project sites. As a result, lead contaminated surface and near-surface soils around the buildings and structures and at certain trash pile locations at the light station complexes would remain in place. Based on the findings of the SI summarized in **Section 1**, the contaminated soil at the light station complexes would present potential exposure pathways to human and ecological receptors. Consequently, this alternative is not protective of human health and the environment.

3.2.2.2 Compliance with ARARs and Other Criteria, Advisories, and Guidance

Similar to the preceding subsection, no remedy is implemented at the project sites, leaving lead contaminated surface and near-surface soils at the light station complexes in place. Based on the findings of the SI, concentrations of lead in the soil around the buildings and structures and at certain trash pile locations exceed the WDNR's Soil Cleanup Standard of 400 mg/kg and the site-specific PRG of 768 mg/kg. Consequently, this alternative is not protective of human health and the environment and does not comply with the ARARs, specifically the chemical-specific ARARs applicable to the project sites at APIS.

In addition, under Section 121 of CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), "remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a five-year review. The NCP further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment. The Five-Year Review requirement applies to all remedial actions selected under CERCLA Section 121. Therefore, sites with CERCLA remedial actions may be subject to a five-year review. Consistent with Executive Order 12580, other Federal agencies (NPS) are responsible for ensuring that five-year reviews are conducted at sites where five-year reviews are required or appropriate" (EPA, 2014).

3.2.2.3 Long-term Effectiveness and Permanence

Under Alternative No. 1 – No Action, no remedy is implemented at the project sites. The contaminated soil at the light station complexes would present potential exposure pathways to human and ecological receptors. Consequently, the long-term effectiveness of the no-action alternative poses long-term risks to human health and the environment and as a remedy, the no-action alternative is not a sustainable, long-term/permanent remedial action.

3.2.2.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

Under Alternative No. 1 – No Action, no remedy is implemented at the project sites. As a result, there is no respective treatment technology to evaluate. Implementation of the no-action alternative does not provide for any reduction in toxicity, mobility, or volume of contaminants at the project sites. Consequently, the no-action alternative is not protective of human health and the environment.

3.2.2.5 Short-term Effectiveness

Under Alternative No. 1 – No Action, no remedy is implemented at the project sites. Residual contamination at the light station complexes would present potential exposure pathways to human and ecological receptors; however, there are no short-term risks to the community, workers, or the environment that would result from the implementation of the described no-action alternative. Consequently, there are no risks associated with the short-term effectiveness of the no-action alternative, despite the long-term potential for exposure related to the contaminated soil remaining in-place.

3.2.3 Implementability

The implementability criterion addresses the technical and administrative feasibility of implementing a selected alternative. The criterion further characterizes the availability of materials and services necessary to complete the proposed remedial action. Finally, the selection and implementation of final remedial alternative identified in the subsequent Action Memorandum is contingent upon the consideration of input from state and community stakeholders regarding the effectiveness and the implementability of the selected remedy.

3.2.3.1 Technical Feasibility

The implementation of Alternative No. 1 – No Action does not include technological or logistical considerations, as no remedy will be put in place at any of the project sites. As such, the proposed no-action alternative is technically feasible for implementation.

3.2.3.2 Administrative Feasibility

The implementation of Alternative No. 1 – No Action does not require the procurement of easements or permits. In addition, coordination with other offices or agency stakeholders were would not be required, as no remedy will be put in place at any of the project sites. As such, the proposed no-action alternative is administratively feasible for implementation.

3.2.3.3 Availability of Services and Materials

The implementation of Alternative No. 1 – No Action does not require the procurement of services or materials, as no remedy will be put in place at any of the project sites. As such, the feasibility of implementing the proposed no-action alternative is not restricted by logistical considerations related to personnel, equipment, technologies, utilities, or similar constraints.

3.2.3.4 State Acceptance

The implementation of Alternative No. 1 – No Action must consider the opinions of the State agencies or offices having jurisdiction over the implementation of the alternative. The opinions of these agencies were also considered in the development of the EE/CA. Although a formal position related to the no-action alternative was not solicited during the EE/CA preparation, it has been assumed that since the proposed alternative does not mitigate or reduce threats to human health and the environment that the remedy would generally be found to be unacceptable as it does not comply with the State of Wisconsin's regulatory statues.

The WDNR and Wisconsin SHPO have been identified as regulatory stakeholders in the development of the EE/CA. In accordance with provisions of the NCP, it is anticipated that these agencies will be provided an opportunity to review and comment on the *Draft Final EE/CA* and any supporting documentation. Following the 30-day public comment period, written responses to significant regulatory comments on the *Draft Final EE/CA* will be prepared, submitted, and incorporated into the administrative record.

State acceptance of Alternative No. 1 – No Action is contingent upon State agency review of the Draft Final EE/CA.

3.2.3.5 Community Acceptance

The implementation of Alternative No. 1 – No Action must also consider the opinions of the public prior to the selection of a final remedial alternative. Public involvement promotes communication between local stakeholders and the NPS, allowing for the integration of stakeholder concerns and comments into the EE/CA and the Action Memorandum.

Although comments were not solicited from the public during the development of the EE/CA, it has been assumed that since the proposed alternative does not mitigate or reduce threats to human health and the environment that the remedy would generally be found to be unacceptable.

As stated in the preceding subsection, the public will be provided an opportunity to review and comment on the *Draft Final EE/CA* and any supporting documentation. Following the 30-day public comment period, written responses to significant regulatory comments on the *Draft Final EE/CA* will be prepared and incorporated into the administrative record.

Community acceptance of Alternative No. 1 – No Action is contingent upon the public's review of the Draft Final EE/CA.

3.2.4 Cost

Direct and indirect capital costs were evaluated under this criterion. Under Alternative No. 1 – No Action, no remedy is implemented at the project sites; however as stated previously contaminated media would be left in-place. As a result, implementation of the no action alternative would likely be subject to the requirements the Five-Year Review process. The Five-Year Review process would require NPS, as the lead agency under CERCLA, to prepare a report documenting the conditions at the project sites for submittal to and review by the EPA. There is no time limitation on the performance of Five-Year Reviews. As such, indirect costs associated with the reporting requirements have been forecasted for 6 review cycles (30 years) as part of this EE/CA. The net present worth of the estimated costs for Alternative No. 1 – No Action are calculated to be $88,187. Estimated costs developed as part of the EE/CA are summarized in **Appendix E**.

3.3 ALTERNATIVE NO. 2 – ICS

The remedial approach outlined under this section is applicable to all of the project sites at APIS. Specifically, this section evaluates the effectiveness of Alternative No. 2 – ICs in achieving the RAOs established for the project sites at APIS.

The implementation of Alternative No. 2 – ICs is primarily an administrative task that includes placing land use restrictions on contaminated areas of the project sites to minimize the potential for exposure to human and ecological receptors. ICs include the "proprietary" controls defined below (EPA 2010).

> "Proprietary controls refer to controls on land use that are considered private in nature because they tend to affect a single parcel of property and are established by private agreement between the property owner and a second party who, in turn, can enforce the controls. Common examples include easements that restrict use (also known as negative easements) and restrictive covenants. These types of controls can prohibit activities that may compromise the effectiveness of the response action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment. State and tribal law authorize proprietary controls. In some states, the authority comes solely from common law. Other states enacted statutes that directly authorize these types of controls for the purpose of preventing use in conflict with environmental contamination or remedies."

"The State of Wisconsin allows some residual contamination to remain after a cleanup of contaminated soil or groundwater. Residual contamination means that some contamination remained above state standards after an environmental cleanup was completed and approved. In order to protect public health, the WDNR will often place a "continuing obligation" on property where there is some environmental contamination. Continuing obligations are legal requirements that apply to a property even after the ownership changes. Continuing obligations are sometimes called "environmental land use controls" or "ICs."

When the state approves a cleanup with residual contamination, it ensures long-term protection of public health and the environment in accordance with *Wis. Admin. Code, Chapter 292, Remedial Action* and other laws. The state does this by establishing continuing obligations in the "closure" letter, which is the state's cleanup approval document. Because Wisconsin does not require removal of all contamination, it is common for approved cleanups to have continuing obligations.

The property owner must do the following, unless this responsibility has been contractually accepted by someone else.

1. Periodically inspect the physical conditions specified in the closure letter, maintain the conditions of the continuing obligations and record these maintenance activities.

2. Obtain prior written approval from the state before changing the physical conditions if there is a property-specific continuing obligation. This pre-approval does not apply to a general requirement to properly handle contaminated soil, which may be done under the guidance of a private environmental consultant." (WDNR, 2014).

The following subsections summarize the findings of the evaluation of Alternative No. 2 as it relates to its effectiveness in mitigating threats to the public health, welfare, and the environment under the CERCLA evaluation criteria.

3.3.1 Treatment Technologies

The implementation of Alternative No. 2 – ICs, by itself results in no changes to the existing conditions at each of the project sites. As such, no removal action or treatment technologies would be implemented under this alternative. For the institutional control alternative to effectively protect human health and the environment, it would need to be implemented with engineering controls, such as capping/paving, fencing, or otherwise demarcating the contaminated areas. The use of fencing and capping as engineering controls are proven control methods that limit exposures to contaminated media.

3.3.2 Effectiveness

The following subsections discuss the alternative's ability to adequately provide protection and comply with laws and regulatory statues having precedence over the implementation of the action.

3.3.2.1 Overall Protection of Human Health and the Environment

Alternative No. 2 – ICs would not result in the removal or reduction of lead contaminated surface and near-surface soils from around the buildings and structures and at certain trash pile locations at the light station complexes. The IC alternative would be protective of human health and the environment by limiting access to the contaminated areas of the project sites. The IC alternative, likely in conjunction with the engineering controls outlined in the preceding subsection would restrict access and or use of the natural resources in the contaminated areas of the project sites. These restrictions on access and future land use would protect humans from exposure risks; however, without the placement of engineering controls in the contaminated areas, the potential for exposure to and migration of the contaminants in the surface soil remains a risk to environmental and ecological receptors.

3.3.2.2 Compliance with ARARs and Other Criteria, Advisories, and Guidance

Implementation of Alternative No. 2 – ICs results in leaving lead contaminated surface and near-surface soils at the light station complexes in place. Concentrations of lead in the soil around the buildings and structures and at certain trash pile locations exceed the WDNR's Soil Cleanup Standard of 400 mg/kg and the site-specific PRG of 768 mg/kg. Implementation of the IC alternative in conjunction with engineering controls would restrict access and or use of the natural resources in the contaminated areas of the project sites. These restrictions on access and future land use would protect humans from exposure risks; however, without the placement of engineering controls in the contaminated areas, the potential for exposure to and migration of the contaminants in the surface soil remains a risk to environmental and ecological receptors. The installation of engineering controls around the contaminated areas of the project sites is likely not consistent with the cultural and historical characteristics of the project sites. Consequently, this alternative is not protective of human health and the environment and does not comply with the ARARs, specifically the chemical-specific, historical preservation, and cultural landscape ARARs applicable to the project sites at APIS.

Similar to Alternative No. 1, the Five-Year Review requirement also applies to the IC alternative. The NPS would be responsible for ensuring that five-year reviews are conducted at the project sites to ensure the controls put in place remain effective at protecting human health and the environment.

3.3.2.3 Long-term Effectiveness and Permanence

Under Alternative No. 2 – ICs, lead contaminated surface and near-surface soils at the light station complexes would remain in place. The use of engineering controls under the IC alternative would limit potential exposure risks associated with the contaminated soils; however, long-term maintenance obligations would be required to ensure that the controls adequately protect human health and the environment. With appropriate engineering controls in place and future land-use in the contaminated areas restricted, the IC alternative would likely be a sustainable, long-term/permanent remedial action.

3.3.2.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

Under Alternative No. 2 – ICs, there is no respective treatment technology to evaluate. Contaminated surface soils would remain in place and access to the contaminated areas would be restricted. There would be no reduction in toxicity, mobility, or volume of contaminants at the project sites. Consequently, the IC alternative does not satisfy the statutory preference for treatment that results in permanent contaminant removal.

3.3.2.5 Short-term Effectiveness

Under Alternative No. 2 – ICs, engineering controls would be required to restrict access to the contaminated areas of the project sites. Residual contamination at the light station complexes would present potential exposure pathways and short-term risks to workers and the environment, as capping and fencing installation could require that workers disturb the contaminated surface soils. Contact or displacement of these soils could result in exposure to workers or cross-contamination of previously non-contaminated areas. Consequently, there are limited risks associated with the short-term effectiveness of the IC alternative; however, these risks can be mitigated through the use of personal protective equipment (PPE) and restrictions on construction to ensure that contaminated media remains in the delineated footprint of contaminated soils at each of the project sites.

3.3.3 Implementability

The implementability criterion addresses the technical and administrative feasibility of implementing a selected alternative. The criterion further characterizes the availability of materials and services necessary to complete the proposed remedial action. Finally, the selection and implementation of final remedial alternative identified in the subsequent Action Memorandum is contingent upon the consideration of input from state and community stakeholders regarding the effectiveness and the implementability of the selected remedy.

3.3.3.1 Technical Feasibility

The implementation of Alternative No. 2 ICs includes limited technological or logistical considerations, specifically related to delivery and installation of fencing or similar engineering controls. In addition, a legal property boundary survey that delineates the restricted areas of each of the project sites will be required to guide the placement of the engineering controls and to support the development of the administrative components of the alternative implementation. Despite the logistical considerations, the proposed IC alternative is technically feasible for implementation.

3.3.3.2 Administrative Feasibility

The implementation of Alternative No. 2 – ICs requires the development of legal documents that detail through text and figures the restricted areas of the property. In addition, the implementation and recording of these controls would require state and local government interaction, minimally to ensure that the documents meet Continuing Obligation criteria established by the WDNR. Although implementation will require multiple administrative components, the proposed IC alternative is administratively feasible for implementation.

3.3.3.3 Availability of Services and Materials

The implementation of Alternative No. 2 – ICs would require the installation of engineering controls including fencing and/or capping. The performance of the proposed work would require the use of contractors and equipment, all of which would be delivered to the island project sites using local barge services. Prior to the installation of engineering controls at the project site, engineering and surveying professionals would be used to develop design and IC documents that would be implemented under this alternative. The presence of local contractors, engineers, and surveyors, who in some cases have previous experience working at APIS, make the feasibility of implementing the IC alternative achievable and unrestricted by logistical considerations related to personnel, equipment, technologies, utilities, or similar constraints.

3.3.3.4 State Acceptance

The implementation of Alternative No. 2 – ICs must consider the opinions of the State agencies or offices having jurisdiction over the implementation of the alternative. The opinions of these agencies were also considered in the development of the EE/CA. Although a formal position related to the IC alternative was not solicited during the EE/CA preparation, it has been assumed that since the proposed alternative does not completely remove threats to human health and the environment that the remedy would generally be found to be less acceptable than a more active removal-focused alternative to comply with the State of Wisconsin’s regulatory statues.

The WDNR and Wisconsin SHPO have been identified as regulatory stakeholders in the development of the EE/CA. In accordance with provisions of the NCP, it is anticipated that these agencies will be provided an opportunity to review and comment on the *Draft Final EE/CA* and any supporting documentation. Following the 30-day public comment period, written responses to significant regulatory comments on the *Draft Final EE/CA* will be prepared, submitted, and incorporated into the administrative record.

State acceptance of Alternative No. 2 – ICs is contingent upon State agency review of the Draft Final EE/CA.

3.3.3.5 Community Acceptance

The implementation of Alternative No. 2 – ICs must also consider the opinions of the public prior to the selection of a final remedial alternative. Although comments were not solicited from the public during the development of the EE/CA, it has been assumed that since the proposed alternative does not mitigate or reduce threats to human health and the environment and could encompass fencing to close-off highly visible portions of the light station grounds that the remedy would generally be found to be unacceptable.

The public will be provided an opportunity to review and comment on the *Draft Final EE/CA* and any supporting documentation. Following the 30-day public comment period, written responses to significant regulatory comments on the *Draft Final EE/CA* will be prepared and incorporated into the administrative record.

Community acceptance of Alternative No. 2 – ICs is contingent upon the public's review of the *Draft Final EE/CA*.

3.3.4 Cost

Direct and indirect capital costs were evaluated under this criterion. Under Alternative No. 2 – ICs, the proposed remedy includes the placement of administrative and engineering controls at each of the project sites. The implementation of the alternative requires materials, equipment, trade contractor and professional services costs. In addition, the IC alternative would likely be subject to the requirements the Five-Year Review process. The net present worth of the estimated costs for Alternative No. 2 – ICs were calculated to be $552,414. Estimated costs developed as part of the EE/CA are summarized in **Appendix E** along with a breakdown by island.

3.4 ALTERNATIVE NO. 3 – EXCAVATION AND OFF-SITE DISPOSAL

The remedial approach outlined under this section is applicable to all of the project sites at APIS. Specifically, this section evaluates the effectiveness of Alternative No. 3 – Excavation and Off-Site Disposal in achieving the RAOs established for the project sites at APIS.

The implementation of Alternative No. 3 – Excavation and Off-Site Disposal includes the mobilization of equipment and personnel to each of the project sites to excavate contaminated surface and near-surface soil from around the buildings and structures and at the trash pile locations that exceed the PRG. The excavated material would be placed in containers to allow for transportation and disposal at an approved landfill. The excavated areas of the project sites would be restored with approved backfill materials and vegetation. Since the removal limits would be to the PRG, NPS would need to implement a policy that prohibits children from living in-residence at the light stations.

The contaminated soil removal would encompass the following estimated areas, volumes, and on-island timeframes (excluding timeframes for vegetation establishment and regrowth):

- Michigan Island - 316.3 square yards (SY), 111.2 in-place CY, 5 weeks;
- Outer Island - 78.7 SY, 32.5 in-place CY, 3 weeks;
- Raspberry Island - 197.1 SY, 75.4 in-place CY, 3 weeks;
- Devils Island - 918.2 SY, 322.1 in-place CY, 4 weeks; and,
- Long Island - 569.5 SY, 317.9 in-place CY, 3 weeks.

The following subsections summarize the findings of the evaluation of Alternative No. 3 as it relates to its effectiveness in mitigating threats to the public health, welfare, and the environment under the CERCLA evaluation criteria.

3.4.1 Treatment Technologies

The implementation of Alternative No. 3 – Excavation and Off-Site Disposal is a proven method of removing contaminants and exposure risk from the environment. Elevated concentrations of lead identified during the SI indicate that soils in select areas of the project site could potentially be characteristically hazardous. These soils would be treated in-place at the project sites using the soil stabilization and delisting procedures described in **Section 3.1**. Pretreatment of the contaminated soils will render the material non-hazardous likely reducing overall costs associated with transportation and disposal. The removal of contaminated surface soils from the project sites effectively eliminates the exposure pathways to human and ecological receptors.

3.4.2 Effectiveness

The following subsections discuss the alternative’s ability to adequately provide protection and comply with laws and regulatory statues having precedence over the implementation of the action.

3.4.2.1 Overall Protection of Human Health and the Environment

Under Alternative No. 3 – Excavation and Off-Site Disposal would result in the removal of lead contaminated surface and near-surface soils from around the buildings and structures and at certain trash pile locations at the light station complexes. The excavation and disposal alternative would be protective of human health and the environment by eliminating the exposure risks associated with the contaminated areas of the project sites. In addition, assuming no residual contamination remains at the project sites in excess of applicable criteria following completion of the removal action, there would not be continuing obligations associated with implementing the removal action other than prohibiting children from living in-residence at the light stations. As a result, the excavation and disposal alternative was determined to be protective of human health and the environment.

3.4.2.2 Compliance with ARARs and Other Criteria, Advisories, and Guidance

Implementation of Alternative No. 3 – Excavation and Off-Site Disposal results in the removal of lead contaminated surface and near-surface soils from around the buildings and structures and trash pile locations at the light station complexes. The excavation and disposal alternative would be protective of human health and the environment by eliminating the exposure risks associated with the contaminated areas of the project sites. Consequently, this alternative is protective of human health and the environment and would comply with the ARARs. In addition, the attainment of ARARS would be integrated into the work during the design phase of the excavation and disposal alternative, thus ensuring that the removal actions at each of the project sites are in compliance with applicable statutes and regulatory requirements.

If residual contaminants were left in place at the completion of the removal action in excess of applicable criteria, the Five-Year Review requirement would also apply to the excavation and disposal alternative. The NPS would be responsible for ensuring that five-year reviews are conducted at the project sites to ensure the controls put in place remain effective at protecting human health and the environment.

3.4.2.3 Long-term Effectiveness and Permanence

Under Alternative No. 3 – Excavation and Off-Site Disposal, lead contaminated surface and near-surface soils around the buildings and structures and at trash pile locations at the light station complexes would be removed. Assuming that there are limited continuing obligations related to not allowing children to live at the light stations associated with the completed removal actions, the excavation and off-site disposal alternative would achieve the RAOs and would provide a sustainable, long-term/permanent remedial action.

3.4.2.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

Under Alternative No. 3 – Excavation and Off-Site Disposal, the removal of the contaminated soils would effectively result in a reduction in toxicity, mobility, and volume of contaminants at the project sites. Although the excavation and disposal alternative would not be characterized as treatment, the removal effectively eliminates the risks to human and ecological receptors.

3.4.2.5 Short-term Effectiveness

Under Alternative No. 3 – Excavation and Off-Site Disposal, lead contaminated surface and near-surface soils at the light station complexes would be removed. During performance of the removal action activities disturbance of the contaminated soils could result in exposure to workers or cross-contamination of previously non-contaminated areas. Consequently, there are limited risks associated with the short-term effectiveness of the excavation and off-site disposal alternative; however, these risks can be mitigated through the use of PPE and restrictions/engineering controls on construction activities to ensure that contaminated media remains in the delineated footprint of contaminated soils at each of the project sites prior to transport off of the island.

3.4.3 Implementability

The implementability criterion addresses the technical and administrative feasibility of implementing a selected alternative. The criterion further characterizes the availability of materials and services necessary to complete the proposed remedial action. Finally, the selection and implementation of final remedial alternative identified in the subsequent Action Memorandum is contingent upon the consideration of input from state and community stakeholders regarding the effectiveness and the implementability of the selected remedy.

3.4.3.1 Technical Feasibility

The implementation of Alternative No. 3 – Excavation and Off-Site Disposal includes extensive logistical considerations, specifically related to delivery of personnel and equipment to the project sites and transportation of the contaminated material from the project sites to a staging location where the contaminated media will be trans-loaded for ground transportation and disposal. These logistical considerations, although potentially complex in nature, are essentially the same whenever the NPS performs work at the light stations. Therefore, the experience of the NPS and the trade contractors who routinely perform work at the islands will be incorporated into the design of the removal action, making the excavation and off-site disposal alternative technically feasible for implementation.

3.4.3.2 Administrative Feasibility

The implementation of Alternative No. 3 – Excavation and Off-Site Disposal would likely require communication, planning, and coordination with local agencies and tribal entities. In addition, it's likely that procurement of permits and/or similar authorizations would be required prior to the initiation of the excavation and disposal alternative. Despite these requirements, subsequent planning and design phases of the work will identify these requirements, making them administratively feasible for implementation.

3.4.3.3 Availability of Services and Materials

The implementation of Alternative No. 3 – Excavation and Off-Site Disposal will require the use of barge services, trade contractor services (personnel and equipment), and material resources to complete the proposed removal activities. The performance of the proposed work would require that personnel, equipment, and materials be transported to the island project sites using local barge services. Prior to implementation, the proposed excavation and disposal alternative would also require engineering and consulting professionals to develop the final remedial design for each project site. The presence of local contractors, engineers, and consultants, who in some cases have previous experience working at APIS, make the feasibility of implementing the excavation and disposal alternative achievable within the limits of project site-specific logistical considerations related to personnel, equipment, technologies, utilities, and similar constraints.

3.4.3.4 State Acceptance

The implementation of Alternative No. 3 – Excavation and Off-Site Disposal must consider the opinions of the State agencies or offices having jurisdiction over the implementation of the alternative. Although a formal position related to the excavation and disposal alternative was not solicited during the EE/CA preparation, it has been assumed that the proposed alternative would be deemed to be acceptable as it eliminates threats to human health and the environment with minimal risks associated with implementation. Further, the removal of the contaminated soil aligns with the State of Wisconsin's regulatory statues, making the project sites eligible for a "closure" letter, which is the state's cleanup approval document.

The WDNR and Wisconsin SHPO have been identified as regulatory stakeholders in the development of the EE/CA. In accordance with provisions of the NCP, it is anticipated that these agencies will be provided an opportunity to review and comment on the *Draft Final EE/CA* and any supporting documentation. Following the 30-day public comment period, written responses to significant regulatory comments on the *Draft Final EE/CA* will be prepared, submitted, and incorporated into the administrative record.

State acceptance of Alternative No. 3 – Excavation and Off-Site Disposal is contingent upon State agency review of the Draft Final EE/CA.

3.4.3.5 Community Acceptance

The implementation of Alternative No. 3 – Excavation and Off-Site Disposal must also consider the opinions of the public prior to the selection of a final remedial alternative. Although comments were not solicited from the public during the development of the EE/CA, it has been assumed that since the proposed alternative eliminates threats to human health and the environment and poses minimal risks during implementation that the remedy would generally be found to be acceptable. However, some community concern is anticipated regarding temporary closure of the project sites during the removals, inhibiting visitation. These concerns will hopefully be minimized by trying to schedule the removals for outside of peak season and/or conducting the removals sequentially to limit the number of light stations affected at a time. As noted in **Subsection 3.4** above, the on-island closure time is estimated to only be a few weeks per location.

The public will be provided an opportunity to review and comment on the *Draft Final EE/CA* and any supporting documentation. Following the 30-day public comment period, written responses to significant regulatory comments on the *Draft Final EE/CA* will be prepared and incorporated into the administrative record.

Community acceptance of Alternative No. 3 – Excavation and Off-Site Disposal is contingent upon the public’s review of the *Draft Final EE/CA.*

3.4.4 Cost

Direct and indirect capital costs were evaluated under this criterion. Under Alternative No. 3 – Excavation and Off-Site Disposal, the proposed remedy includes the excavation and disposal of lead-contaminated soil from each of the project sites. The implementation of the alternative requires materials, equipment, trade contractor, and professional services costs, which vary between each project site due to logistical considerations such as terrain, access, and similar caveats. For the purposes of this estimate, it has been assumed that limited Continuing Obligations will be required following implementation of the removal action. The net present worth of the estimated costs for Alternative No. 3 – Excavation and Off-Site Disposal were calculated to be $2,336,674. Estimated costs developed as part of the EE/CA are summarized in **Appendix E** along with a breakdown by island.

SECTION 4

COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This Section compares the removal action alternatives individually evaluated in **Section 3**, to one another. The comparative analysis evaluates the relative performance of each alternative in relation to the respective evaluation criteria. The results of the comparative analysis will identify key advantages and disadvantages of implementing one alternative over another. Ultimately, this analysis will highlight which proposed alternative provides the greatest overall benefit while achieving the RAOs for each project site.

4.1 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The following subsections summarize the findings of a comparative analysis of the following three removal alternatives:

- Alternative No. 1 – No Action;
- Alternative No. 2 – ICs; and,
- Alternative No. 3 – Excavation and Off-Site Disposal.

Project site conditions and perceived outcomes determined by the project technical team were used to evaluate the remedial action alternatives. The evaluations summarized in this section are applicable to all of the subject project sites at APIS.

4.1.1 Treatment Technologies

None of the evaluated alternatives utilize treatment technologies as a sole remedy at the project sites. Alternative No. 3 – Excavation and Off-Site Disposal is a proven method of eliminating contaminants and exposure risk from the environment. Under the proposed excavation and disposal alternative soils that are determined to be characteristically hazardous would be treated in-place at the project sites using soil amendments. Pretreatment of the contaminated soils will render the material non-hazardous likely reducing overall costs associated with transportation and disposal. The removal of contaminated surface soils from the project sites effectively eliminates the exposure pathways to human and ecological receptors. Under the no action alternative and the IC alternative, the contaminated media remains in-place requiring engineering controls and posing long-term management requirements for each project site.

Alternative No. 3 – Excavation and Off-Site Disposal utilizes pretreatment of the contaminated soil and likely provides the greatest benefit to the protection of human health and the environment.

4.1.2 Effectiveness

The following subsections compare each alternative's ability to adequately provide protection and comply with laws and regulatory statues having precedence over the implementation of the action.

4.1.2.1 Overall Protection of Human Health and the Environment

Alternatives No.1 and No. 2 result in the contaminated soil exceeding the PRG being left in-place at the project sites. The contaminated soil at the light station complexes would present potential exposure pathways to human and ecological receptors without the application of ICs and engineering controls. Consequently, the alternatives are not protective of human health and the environment

Alternative No. 3 – Excavation and Off-Site Disposal would result in the removal of lead contaminated surface and near-surface soils from around the buildings and structures and at trash pile locations at the light station complexes. The excavation and disposal alternative would be protective of human health and the environment by eliminating the exposure risks associated with the contaminated areas of the project sites. In addition, assuming no residual contamination remains at the project sites in excess of applicable criteria following completion of the removal action, the only continuing obligations associated with implementing the removal action would be not allowing young children to live at the light stations. As a result, the excavation and disposal alternative was determined to provide the highest level of protection to human health and the environment.

4.1.2.2 Compliance with ARARs and Other Criteria, Advisories, and Guidance

Alternative No. 1 – No Action would not attain chemical-specific ARARs for the project sites. Alternative No. 2 – ICs would likely be unable to attain select ARARs for the project sites. Alternatives No.1 and No.2 would also be subject to Continuing Obligations under Wisconsin statutes. In addition, these alternatives would be subject to the Five-Year Review requirements under CERCLA. The NPS would be responsible for ensuring that five-year reviews are conducted at the project sites to ensure the controls put in place remain effective at protecting human health and the environment.

Implementation of Alternative No. 3 – Excavation and Off-Site Disposal results in the removal of lead contaminated surface and near-surface soils at the light station complexes. Consequently, this alternative is protective of human health and the environment and would comply with the ARARs.

Alternative No. 3 – Excavation and Off-Site Disposal has the greatest likelihood of attaining ARARs at each of the project sites. The final design will determine what mitigation measures, if necessary, will be required to comply with the requirements of the NHPA and SHPO/THPO as applicable.

4.1.2.3 Long-term Effectiveness and Permanence

Alternative No.1 and Alternative No. 2 leave lead contaminated surface and near-surface soils at the light station complexes. The use of engineering controls under the IC alternative would limit potential exposure risks associated with the contaminated soils; however, long-term maintenance obligations would be required to ensure that the controls adequately protect human health and the environment. Under Alternative No. 3 – Excavation and Off-Site Disposal, lead contaminated surface and near-surface soils at the light station complexes would be removed.

Alternative No. 3 – Excavation and Off-Site Disposal achieves the RAOs and provides a sustainable, long-term/permanent remedial action that would have Continuing Obligations related to young children living at the light stations but would not be subject to long-term maintenance and monitoring requirements.

4.1.2.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

Under Alternative No.1 and Alternative No. 2, there are no respective treatment technologies to evaluate. Contaminated surface soils would remain in place. Access to the contaminated areas would be restricted under Alternative No. 2. There would be no reduction in toxicity, mobility, or volume of contaminants at the project sites. Under Alternative No. 3 – Excavation and Off-Site Disposal, the removal of the contaminated surface soils would effectively result in a reduction in toxicity, mobility, and volume of contaminants at the project sites. Although the excavation and disposal alternative would not be characterized as treatment, the removal effectively eliminates the risks to human and ecological receptors.

Alternative No. 3 – Excavation and Off-Site Disposal is the only alternative that results in a reduction in toxicity, mobility, and volume of contaminants at the project sites.

4.1.2.5 Short-term Effectiveness

Under Alternative No. 1 – No Action, no remedy is implemented at the project sites. Consequently, there are no risks associated with the short-term effectiveness of the no-action alternative, despite the long-term potential for exposure related to the contaminated soil remaining in-place. Alternative No. 2 – ICs, would require engineering controls to restrict access to the contaminated areas of the project sites. Residual contamination at the light station complexes would present potential exposure pathways and short-term risks to workers and the environment, as capping and fencing installation could require that workers disturb the contaminated surface soils. Under Alternative No. 3 – Excavation and Off-Site Disposal, lead contaminated surface and near-surface soils at the light station complexes would be removed. During performance of the removal action activities disturbance of the contaminated soils could result in exposure to workers or cross-contamination of previously non-contaminated areas. As a result, there are limited risks associated with the short-term effectiveness of the excavation and disposal alternative; however, these risks can be mitigated through the use of PPE and restrictions/engineering controls on construction activities to ensure that contaminated media remains in the delineated footprint of contaminated soils at each of the project sites prior to packaging and transport off of the islands.

Alternative No. 1 – No Action provides the greatest security in short-term effectiveness; however, there would be long-term potential for exposure related to the contaminated soil remaining in-place. The short-term risks posed by Alternatives No.2 and No.3 would be managed through administrative and engineering controls, and ultimately they provide the greatest overall benefit to human health and the environment.

4.1.3 Implementability

The implementability criterion evaluates the overall technical and administrative feasibility and stakeholder acceptability of each of the evaluated remedial alternatives.

4.1.3.1 Technical Feasibility

The implementation of Alternative No.1 is technically feasible as no remedy is put in place. Alternative No. 2 includes limited technological and logistical considerations, specifically related to delivery and installation of fencing or similar engineering controls. Despite the logistical considerations, Alternative No.2 is technically feasible for implementation. Alternative No. 3 – Excavation and Off-Site Disposal is the most complex as it relates to extensive logistical considerations, specifically related to delivery of personnel and equipment to the project sites and transportation of the contaminated material from the project sites to a staging location where the contaminated media will be trans-loaded for ground transportation and disposal.

Alternative No. 1 – No Action is the most technically feasible alternative since no remedy would be implemented. Similar to the preceding criterion, Alternatives No.2 and No.3, although more technically complicated provide the greatest overall benefit to human health and the environment.

4.1.3.2 Administrative Feasibility

The implementation of Alternative No.1 is administratively feasible as no remedy is put in place. Alternative No. 2 includes the preparation, submittal, and recording of ICs for each of the project sites. These administrative procedures likely make the IC alternative the most complicated from an administrative standpoint; however it is administratively feasible for implementation. Alternative No. 3 – Excavation and Off-Site Disposal would likely require communication, planning, and coordination with local agencies and tribal entities. In addition, it's likely that procurement of permits and/or similar authorizations would be required prior to the initiation of excavation and disposal alternative.

Alternative No. 1 – No Action is the most administratively feasible alternative since no remedy would be implemented. Similar to the comparative evaluation under the preceding criterion, Alternatives No.2 and No.3, although more administratively complicated, provide the greatest overall benefit to human health and the environment.

4.1.3.3 Availability of Services and Materials

Alternative No. 1 – No Action would not rely on the availability of services or materials since no remedy would be implemented. Alternatives No.2 and No.3 utilize services and materials and they are available locally or regionally. The presence of local contractors, engineers, and consultants, who in some cases have previous experience working at APIS, make it feasible to implement both Alternative No.2 and No.3.

The comparative evaluation of the availability of services and materials does not indicate that one of the alternatives is more implementable than another. If the criterion is further evaluated on the basis of frequency or duration, the most suitable criteria would be Alternative No.1 – No Action. Alternatives No.2 and No.3 rely heavily on the availability of barge services. If there is competing work, for example renovations on a structure, the availability of the barge services may be reduced and could negatively affect the implementation schedule for the selected removal alternative.

4.1.3.4 State Acceptance

Although a formal position related to any of the alternatives was not solicited during the EE/CA preparation, it has been assumed that since Alternative No.1 and No.2 do not completely remove or reduce threats to human health and the environment that these remedies would generally be found to be unacceptable as they do not comply with the State of Wisconsin’s regulatory statues.

The implementation of Alternative No. 3 – Excavation and Off-Site Disposal has been assumed to be acceptable since the proposed alternative would address threats to human health and the environment with minimal risks associated with implementation. Further, the removal of the contaminated soil aligns with the State of Wisconsin’s regulatory statues, making the project sites eligible for a "closure" letter, which is the state's cleanup approval document.

State acceptance of any of the alternatives is contingent upon State agency review of the Draft Final EE/CA.

4.1.3.5 Community Acceptance

Although a formal position related to any of the alternatives was not solicited during the EE/CA preparation, it has been assumed that since Alternative No.1 and No.2 do not completely remove or reduce threats to human health and the environment that these remedies would generally be found to be unacceptable. In addition, Alternative No.2 would create restrictions that would forbid the use of select areas of the islands by visitors and personnel.

The implementation of Alternative No. 3 – Excavation and Off-Site Disposal has been assumed to be acceptable since the proposed alternative would address threats to human health and the environment. Alternative No.3 would also result in unrestricted use of the properties by visitors and personnel with the exception of not allowing children to live in-residence at the light stations. There would be temporary short duration closures of the light station grounds during the removal activities but they would be limited to a few weeks in duration while providing a long term benefit to human health and the environment.

Community acceptance of any of the alternatives is contingent upon public review of the Draft Final EE/CA.

4.1.4 Cost

Direct and indirect capital costs were evaluated under this criterion. The implementation costs for Alternative No.1 and Alternative No. 2 were calculated to be $88,187 and $552,414, respectively. Costs to implement Alternative No. 3 were calculated to be $2,336,674. Costs attributable to each of the project sites are tabulated in **Appendix E**. Although the difference in costs is relatively significant, the level of effort and the effectiveness of each remedy is generally scalable to the costs.

No remedy is implemented under Alternative No.1 and costs are related to the performance of Five Year Reviews at each of the project sites. Alternative No.2 includes the installation of fencing and recording of ICs to restrict access at each of the project sites. Alternative No. 2 also includes costs associated with the completion of Five Year Reviews. In general these alternatives are feasible for implementation based on projected costs.

Alternative No.3 is the most costly alternative, but it also provides the greatest overall benefit to human health and the environment. The implementation of the alternative requires materials, equipment, trade contractor, and professional services, which vary in cost between each project site due to logistical considerations such as terrain, access, and similar constraints. Alternative No.3 would not require long-term maintenance but would have Continuing Obligations requirements in the form of administrative controls preventing young children from living in residence at the light stations.

Despite having the highest costs, Alternative No.3 provides the greatest overall value by significantly reducing the threats posed by the contaminated soil through removal and allowing for the anticipated uses of the light station sites with minimal restriction.

4.2 ADVANTAGES AND DISADVANTAGES OF REMOVAL ACTION ALTERNATIVES

The purpose of the comparative analysis is to assist in the determination of the recommended alternative at the project sites. It should be noted that different alternatives could be implemented at different project sites. **Table 4-1** provides a summary of the perceived advantages and disadvantages derived from the comparative analysis.

Table 4-1
Summary of Alternative Advantages and Disadvantages

Alternative	Advantages	Disadvantages
Alternative No.1 No Action	▪ Relatively low cost ▪ Relatively low effort ▪ Relatively simple logistical issues related to implementation ▪ Technically feasible ▪ Administratively feasible ▪ Does not use services and materials for implementation	▪ No treatment technology utilized in remedial approach ▪ Not protective of human health and the environment ▪ Continuing Obligations under Wisconsin statutes ▪ Will not attain chemical-specific ARARs ▪ Does not reduce the toxicity, mobility, and volume of contaminants at the project sites ▪ Unlikely to be an acceptable remedial option by the State and community stakeholders
Alternative No.2 Institutional Controls	▪ Relatively low cost ▪ Relatively low effort ▪ Relatively simple logistical issues related to implementation ▪ Technically feasible ▪ Administratively feasible ▪ Services and materials are locally/regionally available.	▪ No treatment technology utilized in remedial approach ▪ Not protective of human health and the environment ▪ Long-term operation and maintenance obligations ▪ Continuing Obligations under Wisconsin statutes ▪ Unlikely to attain chemical specific ARARs ▪ Poses short term risks to the environment and workers during implementation ▪ Does not reduce the toxicity, mobility, and volume of contaminants at the project sites ▪ Unlikely to be an acceptable remedial option by the State and community stakeholders
Alternative No. 3 Excavation and Disposal	▪ Protective of human health and the environment ▪ No long-term maintenance requirements ▪ Attainment of ARARs is achievable ▪ Provides a sustainable, long-term solution ▪ Effectively reduces the toxicity, mobility, and volume of contaminants at the project sites ▪ Technically feasible ▪ Administratively feasible ▪ Services and materials are locally/regionally available. ▪ Likely to be an acceptable remedial option by the State and possibly community stakeholders	▪ Relatively high cost ▪ Relatively high level of effort ▪ Relatively complex logistical issues related to implementation ▪ Some continuing obligations under Wisconsin statutes related to children in-residence ▪ Poses short term risks to the environment and workers during implementation ▪ May require mitigation plans for the project sites to comply with the NHPA and the SHPO/THPO May not be acceptable to community stakeholders since temporary light station closures will be needed

SECTION 5

RECOMMENDED REMOVAL ACTION ALTERNATIVE

The alternatives evaluated for potential removal actions at the Sites include:

- Alternative No. 1: No Action;
- Alternative No. 2: Land Use Restrictions; and,
- Alternative No. 3: Excavation and Off-Site Disposal.

The previously conducted assessment activities indicate that lead is present in soils at the project sites above the RAOs. Removing soils where lead concentrations exceed the applicable criteria will permanently reduce human and ecological exposure.

Alternatives No. 1 and No. 2, while relatively easy to implement with fairly low costs, do not meet the RAOs. Alternative 1 does not mitigate exposures to human health and the environment. Alternative No. 2 does not meet cultural landscape and historical preservation objectives. Alternative No. 3, Excavation and Off-Site Disposal, while expensive and requiring an institutional control preventing young children from living in residence at the light stations based on the RA results, provides the most long-term effectiveness and reduces the risk to human and ecological receptors with only short term impacts to the cultural landscape. Excavation and off-site disposal is the recommended alternative. Details of the recommended alternative, by island, are discussed further below.

5.1 IMPLEMENTATION DETAILS

5.1.1 Common Implementation Elements

Soil samples will be collected from each of the project sites for waste characterization purposes and in support of a bench-scale treatability study. If warranted based on waste characterization results, the treatability study will determine the amount of stabilization reagent required to be mixed in with the soil during excavation to stabilize the lead and render the soils non-hazardous. The stabilization reagent may be a product such as EnviroBlend® or other phosphate or Portland cement-type product. During the removal action design phase, further evaluation will be applied to potential stabilization reagents.

Prior to commencing soil removal, non-invasive utility and underground obstruction locating is proposed, such as ground penetrating radar and pipe tracing across the removal areas. The excavation and off-site disposal alternative will involve the use of small mechanized equipment such as a mini-excavator and track-mounted skid-steer to scrape/excavate impacted soils from the areas identified in **Figure 1-9** through **Figure 1-13**. Considerations necessary to access the Sites with the equipment and restore access pathways will be included in the design documents.

Sidewalks and other objects that have been in-place since structure construction will be retained and protected without excavation extending beneath these objects. Small objects that must be removed to facilitate soil removal such as stones around plantings will have their locations documented, components logged, photographs taken, and then stored on-island until placed back in-position during restoration. Hand tools will be used to remove soils in contact with building foundations to avoid potential damage from mechanized equipment.

Stabilization reagent will be mixed with the excavated soil as necessary and contaminated soil will be staged for trans-loading. All contaminated soil in bulk form or in super sacks will be staged on and under heavy-gauge plastic sheeting. Contaminated soil could also be staged in drums depending upon conditions and logistical considerations. For Michigan, Outer, and Raspberry Islands, if the tram system is used for material handling, the tram cart and winch equipment will be temporarily replaced with contractor-provided equipment to preserve the existing on-island equipment. At Raspberry and Long Islands the use of a contractor-provided conveyor system to trans-load material may be feasible.

Barge transport will be used to bring contaminated soil to the mainland for trans-loading to haul trucks. Contaminated soil will be transported via truck to an appropriate, licensed landfill for disposal.

Backfill soil will consist of sand and topsoil from local mainland sources for all islands except Devils Island and Long Island. On Devils Island, sphagnum moss is proposed based on recent projects in lieu of topsoil and on Long Island sphagnum moss and/or just sand replanted with beach grass is conceptualized.

For each light station, to prevent young children (ages 0 to 7) from living in residence such as with a Volunteer Lighthouse Keeper, an institutional control such as a Superintendent's Closure/Superintendent's Order will be developed. It is generally not possible to implement more traditional institutional controls such as a deed restriction or other encumbrances on federal lands that are enforceable by non-Federal parties as such encumbrances would violate the Property Clause of the

Constitution. The document content should be agreed upon with WDNR in advance and may be identified as a continuing obligation in WDNR's "closure" letter.

5.1.2 Michigan Island

The contaminated soil removal on Michigan Island will require the cutting and removal of a small portion of the encroaching brush north of the Shed. The July 2011 *Cultural Landscape Report Historic Structure Report Volume II of VI: Michigan Island CLR/HSR* indicates that this area was originally cleared. The limited tree removal necessary to facilitate the contaminated soil removal will aid in restoring the cultural integrity. The excavation activities north of the Shed may infringe upon the integrity of the nearest cherry tree northeast of that structure, which is a contributing factor identified from the July 2011 CLR/HSR. Efforts should be made to save the cherry tree(s) by using hand tools and regular screening of the lead content of the soil during excavation to remove only the soil that must be removed and protect the integrity of the cherry tree's root system. If this contributing factor must be removed, it should be replaced with a like species. Hand tools will also be necessary to address the Trash Pile TP3 location which is well into the wooded area northeast of the Shed.

5.1.3 Outer Island

The lead impacted soil removal on Outer Island will require the removal of a small portion of the lilacs on the east side of the Oil Storage Shed and will be close to the lilac on the east side of the Fog Signal Building. Based on the July 2011 *Cultural Landscape Report Historic Structure Report Volume III of VI: Outer Island CLR/HSR*, the lilacs are contributing features. Care should be taken to protect the root system of the lilac east of the Fog Signal Building and to remove as few of the lilacs east of the Oil Storage Shed as possible. Replanting of the small area of removed lilacs east of the Oil Storage Shed could be conducted if warranted to support the integrity of the cultural landscape. If the excavation west of the Oil Storage Shed extends into the encroaching forest, the removed trees will not be replaced in support of restoring the cultural landscape integrity.

5.1.4 Raspberry Island

Removal of lead impacted soil at Raspberry Island will require the temporary removal of some of the flower beds and plantings around the Lighthouse and south of the west shed. It is understood from the November 2004 *Cultural Landscape Report and Environmental Assessment Raspberry Island Light*

Station Apostle Islands National Lakeshore Bayfield County, Wisconsin that "the majority of the extant gardens are reconstructions". "Gardens that were not reconstructed in the 1980s, and which appear to be historic in terms of their location and size, include the…day lily bed south of the shed, and the tiger lily bed between the steps on the west side of the lighthouse." "The reconstructed gardens are non-historic features, do not meet National Register eligibility criteria, and are not considered contributing elements within the cultural landscape. Nevertheless, they currently serve an important function in terms of site interpretation." During excavation activities to remove lead impacted soil, it is proposed that the existing locations and types of plantings be documented as necessary to supplement existing records and the bulbs of perennials be saved for replanting. This would be best facilitated by conducting the removal activities on Raspberry Island late in the season. Annuals could be replanted the following season, following current planting plans.

5.1.5 Devils Island

The contaminated soil removal on Devils Island will require the cutting and removal of a portion of the spruce, balsam, and white birch trees that have encroached on the south and east sides of the Light Tower and around the Tramway Building. The July 2011 Cultural Landscape Report Historic Structure Report Volume IV of VI: Devils Island CLR/HSR indicates that these areas were originally cleared and the forest encroachment has diminished the integrity of the cultural landscape. The tree removal necessary to facilitate the contaminated soil removal will aid in restoring that integrity. The soil removal around the west oil storage (Oil House #2) should not impact the stone-lined planter and rosebush to the north. Hand tools should be used to remove soil from the Trash Pile TP-1 location within the spruce trees as the July 2011 CLR/HSR indicates that this area was not historically cleared.

5.1.6 Long Island

Soil removal around the structures on Long Island will require removal of a portion of the red pine, jack pine, and oak trees that have encroached on the structures and grounds. The July 2011 Cultural Landscape Report Historic Structure Report Volume V of VI: Long Island CLR/HSR indicates that a significantly larger cleared area historically existed than exists today. The spatial organization has been diminished due to encroaching forest vegetation and the "extensive encroachment of forest vegetation diminishes the integrity of the cultural landscape." However, several cottonwood and maple trees at the Original LaPointe Lighthouse "may be original plantings or descendants of original plantings. These plantings are contributing features" and should be retained if possible if they are present within the area of identified soil contamination. The tree removal necessary to facilitate the contaminated soil removal will aid in restoring the integrity of the cultural landscape.

At Long Island, consideration should be given to using dredged sand from offshore of the island as backfill material in lieu of material sourced from the mainland. Appropriate approvals and acceptable environmental sampling results would be necessary before this consideration could be carried forward.

SECTION 6

REFERENCES

1. achp.gov, Advisory Council on Historic Preservation, http://www.achp.gov/ 106summary.html, *Section 106 Regulations Summary*. 2/17/14.

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FIGURES

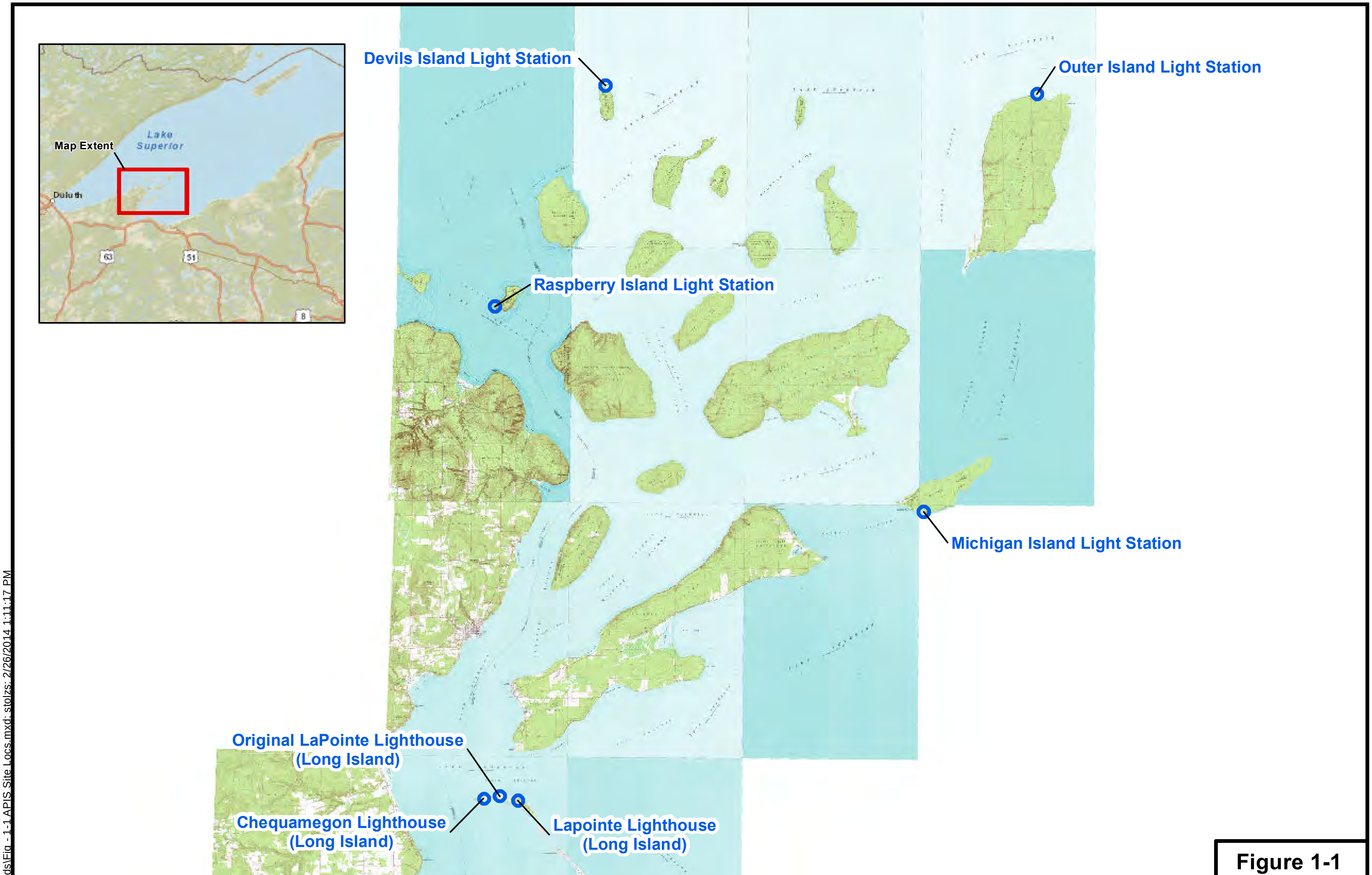

Figure 1-1

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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Bayfield WI, 54814

Prepared by:
WESTON SOLUTIONS of MI, INC
P.O. Box 577
Houghton, MI 49931

APOSTLE ISLANDS NATIONAL LAKESHORE SITE LOCATION MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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Figure 1-2

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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Houghton, MI 49931

MICHIGAN ISLAND PROJECT
SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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Figure 1-3

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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OUTER ISLAND PROJECT
SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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Figure 1-4

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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RASPBERRY ISLAND PROJECT
SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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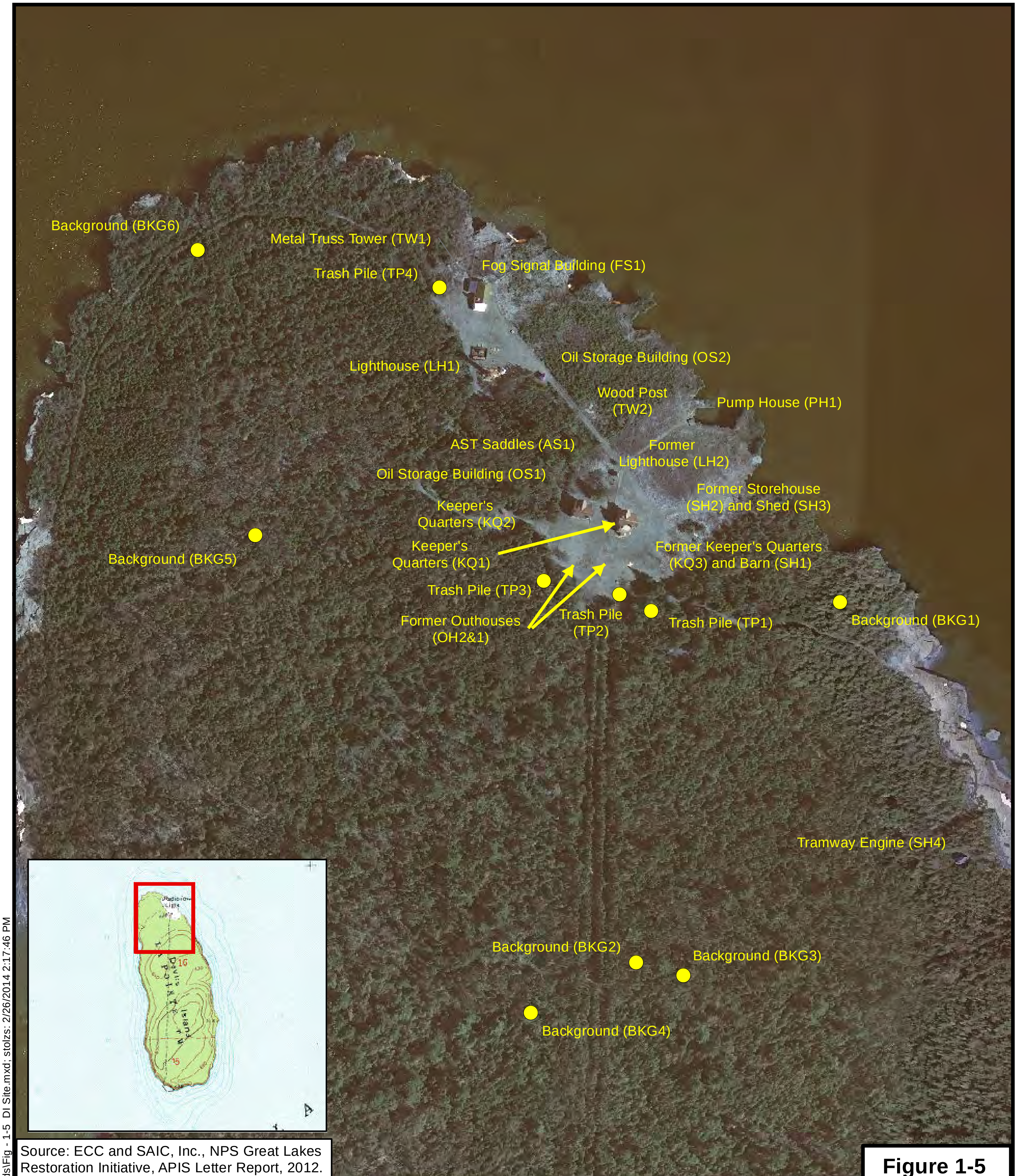

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

Figure 1-5

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WESTON SOLUTIONS of MI, INC
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Houghton, MI 49931

DEVILS ISLAND PROJECT
SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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Figure 1-6

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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P.O. Box 577
Houghton, MI 49931

LONG ISLAND - LAPOINTE LIGHT STATION PROJECT SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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Figure 1-7

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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Prepared by:
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Houghton, MI 49931

LONG ISLAND - ORIGINAL LAPOINTE LIGHT STATION PROJECT
SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

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Figure 1-8

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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LONG ISLAND -CHEQUAMEGON STATION PROJECT SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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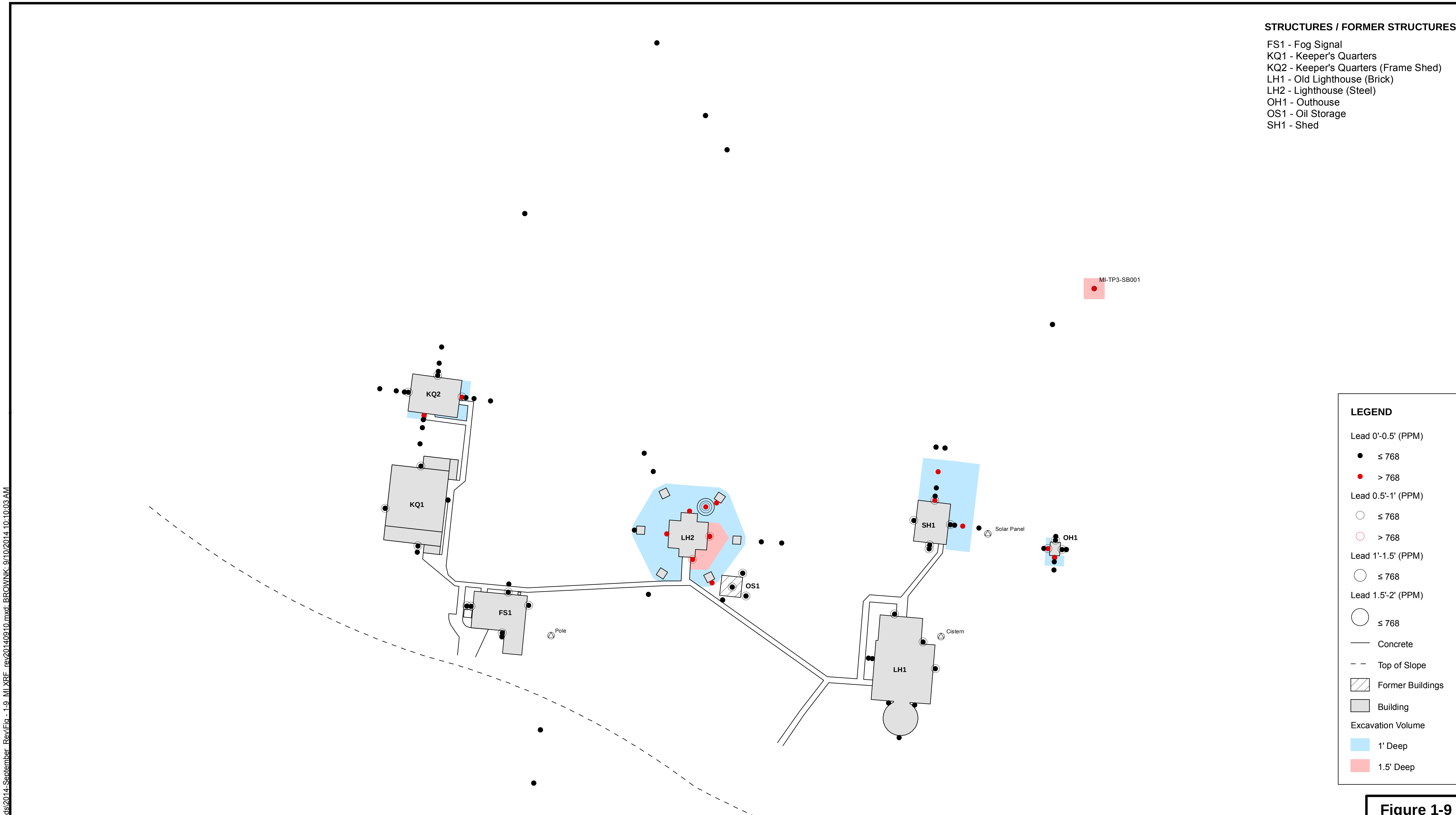

Figure 1-9

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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MICHIGAN ISLAND XRF RESULTS AND ESTIMATED EXCAVATION LIMITS
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

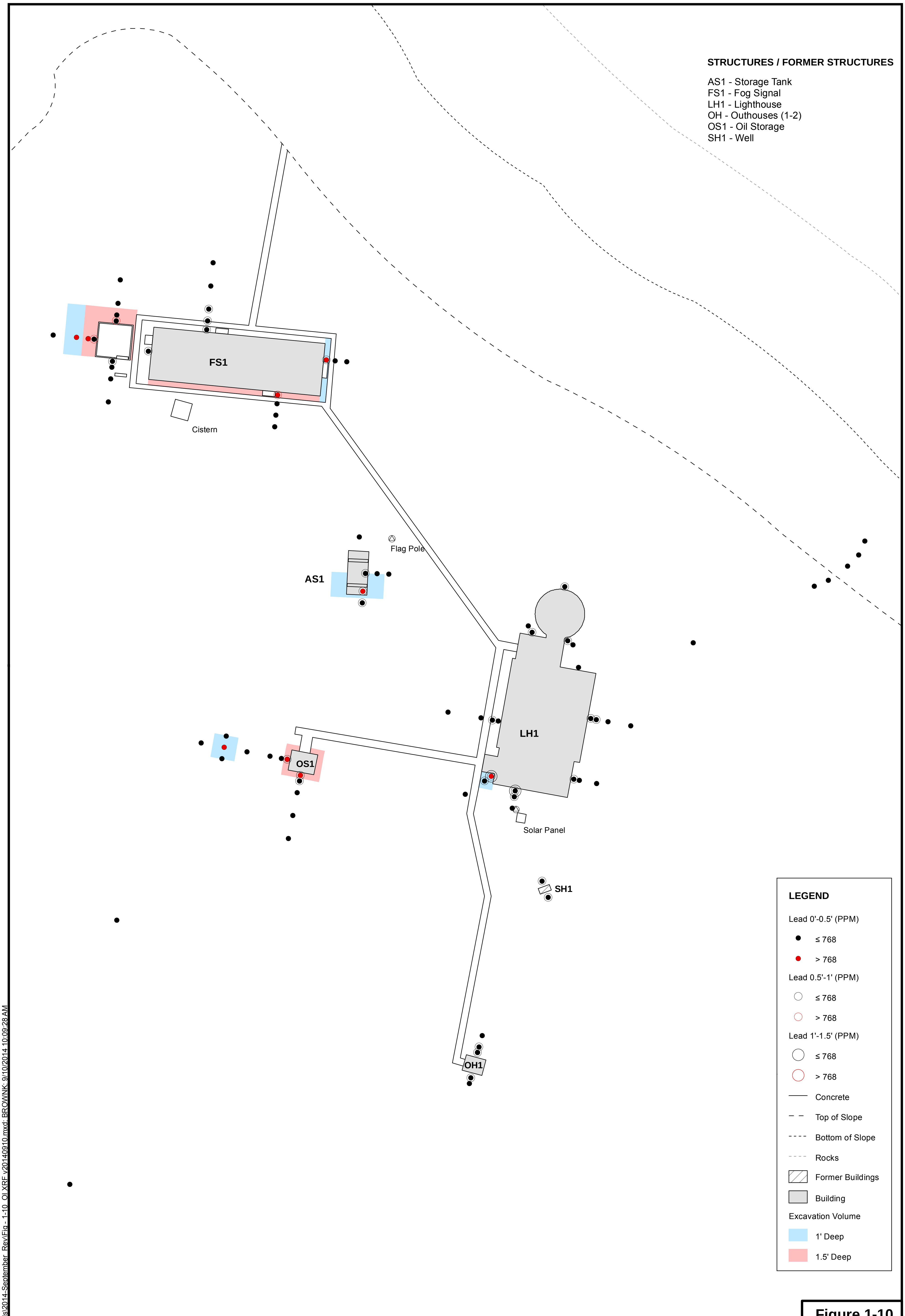

Figure 1-10

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

N W E S

0 15 30 Feet

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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Prepared by:
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P.O. Box 577
Houghton, MI 49931

OUTER ISLAND XRF RESULTS AND ESTIMATED EXCAVATION LIMITS
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

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Figure 1-11

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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RASPBERRY ISLAND XRF RESULTS AND ESTIMATED EXCAVATION LIMITS
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

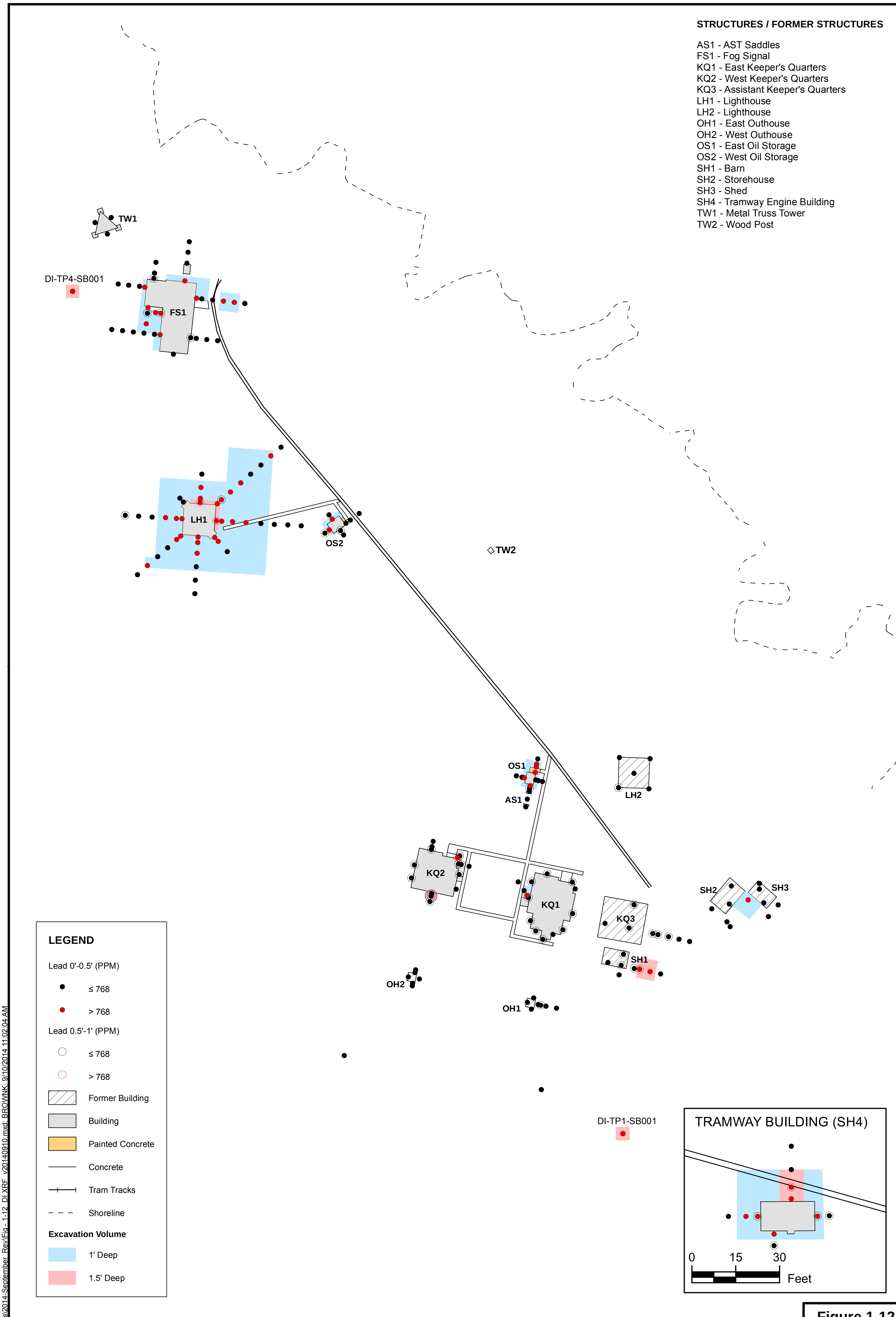

Figure 1-12

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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DEVILS ISLAND XRF RESULTS AND ESTIMATED EXCAVATION LIMITS
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

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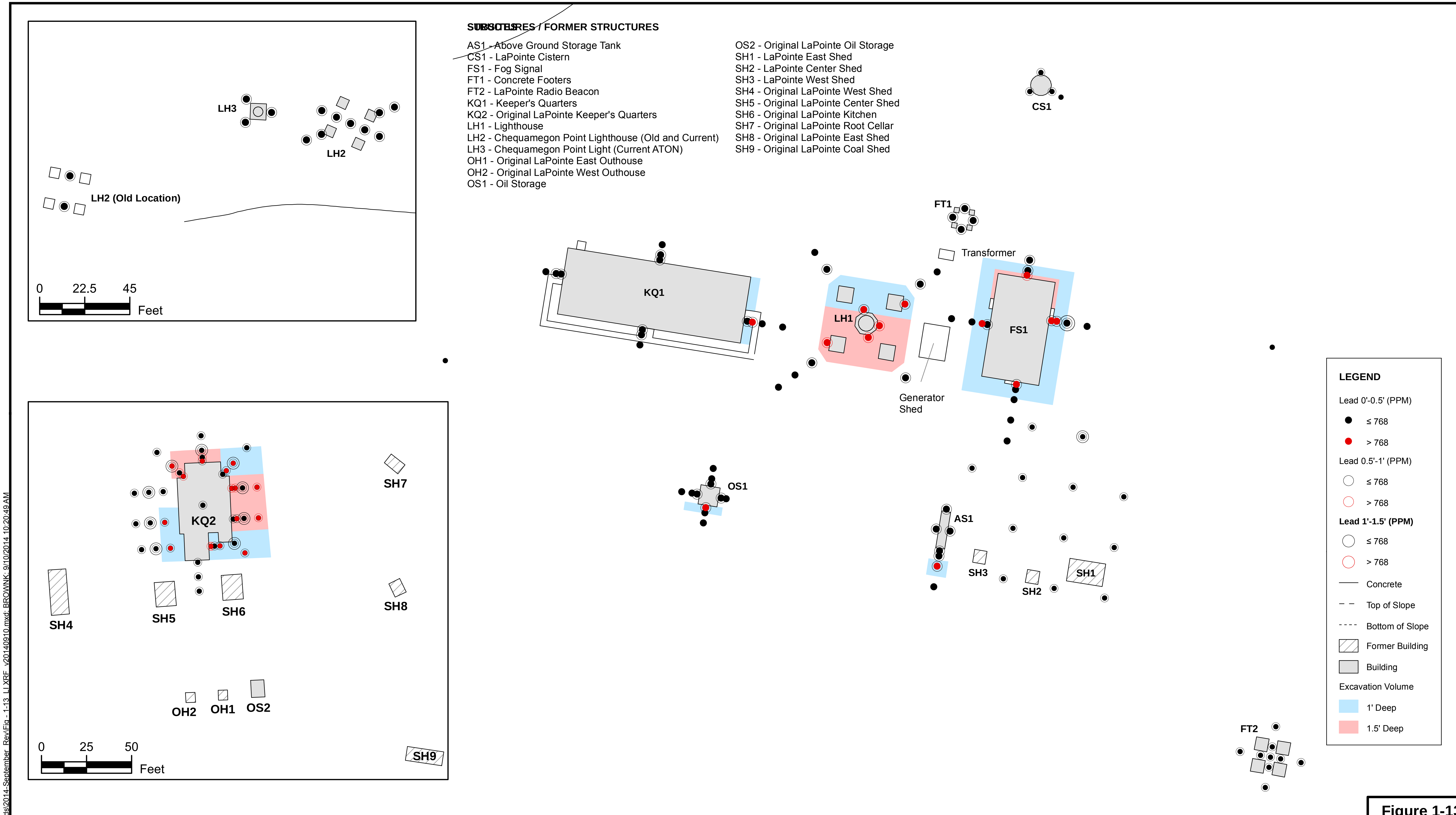

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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P.O. Box 577
Houghton, MI 49931

LONG ISLAND XRF RESULTS AND ESTIMATED EXCAVATION LIMITS
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE
SEPTEMBER 2014

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APPENDIX A

NATIONAL PARK SERVICE STATEMENT OF WORK - JULY 2013

STATEMENT OF WORK
ENGINEERING EVALUATION/COST ANALYSIS (EE/CA)
FOR
APOSTLE ISLANDS NATIONAL LAKESHORE

Introduction. The National Park Service (NPS) is exercising its authority as lead agency under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to undertake response activities as set forth herein at Apostle Islands National lakeshore (APIS). The response activities will address exposure to lead impacted soils at the Apostle Islands light stations; Michigan Island, Outer Island, Raspberry Island, Devil's Island, and Long Island (Sites). Appropriate criteria will include, inter alia, the following:

1.0 Background.

1.1 Located in Lake Superior, the Apostle Island archipelago consists of 22 islands in northwestern Wisconsin off of the Bayfield Peninsula. All five of the APIS island sites are accessible by boat on a seasonal basis (generally April through October). All project sites are located on NPS property.

1.2 Due to heavy traffic in the shipping lanes, multiple lighthouses were constructed in the mid-1800s to the early 1900s. These lighthouses required constant maintenance. The light station complexes range in size from a few buildings to large multi-building complexes that housed multiple keepers and their families. Lead-based paint was used on numerous structures on the island and trash piles were generated by the keepers. Additionally, during this time the standard disposal procedure was to bury or discard the lighthouse batteries down the nearby slopes. During the 1960s and 1970s, these lighthouses became automated and no longer required the constant care the onsite keepers provided. Today these complexes have been added the National Register of Historic Places. The grounds are open to the public for hiking and recreational use. Some of the buildings have been restored and are open for guided tours.

1.3 Physical Setting: The Apostle Islands were formed by glacial activity. The dominant bedrock in the entire Apostle Islands region includes the members of the Bayfield Group. The common bedrock for all the islands is the Chequamegon Sandstone, described as a red, brown, and white feldspathic sandstone, generally thick bedded and commonly cross-bedded. Rare inter-beds of red shale and conglomerate are found (Cannon et al. 1996). The light station complex soil profiles consist predominantly of red clay, silts, and sands. The surficial landscape is sandstone and glacial till that have been weathered by lake processes to produce beaches, spits, and caves. The islands, with the exception of Long Island, are heavily vegetated by predominantly northern mesic forest. Long Island vegetation is sandscape, which is characterized by beach grass, beach pea, trees, and shrubs that help stabilize the sand dunes. Groundwater flow and water table elevation are assumed to be controlled by the level of Lake Superior. Surface water drainage is assumed to be directed to the lake.

STATEMENT OF WORK
ENGINEERING EVALUATION/COST ANALYSIS (EE/CA)
FOR
APOSTLE ISLANDS NATIONAL LAKESHORE

1.4 Previous Investigations:

1.4.1 All five islands were part of an NPS Preliminary Assessment/Site Investigation conducted in 2008. The results of this study and any additional available studies are summarized in the SSA FSP for APIS. During the 2008 study, soil samples were collected adjacent to light station structures as well as the trash piles. In summary, lead contamination was identified as a concern in the soil surrounding the light station structures. In addition, trash piles and battery disposal areas were identified as potential contamination sources but were not fully characterized. Based on the observations of the Site and review of available information regarding the past use of the Site, it was likely that a release of lead to the soil, surface water, and possibly to groundwater has occurred. Based on the results of the PA, Versar recommended that a SI be performed.

1.4.2 SAIC / ECC under contract with the U.S. Army Corps of Engineers completed a site investigation in two mobilizations, the first in 2011 and the second in 2012. The site investigation focused on lead-based paint contamination in soil, debris piles, former battery disposal areas, and collection of background samples. The results of the investigation are provided in a report dated November 2012.

2.0 Engineering Evaluation/Cost Analysis (EE/CA). An EE/CA shall be prepared to summarize results from previous sampling efforts, assess human and ecological risk, identify ARARs (including NHPA §106, 36 CFR 6, NPS Organic Act, APIS enabling legislation, among others), establish target risk levels, develop site-specific preliminary remedial goals (PRGs), and analyze an appropriate array of alternatives consistent with CERCLA and the NCP.

2.1 Response Activities. Based on the findings of the previous site investigations and EE/CA all areas that contain concentrations that exceed site-specific action levels may be subject to response action to be performed under a separate SOW.

3.0 **Statement of Work.**

3.1 Project Conference and Schedule.

3.1.1 Project Conference. The contractor shall conduct a conference call with the NPS to discuss the overall schedule and project planning.

3.1.2 Schedule. The contractor shall submit a work schedule electronically via e-mail to the contracting officer's representative (COR) and to the program manager (PM) detailing the specific activity and proposed timing for approval in accordance with Section 6.0. Changes in the work schedule that involve field work must be coordinated at least 72 hours in advance with the COR and NPS.

3.2 Initial Field Visit. An initial field visit shall be completed to assist in developing remedial alternatives.

3.3 EE/CA Development.

The Contractor shall:

A. Prepare and submit to NPS a draft Site Administrative Record (AR) File and Administrative Record Index (in chronological order) in accordance with the NCP and U.S. EPA Final Guidance on Administrative Records for Selecting CERCLA Response Actions (Dec. 3, 1990; OSWER Directive 9833.3A-1).

B. Incorporate NPS-required modifications to the draft AR File and AR Index and submit to NPS the final AR File and AR Index.

C. Concurrent with development of the EE/CA, prepare and submit to NPS a draft Community Relations Plan (CRP) in accordance with the NCP and U.S. EPA Superfund Community Involvement Handbook (April 2002; EPA 540-K-01-003).

D. Incorporate NPS-required modifications to the draft CRP and submit to NPS the final CRP.

E. Prepare and submit to NPS a draft EE/CA Report in accordance with the NCP and the U.S. EPA Guidance referred to in paragraph D above in accordance with U.S. EPA Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA (August 1993; EPA/540-R-93-057)..

F. Incorporate NPS-required modifications to the draft EE/CA Report and submit to NPS and regulatory agencies the draft final EE/CA Report.

G. Prepare and submit to NPS a draft response to significant regulatory and public comments received on the draft final EE/CA Report. (The NCP mandates a minimum 30-day public comment period on the EE/CA Report.)

H. Incorporate NPS-required modifications to the draft response to significant regulatory and public comments and submit to NPS the final response to significant public comments.

I. Incorporate NPS-required modifications to the draft final EE/CA Report and submit to NPS and regulatory agencies the final EE/CA Report.

J. Prepare and submit to NPS a draft EE/CA Action Memorandum in accordance with the U.S. EPA Superfund Removal Procedures Action Memorandum Guidance (December 1990; EPA/540/P-90/004) and the U.S. EPA Guidance.

K. Incorporate NPS-required modifications to the draft EE/CA Action Memorandum and submit to NPS the final EE/CA Action Memorandum.

L. Prepare and submit to NPS a draft update to the AR File and AR Index in accordance with the NCP and the U.S. EPA Guidance referred to in paragraph A above, including the final EE/CA Action Memorandum.

M. Incorporate NPS-required modifications to the draft AR File and AR Index update and submit to NPS the final AR File and AR Index update.

4.0 General Requirements.

4.1 Coordination. The contractor shall maintain close and continuous coordination with NPS to assure adequate and timely flow of information. Conference calls with regulatory agencies will be required to discuss review comments and to develop final products.

5.0 Administrative Conditions.

5.1 Government-Furnished Materials. The U.S. Government will provide a copy of the PA (Versar 2005) and site investigation report to the contractor after award and may, when possible, assist the contractor in obtaining pertinent documentary materials, historical information, maps, photographs, site plans, forms, and other material as available.

5.2 Disposition of Materials and Information. All documentary materials provided to the contractor or generated by the contractor in the course of investigations will remain as, or become property of, the U.S. Government and must be returned to the NPS before final payment will be rendered.

5.3 Contracting Officer (CO) and Contracting Officer's Representative (COR). The CO will provide authoritative contract interpretation with associated guidance and direction. It is the COR's responsibility to seek timely progress of the work and a satisfactory outcome to the project. The COR will provide liaison, supply or assist in obtaining government-furnished materials and documents, monitor the contractor's performance, and verify compliance with progress of the project and contract.

5.4 Contractor's Project Manager (CPM) and Technical Staff. After this work order is awarded, the contractor shall designate a CPM. This CPM shall be responsible for supervising the work and overall product quality specified under this work order and shall serve as liaison between the contractor and the COR. The COR shall be apprised in advance of any proposed changes in the CPM by the contractor.

5.5 Extra Services. The contractor is advised not to render any services requested by any person verbally or in writing that could be considered a change in the terms or scope of this SOW and that would necessitate an adjustment in contract price. In the event that additional work was called for, a written proposal would be submitted to the CO, a mutually satisfactory fee negotiated, and a written notice to proceed issued.

6.0 Schedule.

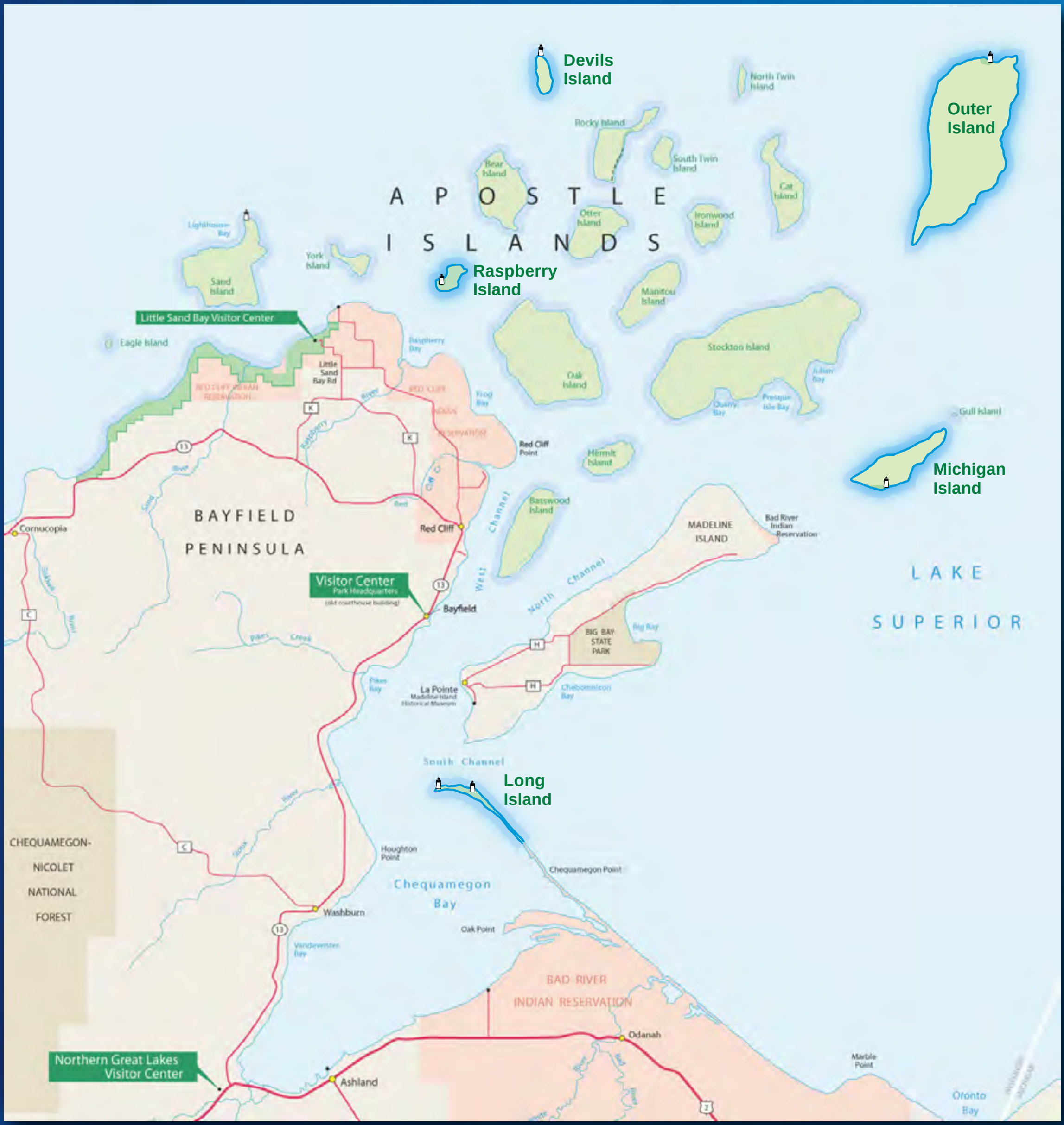
6.1 Submittals and Schedule. The contractor shall furnish sufficient technical, supervisory, and administrative personnel to ensure that the work is completed in accordance with the progress schedule. The contractor shall keep the COR fully advised at all times concerning delays or difficulties that may prohibit completion of any or all of the work according to the established schedule. The contractor shall submit with any payment requests a brief summary of the activities accomplished in the payment period and of the activities anticipated for the next payment period. The contractor shall furnish sufficient technical, supervisory, and administrative personnel to ensure the execution of the work and develop a schedule for submission of all deliverables. The Contractor shall also provide one electronic version of all submittals (except the AR File and AR File Updates) on CD. All electronic documents shall be in both PDF and the original software format (e.g., Microsoft Word, Excel). Hard copies of draft, draft final and final documents shall be submitted as follows; APIS (3), MWRO (2), state and federal regulatory agencies as required. Schedule for this scope of work shall be completed within 270 days of contract award.

APPENDIX B

DRAFT RISK ASSESSMENT REPORT - MARCH 2014

Apostle Islands National Lakeshore

Draft Risk Assessment Report
Engineering Evaluation/Cost Analysis for Lead-Impacted Soils at Light Stations on Michigan, Outer, Raspberry, Devils, and Long Islands



Prepared for:

National Park Service
415 Washington Avenue
Bayfield, WI 54814

Prepared by:

Weston Solutions, Inc.
P.O. Box 577
Houghton, MI 49931

and

PRIZIM, Inc.
4740 White Bear Parkway, Suite 102
White Bear Lake, MN 55110

Work Order Number: 15069.004.001.0010

March 2014

14P-0009-2

Draft
Risk Assessment Report

Engineering Evaluation/Cost Analysis for Lead-Impacted Soils at Light Stations on Michigan, Outer, Raspberry, Devils, and Long Islands

Apostle Islands National Lakeshore
Bayfield, Wisconsin

Prepared for:

National Park Service
Apostle Island National Lakeshore
415 Washington Avenue
Bayfield, WI 54814

Prepared by:

Weston Solutions, Inc.
P.O. Box 577
Houghton, MI 49931

PRIZIM Inc.
4740 White Bear Parkway, Suite 102
White Bear Lake, MN 55110

DRAFT
RISK ASSESSMENT REPORT FOR THE APOSTLE ISLANDS NATIONAL LAKESHORE ENGINEERING EVALUATION/COST ANALYSIS FOR LEAD-IMPACTED SOILS AT LIGHT STATIONS ON MICHIGAN, OUTER, RASPBERRY, DEVILS AND LONG ISLANDS BAYFIELD, MICHIGAN

Prepared for:

NATIONAL PARK SERVICE
Apostle Islands National Lakeshore
415 Washington Avenue
Bayfield, Wisconsin 54814

____
Terry Bosko
Technical Manager, RA Specialist

____
Jed Chrestensen, P.E.
Principal Project Engineer

____
Jeffrey S. Binkley
Senior Client Services Manager

Prepared by:

WESTON SOLUTIONS, INC.
P.O. Box 577
Houghton, Michigan 49931
and
PRIZIM Inc.
4740 White Bear Parkway, Suite 102
White Bear Lake, Minnesota 55110

March 2014

W.O. No: 15069.004.001.0010

EXECUTIVE SUMMARY

Weston Solutions, Inc. (WESTON®) has prepared this Risk Assessment (RA) Report as part of the Engineering Evaluation/Cost Analysis (EE/CA) for lead-impacted soils at light stations on Michigan, Outer, Raspberry, Devils, and Long Islands within the Apostle Islands National Lakeshore (Sites) located in Bayfield, Wisconsin. The RA was generally conducted in accordance with Wisconsin Department of Natural Resources (WDNR) and U.S. Environmental Protection Agency (EPA) procedures. The RA has been prepared under PRIZIM Inc.'s (PRIZIM's) Contract No. B2420090003 with NPS Midwest Region and WESTON's Proposal for EE/CA, Apostle Islands National Lakeshore, Bayfield, Wisconsin dated August 2013.

The results of the previous investigations at the Sites determined that contaminant concentrations exceeding human health action levels were present at each light station making them subject to processes and rules promulgated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plane (NCP). This RA was conducted to develop site-specific human health preliminary remediation goals (PRGs) and determine whether available data indicate the potential for ecological impacts from lead in soil for use in evaluating remedial options in the EE/CA.

The Adult Lead Model (ALM) was used to evaluate lead exposure by calculating a blood lead concentration of a Maintenance Worker, Interpretive Park Ranger, and Volunteer Lighthouse Keeper (adult [>16 years old] and adolescent [7 to 16 years old]) and estimating the probability of fetal blood lead concentration of a pregnant female worker exceeding 10 microgram per deciliter (µg/dL). Both 95th percentile upper confidence limit (95UCL) on the arithmetic mean and maximum soil concentrations were used in the evaluation of risk so that potential hotspots of contamination were not overlooked.

PRGs were developed for each receptor group using the ALM. Exposure frequencies of five days per week and an averaging time of mid-April through mid-October (183 days) were used for the Maintenance Worker. An exposure frequency of one and five days per week for an Interpretive Park Ranger and seven days per week for a Volunteer Lighthouse Keeper were used for an averaging time of mid-June through September (107 days). Continuous exposure for three months was also considered for a Volunteer Lighthouse Keeper. PRGs were calculated as follows:

- § Maintenance Worker – Mid-April through Mid-October: 939 milligrams per kilogram (mg/kg);
- § Interpretive Park Ranger (one day/week) – Mid-April through Mid-October: 9,458 mg/kg;
- § Interpretive Park Ranger (five days/week) – Mid-June through End September: 1,881 mg/kg;
- § Volunteer Lighthouse Keeper – Mid-June through End September - Adult: 1,344 mg/kg; and,
- § Volunteer Lighthouse Keeper – Mid-June through End September - Adolescent: 768 mg/kg.

Based on the infrequent use of the Sites by young children, this receptor group is not evaluated in the Human Health Risk Assessment (HHRA). The EPA's Integrated Exposure-Uptake Biokinetic Model (IEUBK) predicts plausible distributions of blood lead levels in children zero to seven years of age. Based on this model, EPA (1994) and WDNR (2013) have established a residential cleanup level of 400 mg/kg. This cleanup level is recommended for the light stations if a young child would be in residence in the keeper's quarters.

The garden soil concentrations on Raspberry Island ranged from 36 milligrams per kilogram (mg/kg) to 65.9 mg/kg lead. EPA (2013d) guidance on gardening states that soil concentrations less than 100 mg/kg present low risk. No specific remediation is needed and there are no restrictions on crop type. Good gardening and housekeeping practices (i.e., wash hands, clothes, and produce) are recommended.

In accordance with EPA ecological risk guidelines, the Screening Level Ecological Risk Assessment (SLERA) included conservative assumptions to ensure ecological receptors and risks are not prematurely eliminated from consideration. The SLERA found that there is potential risk to plants, soil invertebrates, small mammals, passerine birds and carnivorous bird and mammals from exposure to lead in soil at all light stations. Under more realistic site use conditions (e.g., 95UCL concentrations and species common to APIS), the risk to site-specific individual organisms would be reduced. Risk estimates were also refined using the lowest observed adverse effect level

(LOAEL)-based alternative toxicity reference values to evaluate a dose which is expected to produce adverse population effects. At the 95UCL soil concentrations on Michigan Island, Devils Island, and Long Island, the LOAEL-based hazard quotient exceeded one for the American woodcock, indicating potential risk to upper trophic level populations of avian insectivores. However, the risk evaluation assumes that woodcock feeds entirely within the light stations, which encompass 1.6 to 3 acres, while the home range of a woodcock is from 7 to 98 acres (EPA, 1993).

There is widespread lead in soil at the Sites at concentrations above natural background and conservative ecological screening levels. These concentrations have been delineated to 250 mg/kg (ECC/SAIC, 2012) and were found to be localized around the buildings/structures. At 250 mg/kg lead, the LOAEL-based hazard quotient (HQ) for all receptor groups does not exceed the threshold of one. The light stations are not included in the adjacent Gaylord Nelson National Wilderness area; the habitat near the building/structures consists of maintained lawns. Some of the buildings are open for guided tours and the grounds are also open to the public for hiking and recreational use (ECC/SAIC, 2012). Human use of the area will limit use by wildlife. Lead does not biomagnify in the food chain or significantly bioaccumulate. Therefore, remediation of lead in site soils for human use is anticipated to result in protection of ecological receptors that may inhabit the developed areas around the light stations.

It is anticipated that completion of a removal action at the Sites will be a final action necessary to address soil contamination related to deterioration of lead-based paint at the subject facilities. Further, achievement of the Remedial Action Objectives at each of the Sites will eliminate threats to human health and the environment while eliminating the need for long-term management of the impacted areas and preserving the mission of the NPS.

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LIST OF ACRONYMS AND ABBREVIATIONS

95UCL	95th percentile upper confidence limit
%	percent
µg/dL	microgram per deciliter
ABLES	Adult Blood Level Epidemiology and Surveillance
AHA	Anderson Hallas Architects
ALM	Adult Lead Model
APIS	Apostle Islands National Lakeshore
Baker	Michael Baker Jr., Inc.
BERA	Baseline Ecological Risk Assessment
BKSF	Biokinetic Slope Factor
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	Chemicals of potential concern
COPECS	Chemicals of potential ecological concern
ECC	Environmental Chemical Corporation
EcoSSL	Ecological Soil Screening Level
EE/CA	Engineering Evaluation/Cost Analysis
EF	Exposure frequency
EPA	United States Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
ESL	Ecological Screening Level
ft	Feet; foot
FSP	Field Sampling Plan
g	gram; grams
GSD	geometric standard deviation
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard quotient
IEUBK	Integrated Exposure-Uptake Biokinetic Model
LOAEL	Lowest observed adverse effect level
mg/kg	Milligrams per kilogram

LIST OF ACRONYMS AND ABBREVIATIONS (CONCLUDED)

NCP	National Contingency Plan
NOAEL	No observed adverse effect level
NPS	National Park Service
PA	Preliminary Assessment
PbB	blood lead
PRG	Preliminary Remediation Goal
PRIZIM	PRIZIM Inc.
Sites	Michigan, Outer, Raspberry, Devils, and Long Islands
RA	Risk Assessment
RAGs	Risk Assessment Guidance for Superfund
RfD	Reference Dose
SAIC	Science Applications International Corporation, Inc.
SI	Site Investigation
SLERA	Screening Level Ecological Risk Assessment
SSA	Site Specific Attachment
TRV	Toxicity Reference Value
UCL	Upper confidence limit
USACE	United States Army Corps of Engineers
UWSP	University of Wisconsin - Steven's Point
WDNR	Wisconsin Department of Natural Resources
WESTON	Weston Solutions, Inc.
XRF	X-ray fluorescence

SECTION 1

INTRODUCTION

Weston Solutions, Inc. (WESTON®) has prepared this Risk Assessment (RA) Report as part of the Engineering Evaluation/Cost Analysis (EE/CA) for lead-impacted soils at light stations on Michigan, Outer, Raspberry, Devils, and Long Islands within the Apostle Islands National Lakeshore (APIS) (Sites) located in Bayfield, Wisconsin. The RA was generally conducted in accordance with Wisconsin Department of Natural Resources (WDNR) and U.S. Environmental Protection Agency (EPA) procedures. The RA has been prepared under PRIZIM Inc.'s (PRIZIM's) Contract No. B2420090003 with National Park Service (NPS) Midwest Region and WESTON's Proposal for EE/CA, Apostle Islands National Lakeshore, Bayfield, Wisconsin dated August 2013.

Risk assessments were prepared based on the findings of remedial investigation activities completed by Environmental Chemical Corporation (ECC) and Science Applications International Corporation, Inc. (SAIC) (2012) at each of the following five islands (Sites) within APIS:

§ Michigan Island;

§ Outer Island;

§ Raspberry Island

§ Devils Island; and,

§ Long Island.

The results of the remedial investigations determined that contaminant concentrations exceeding human health action levels are present at each light station making them subject to processes and rules promulgated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP). The RA has been conducted to develop site-specific human health preliminary remediation goals (PRGs) and determine whether available data indicate the potential for ecological impacts from lead in soil for use in evaluating remedial options in the EE/CA.

This report summarizes the findings of previous investigations and the recent RA activities, and is organized into five sections of text, in addition to figures, tables, and appendices. A brief description of each section follows:

Section 1 – Introduction: Presents the purpose and scope of the report.

Section 2 – Background: Describes the location, general features, and history of the Sites.

Section 3 – Risk Assessment: Presents the human health and ecological RAs for the Sites, and develops site-specific PRGs.

Section 4 – Conclusions and Recommendations: Summarizes the findings of the RA and provides the recommended course of action for the Sites.

Section 5 – Referenced Reports: Provides a list of the references for sources of site-specific data, information, and previous conclusions that are discussed or referenced within this report.

SECTION 2

BACKGROUND

Located in Lake Superior, the Apostle Island archipelago consists of 22 islands in northwestern Wisconsin off of the Bayfield Peninsula. The location of APIS and the locations of the five island Sites included in this RA are depicted in **Figure 2-1**. All five of the Sites are accessible by boat on a seasonal basis (generally April through October) and are located on NPS property. The site characterization activities summarized in this RA are excerpted from the November 2012 *National Park Service Great Lakes Restoration Initiative Apostle Islands National Lakeshore Letter Report* (ECC/SAIC, 2012) and are focused on the light station complexes at each of the five Sites.

"The Apostle Islands were formed by glacial activity. The dominant bedrock in the entire Apostle Islands region includes the members of the Bayfield Group. The common bedrock for all the islands is the Chequamegon Sandstone, described as a red, brown, and white feldspathic sandstone, generally thick bedded and commonly cross-bedded. Rare inter-beds of red shale and conglomerate are found (Cannon et al. 1996). The light station complex soil profiles consist predominantly of red clay, silts, and sands.

The surficial landscape is sandstone and glacial till that have been weathered by lake processes to produce beaches, spits, and caves. The islands, with the exception of Long Island, are heavily vegetated by predominantly northern mesic forest. Long Island vegetation is sandscape, which is characterized by beach grass, beach pea, trees, and shrubs that help stabilize the sand dunes.

Groundwater flow and water table elevation are assumed to be controlled by the level of Lake Superior. Surface water drainage is assumed to be directed to the lake" (ECC/SAIC, 2012).

Due to heavy traffic in the shipping lanes, multiple lighthouses were constructed in the mid-1800s to the early 1900s. These lighthouses required constant maintenance. The light station complexes range in size from a few buildings to large multi-building complexes that housed multiple keepers and their families. Lead-based paint was used on numerous structures. During the 1960s and 1970s, these lighthouses became automated and no longer required the constant care the onsite keepers provided.

Today these complexes have been added to the National Register of Historic Places. The grounds are open to the public for hiking and recreational use. Some of the buildings have been restored and are open for guided tours. For additional site history information, refer to the APIS Site Specific Attachment (SSA) Field Sampling Plan (FSP) and its Addendum (NPS 2011a and NPS 2012).

The following subsections provide a brief description of each of the five Sites evaluated in this RA.

2.1 MICHIGAN ISLAND

The lighthouse on Michigan Island was constructed in 1856 and entered service in the spring of 1857, but was closed after only one year of operation. For more than a decade, the Michigan Island tower sat vacant, and in the harsh Lake Superior climate, it quickly began to deteriorate. In 1869, the light was refurbished and equipped with a three-and-a-half order Fresnel lens and returned to service" (NPS, 2014).

"The light station grounds on Michigan Island are located on a bluff, rising approximately 60 feet (ft) above Lake Superior. The overall island topography consists of a landscape of gently rolling, forested hills ending in steep banks that slope down to rocky or sandy beaches. The light station grounds are primarily flat with several small drainages leading from the interior of the island to the bluff edge and shoreline. The embankment slope is highly erodible but stable. The shoreline adjacent to the light station is primarily a narrow rocky cobble beach east of the boat dock with sand beaches to the west fluctuating in width. The topography of the light station and reservation is in good condition.

The light station grounds are arranged in a fairly formal, rectangular shape. The forest/encroaching vegetation creates an outer perimeter, the buildings and tram tracks form an inner perimeter, with the open lawn in the central portion of the site. Within the grounds the structures and tram tracks reinforce this outdoor common space. Centered in the grounds is the dominant element, the tall, steel Light Tower." (Anderson Hallas Architects [AHA], 2011).

The Michigan Island Light Station buildings include:

- The Old Michigan Island Lighthouse (LH1);
- Lighthouse (LH2);
- Fog Signal Building (FS1);
- Keepers Quarters (KQ1);
- Assistant Keepers Quarters (KQ2);
- Outhouse (OH1); and,
- Utility Building/Shed (SH-1).

Structures on Michigan Island include the boat dock, tramway, tram turntable and tram tracks.

"The concrete boat dock extends from the shore in an 'L' shape to the south (140 ft) and west (70 ft) of the shore. The existing dock was constructed in 1987 and was modified in 1993. It is a steel sheet pile structure infilled with stone rubble and capped with a concrete deck. The top of the boat dock has tram rails set into the surface, which are connected to the inclined tramway." "The inclined tramway is 158 ft long and connects the boat dock to the top of the bluff, rising approximately 60 ft above the shoreline." (AHA, 2011).

The Michigan Island project site is depicted on **Figure 2-2**.

2.2 OUTER ISLAND

"Standing on a high bluff at the most remote point of the Apostle Islands chain, the Outer Island lighthouse was built in 1874 to guide ships past the archipelago to the rapidly growing ports of Duluth and Superior" (NPS, 2014).

The brick tower stands 90 ft high and was sited to cast its beam far across the open lake. "The Outer Island light had a large, "third-order" Fresnel lens with a central band of six glass prism bull's-eye panels. These bull's-eyes concentrated the light into six brilliant beams. Rotation of the lens on a clockwork mechanism powered by weights caused the beams to sweep the horizon, making the light appear to flash.

The light station on Outer Island is exposed to the full force of Lake Superior. In its first year of operation, the station dock washed away. Waves eroded the clay banks until they collapsed, destroying the fog signal building at their base." "The original fog signal building was replaced by a structure at the top of the cliff in 1875. In 1878, a third fog signal building, virtually identical to the second, was built at cliff top, adjacent to its twin. These two buildings were renovated and combined into a single structure in 1900, assuming the form that we see today" (NPS, 2014).

"The light station grounds on Outer Island are located on a bluff, rising approximately 50 ft above Lake Superior. The overall island topography consists of a landscape of gently rolling, forested hills ending in steep banks that slope down to rocky or sandy beaches. The light station grounds are primarily flat with the Outer Island Tower, Keepers Quarters, and Fog Signal Building occupying the highest points of the site. The remainder of the site slopes gently south, east, and west towards the bordering forest. A drainage swale, constructed in 2005, runs the length of the light station grounds along the northern perimeter. At the north edge of the grounds, steep banks slope down to Lake Superior. The embankment slope is highly erodible but currently stable. The shoreline adjacent to the light station features a stone revetment approximately 50 ft wide at the bottom of the bank."

"Extensive erosion control measures were implemented on the northern island banks in the early 1980s and again in 2005 to reduce erosion of the banks and potential impacts to the light station grounds and structures. The work included installation of a stone revetment covering the shoreline zone (which was once a sandy beach), bioengineering along the shoreline banks primarily with log cribs and planting of native shrubs and forbs, a drainage swale along the northern edge of the light station grounds, and terracing portions of the banks. The drainage swale has created a subtle change to the landscape while the slope terracing has a more apparent impact to the topography." "Overall, the condition of the light station's topography is good, with the exception of the shoreline bank, which is fair with high erosion potential" (AHA, 2011).

The Outer Island Light Station buildings include:

- The Outer Island Tower/Keeper's Quarters (LH1);
- Fog Signal Building (FS1);
- Oil Storage Building (OS1); and,
- Outhouse (OH1).

The structures on Outer Island include the boat dock, tramway, and tram tracks.

"The concrete boat dock is 14 ft wide and extends from the shore in an 'L' shape to the north (100 ft) and then jogs west (200 ft), to form the breakwater. The existing dock was constructed in 1958. It is a steel sheet pile structure in-filled with stone rubble, capped and sided with concrete. The top of the boat dock has approximately 80 ft of tram rails set into the surface, which are connected to the inclined tramway" (AHA, 2011).

"The inclined concrete tramway is 105 ft long and connects the boat dock to the top of the bluff, rising approximately 50 ft above the shoreline. The tramway consists of: concrete structural support footings, cast iron tram rails with formed concrete steps between the rails, a tram hoist at the top of the tramway, and a steel pipe railing located on the east side of the structure." "The upper portion of the tramway structure (approximately 40 ft) is constructed at a slope of approximately 19 degrees. The lower portion (approximately 65 ft) is constructed at a steeper slope of approximately 28 degrees.

The tramway is in good condition and retains all of its original elements including: concrete structural supports with footings and stairs, steel handrail, and cast iron tram rails." (AHA, 2011).

The Outer Island project site is depicted on **Figure 2-3**.

2.3 RASPBERRY ISLAND

Construction of the lighthouse began in 1861, and in mid-July of 1863 the lens was installed and the light station officially began operation. As originally built, the Raspberry lighthouse was a boxy, two-bedroom house with a shed at one side containing the kitchen. Rising from the center of the roof was a short tower that supported the lantern" (NPS, 2014).

"With continuing expansion in shipping traffic on Lake Superior, demand rose for a fog signal at Raspberry Island. State-of-the-art technology called for a coal-fired steam whistle, and such equipment demanded extra personnel to share the workload. In 1903, the current fog signal building was constructed, and a second assistant authorized" (NPS, 2014).

"In 1906, the Lighthouse Service remodeled the building from the ground up. Portions of the old structure were incorporated into the new building, but final result was a lighthouse that was much larger and more imposing than the original. The new lighthouse was occupied until 1947, when the light was converted to automatic operation. The lens remained in the tower until 1957, when the Coast Guard replaced it with a battery-operated beacon mounted on a pole in front of the lighthouse" (NPS, 2014).

"While the lighthouse we see on Raspberry Island appears much the same as it did in 1906, the surrounding setting has changed substantially. When the lighthouse was built, the surrounding area was cleared of trees so that ships would have a clear view of the beacon. Photos taken as recently as the 1940s show an open area of several acres around the station. Today, forest has encroached upon the site, and only a portion of the original clearing remains." (NPS, 2014).

"The topography of Raspberry Island played a major role in the selection of the island as the site for a lighthouse. The level, elevated bluff that rises forty feet above the water's edge at the west end of the island – directly adjacent to the navigation channel, offered an ideal site for a lighthouse and the associated infrastructure needed to support the lighthouse keepers. Historic maps from 1877 and 1910 indicate that the topography of the island has experienced little change since establishment of the station, with the exception of erosion of the bluff immediately west of the lighthouse as a result of wave action. The highest point of the island is centrally located between the lighthouse yard and the sand point, well within the forest canopy.

Within the station clearing the land slopes from east to west (from the historic edge of the clearing towards the bluff) at an approximate rate of 1 Horizontal (H):10 Vertical (V).

Natural erosion and human efforts to stem this erosion have significantly altered the bluff. Erosion of the bluff has altered spatial relationships in the lighthouse yard by eliminating a strip of level ground between twenty and forty feet in width from the area immediately west of the lighthouse and fog signal building.

The existing condition of the bluff reflects a major stabilization project, completed in 2003, which added nearly forty feet of material to the base of the bluff. This engineered revetment consists of a French drain installed at the top of the bluff to aid drainage, stone riprap placed along the bottom third of the bluff, and replanted native species on the upper two-thirds of the slope. This planting design is intended encourage revegetation of native species while protecting the bluff face and allowing the view from the top of the bluff to the west to remain unimpaired.

The other principal topographic feature at the site is a small ditch, created by the NPS, dug around the perimeter of the lighthouse yard. This ditch aids in the drainage of the heavy clay soil. It is visually hidden by unmown grass.

All the buildings and structures associated with the Raspberry Island Light Station are located in a single cluster within the light station clearing at the southwest end of the island. The dates of construction of these resources range from 1862 (original portions of the lighthouse) to the 1940s. Previous preservation and planning efforts have focused on the lighthouse, which forms the focal point of the building cluster. The Lakeshore personnel conduct routine maintenance at the buildings. Several of the ancillary buildings are in need of stabilization to arrest ongoing deterioration" (NPS, 2004).

The Raspberry Island Light Station buildings include:

- The Raspberry Island Lighthouse/Keeper's Quarters (LH1);
- Fog Signal Building (FS1);
- Oil Storage Building (OS1);
- Shed (SH1);
- Cabin (SH2);
- Barn/Warehouse (SH3); Outhouse (OH1); and,

- Head Keeper’s Outhouse (OH2).

The Raspberry Island project site is depicted on **Figure 2-4**.

2.4 DEVILS ISLAND

“The beacon on Devils Islands was lit in 1891. A two-story, red brick, Queen Anne- style keeper's dwelling and a building for the steam fog signal were completed at this time, but the light was placed in a temporary tower. The tower, made of wooden timbers, held a fourth order, non-flashing red light.

A two-story, brick and shingle house similar in design to the keeper's dwelling was built for the assistant keepers in 1897. Work began on the permanent tower, an 82-ft tall steel cylinder, that same year. Although the tower was ready in the fall of 1898, there was a three year delay in supplying it with a lens. A third order lens…arrived in April 1901. The permanent tower was placed in service shortly afterward, and the temporary tower torn down the same year.

The lighthouse was originally designed as a plain, self-supporting cylinder, but the high winds of its exposed location caused the tower to shake so badly that lightkeepers complained that the motion sometimes extinguished the lamp. In 1914, the Lighthouse Service reinforced the structure with external braces, alleviating the problem and giving the tower the appearance we see today” (NPS, 2014).

“The topography of Devils Island consists of low, undulating landscape that rises approximately 58 ft above Lake Superior at its highest point. Bedrock under the northern two thirds of the island is the Devils Island brownstone formation. The outcrop along the island’s shoreline forms the island’s characteristic sandstone cliffs and sea caves. The topography at the light station grounds is generally level and elevated approximately 20 ft above Lake Superior. A shallow depression exists east of the Keepers Quarters, marking the location of the non-extant Assistant Keepers Quarters” (AHA, 2011).

The Devils Island Light Station buildings include:

- The Devils Island Lighthouse (LH1);

- Keeper's Quarters (KQ1);
- Assistant Keeper's Quarters (KQ2)
- Fog Signal Building (FS1);
- Oil Storage Building (OS1); and,
- Oil Storage Building (OS2).

The structures on Devils Island include the tram tracks, pump house, boat dock, radio antenna tower, and NPS Vault Toilet.

"The tram tracks on the light station connect the Fog Signal Building to the Tramway Engine House, running the length of the grounds (approximately 1,600 linear ft) following a straight line that parallels the shoreline of the island." "The tracks remain in place but are nonfunctional as a system. The condition of the tram tracks is poor as the timbers beneath are rotted, the area between the tracks has become filled with soil and vegetation, and portions of the rails have been damaged and bent" (AHA, 2011).

"The pump house is located northeast of the Keepers Quarters, and is built into the edge of the shoreline cliff, overhanging open water below. It is a board formed, cast-in-place, concrete structure, approximately 10 ft x10 ft with a concrete stairway leading down to an access door on its north facade. The pump house is in poor condition and is nonfunctional" (AHA, 2011).

The Devils Island project site is depicted on **Figure 2-5**.

2.5 LONG ISLAND

"The first LaPointe light was constructed about one-quarter mile east of the island's western tip. This small, wooden structure was hastily erected in 1858, when authorities found that in the previous year, the lighthouse intended for Long Island had been placed on Michigan Island" (NPS, 2014).

"Over the years, the focus of shipping in the area shifted from venerable LaPointe to the bustling industrial port of Ashland. To accommodate this change, authorities installed a steam-powered fog signal and replaced the old lighthouse with two newer towers, spaced nearly a mile apart.

The fog signal came first, built in 1891, several thousand feet east of the original light. In 1897, it was joined by the "New" LaPointe light, a 67-ft cylindrical tower constructed alongside. The old lighthouse had its lantern room removed, and continued to serve as housing for keepers and their families until it was finally abandoned in 1940, replaced by a triplex apartment block. Only ruins remain today, hidden in thick vegetation” (NPS, 2014).

“The Chequamegon Point light, a 42-ft tower at the western tip of the island, was also erected in 1897. LaPointe light station and the Chequamegon Point light were fully automated in 1964. The fog signal building was demolished in 1986.

Of the three historic lighthouses of Long Island, only the new LaPointe tower remains in use. In 1987, concerned about erosion, the U.S. Coast Guard moved the Chequamegon Point tower, lifting it with a helicopter and transporting it about one hundred feet back from the shoreline. The beacon was placed on a modern cylindrical structure, and the old tower stands empty, surrounded by trees” (NPS, 2014).

In contrast to the other islands at APIS, “Long Island is a barrier spit that is primarily composed of low ridge and swale topography, typical of sandy dunes and beaches. The interior of the island rises to approximately 10 ft above the edge of Lake Superior and consists of dune vegetation, scrub forest and areas of low wetlands.” “All three of the Long Island Light Station sites are located on or near dynamic sandy landscapes. The Lake Superior shoreline of the island is constantly reshaped by the natural forces of weather and water. Historic photographs and maps indicate the shoreline has changed significantly since the initial light station development on the island.

The dynamic nature of the island has changed the Original LaPointe Lighthouse site from a shoreline location to pine barren, rolling dune character that is now over 400 ft from the water. This change from natural forces has affected the character and visibility of the site. The topography of the LaPointe site has changed in the same manner but to a lesser degree. The area between the grounds and shoreline has decreased and the shoreline is closer to the buildings and structures than during the period of significance. At Chequamegon Point, the shifting sandscape at the tip of the island has changed significantly enough to necessitate the relocation of the original light tower approximately 170 ft further inland (northeast)" (AHA, 2011).

The Long Island Light Station buildings include:

- The LaPointe Lighthouse (LH1);
- Keeper's Quarters/Triplex Resident (KQ1);
- The Old Chequamegon Point Lighthouse (LH2); and,
- The New Chequamegon Point Lighthouse (LH3).

Structures at the LaPointe site include a boat dock, Fog Signal Building foundation, utility unit (fiberglass generator hut) and shed.

"The boat dock is located on the Lake Superior shoreline directly north of the LaPointe Light Tower. The dock is approximately 80 ft long and 8 ft wide and is built of steel pipe framing with a concrete deck. In 2009, the south end of the dock was approximately 15 ft from the shoreline. Due to the nature and location of the boat dock, this dock and its predecessors have frequently been damaged or destroyed by the harsh wave and ice action of Lake Superior. The dock is used for landing small boats by visitors and park staff." "The current boat dock was built in 2000 on the structural framing of the previous dock" (AHA, 2011).

The Long Island Sites for the LaPointe Lighthouse and the Original LaPointe Lighthouse are depicted on **Figure 2-6** and **Figure 2-7**, respectively.

2.6 PREVIOUS INVESTIGATIONS

All five Sites were part of an NPS Preliminary Assessment/Site Investigation (PA/SI) conducted in 2008 prepared by Michael Baker Jr., Inc. (Baker, 2010). During the 2008 study, soil samples were collected from areas adjacent to light station structures on each island. Lead contamination was identified as a concern in the shallow soil surrounding the light station structures. In addition, trash piles and battery disposal areas were identified as potential contamination sources but were not fully characterized.

The findings of the PA/SI postulated that a potential release of lead to the soil, surface water, and possibly to groundwater had occurred. Based on the results of the PA/SI, it was recommended that a SI be performed to further characterize the Sites.

ECC and SAIC, Inc., under contract with the United States Army Corps of Engineers (USACE) completed a SI in two mobilizations, the first in 2011 and the second in 2012. The SI focused on lead-based paint contamination in soil, debris piles, former battery disposal areas, and collection of background samples.

Site characterization data was gathered during the SI to determine the source, nature and extent of contamination at each of the Sites. As reported by ECC/SAIC (2012), site characterization activities were completed over two mobilizations; the first was conducted in September and October 2011 at Michigan Island, Outer Island, Raspberry Island, and Long Island. The second site characterization mobilization was completed in June 2012 at Devils Island. In addition to characterizing the Devils Island light station, ECC/SAIC also characterized additional structures at Michigan, Outer, and Long Islands and collected analytical samples from the garden on Raspberry Island.

The results of the investigation are summarized in a report titled *National Park Service, Great Lakes Restoration Initiative, Apostle Islands National Lakeshore Letter Report* (ECC/SAIC, 2012).

SECTION 3

RISK ASSESSMENT

This section of the report presents the human health risk assessment (HHRA) and Screening Level Ecological Risk Assessment (SLERA) conducted for the five Sites (Michigan Island, Outer Island, Raspberry Island, Devils Island, and Long Island). The primary objective of the RAs is to identify whether lead in soil at the Sites may pose a threat to human health and the environment. The risk assessments can be used to help determine the nature and extent of any contamination present, and the necessity for remediation. The results of the RA can be used to support an EE/CA.

3.1 HUMAN HEALTH RISK ASSESSMENT

Under CERCLA, a HHRA is conducted for the "no action scenario" (i.e., no remedy is implemented for existing chemical contamination). The objectives of the HHRA for the Sites are to:

- Estimate potential risk to people contacting lead in soil under current and plausible future land-use scenarios.
- Provide an analysis of risks and help determine the need for removal action (RA) at the Sites.
- Identify specific media and areas associated with unacceptable risk, if applicable.

The RA followed EPA (1989) Risk Assessment Guidance for Superfund (RAGs) and WDNR NR720 methodology. There are four components of a RA: data evaluation, exposure assessment, toxicity assessment, and risk characterization. These components are presented in the following sections.

3.1.1 Data Evaluation

The data evaluation step consisted of reviewing and evaluating available data and identifying chemicals of potential concern (COPC). During the PA/SI (Baker, 2008), soil samples were collected adjacent to the light stations at each of the five islands, and lead contamination was identified as a concern in the soil surrounding the light station structures. Additional samples were collected during the SI (ECC/SAIC, 2012), including soil, debris piles, former battery disposal areas, and background samples. The RA includes evaluation of this existing soil data collected during the SI by ECC/SAIC (ECC/SAIC, 2012). This subsection describes this analytical information used in the RA. Based on these previous studies, it has been determined that lead impacted soil is the primary concern at the Sites.

Shallow soil adjacent to current and former painted structures was characterized for the presence of lead impacts due to the historical use of lead-based paint. This characterization objective was achieved through the use of x-ray fluorescence (XRF) field screening and laboratory analyses to determine the extent of elevated lead concentrations in soil. The XRF sampling program attempted to bound the areas of lead contamination at concentrations below the screening level of 250 milligrams per kilogram (mg/kg) (WDNR, 2001; 2007). One surface soil sample (0 to 0.5 ft bgs) and one shallow soil sample (0.5 to 1 ft bgs) were generally collected at each location. The actual sample intervals collected depended on field observations and soil conditions. The analytical results and sample location maps excerpted from ECC/SAIC 2012 are provided in **Appendix A**.

ECC/SAIC (2012) conducted a statistical comparative evaluation of the XRF field screening and the laboratory analytical results to determine the suitability of field XRF analyses during future project phases. One outlier (APISSB0171) was excluded from the analysis; the relatively significant difference between the field XRF result (1,844 milligrams per kilogram [mg/kg]) and the laboratory result (7,610 mg/kg) was attributed to heterogeneity within the sample material and was not considered to be representative of the entire data set. Excluding the outlier, a linear regression showed a high degree of correlation between the XRF and the laboratory results (R^2 = 0.9789). The results of the comparative evaluation demonstrate a relatively high level of confidence for the field XRF analyses, and the data is considered to meet definitive level data criteria because the r value is 0.9 or greater (EPA SW846 Test Method 6200; http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/6200.pdf). In addition, ECC/SAIC (2012) notes that the relatively high screening level value (250 mg/kg) also demonstrates the suitability of the field XRF method when compared to the much lower average limit of detection value reported by the XRF instrument (11.5 mg/kg).

All non-detect results were excluded from the dataset for statistical analysis; the maximum concentration was used where both XRF and laboratory data were available for a sample location.

3.1.2 Exposure Assessment

The objectives of the exposure assessment were to characterize potentially exposed human populations in the area associated with the Sites, to identify actual or potential exposure pathways, and to determine (quantify) the extent of exposure.

3.1.2.1 Potential Receptors and Exposure Pathways

The lighthouse grounds are open to the public for hiking and recreational use. Raspberry, Michigan, and Devils Island lighthouses have tours that are conducted by NPS personnel and volunteers. Backcountry campgrounds are present on Michigan, Outer, and Devils Islands, but are not in close proximity of the lighthouses. A picnic area, flower beds, and a vegetable garden are present on Raspberry Island.

A complete exposure pathway includes: a chemical source and release mechanism, a transport or retention medium, an exposure point where human contact with the contaminated medium occurs, and a route of intake for the contaminant into the body at the exposure point. Based on the current and projected future lighthouse uses, the three potentially exposed populations include:

§ NPS Maintenance Employee or Contracted Maintenance Worker (Adult);

§ Volunteer Light House Keeper or Interpretive Park Ranger (Adult/Adolescent); and,

§ Visitor (Adult/Child).

NPS Maintenance Worker or Contracted Maintenance Worker (Adult)

The NPS Maintenance Worker at APIS are a non-residential exposure scenario. Park staff performs maintenance duties (e.g., lawn mowing or dock repair) on the islands that range in duration from one day per week to five days per week for several consecutive weeks per season (mid-April to mid-October). Contracted maintenance/restoration workers may stay on an island for much of the construction season. Maintenance is assumed to occur during late spring, summer, and early fall months. Thus, maintenance activities are assumed to occur for a maximum exposure duration of 183 days per year (mid-April [15 days], May [31 days], June [30 days], July [31 days], August [31 days], September [30 days] to mid-October [15 days]) and an exposure frequency ranging from 1 day/week (26 days), 2 days/week (52 days), 3 days/week (78 days), 4 days/week (105 days), to 5 days/week (131 days). Most Maintenance Workers come in mid-morning on a Monday and leave mid-afternoon on a Thursday.

Volunteer Lighthouse Keeper or Interpretive Park Ranger

Volunteer Lighthouse Keepers at Devils and Michigan Island lighthouses provide visitor access to historic lighthouses from mid-June to the end of September (NPS, 2013). These volunteers live in the keeper's house during this period, and their length of stay would be for the entire period. This equates to a maximum exposure frequency of 107 days per year for volunteers at Devils and Michigan Islands (June [15 days], July [31 days], August [31 days], and September [30 days]). Interpretive Park Ranger guided tours of the restored lighthouse on Raspberry Island are offered from mid-June to the end of September. The maximum exposure duration for Rangers at Raspberry Island is 107 days (June [15 days], July [31 days], August [31 days], and September [30 days]). Rangers would be on Raspberry Island for a maximum of 5 days per week, for an exposure frequency of 77 days.

Currently, no inhabited keeper's quarters are present on Outer Island and Long Island; nor are they planned for refurbishment. However, the hypothetical re-use of the quarters on Outer Island and Long Island for seven days per week for up to three months (90 days) per year is considered should refurbishment be performed in the future.

These Volunteer Lighthouse Keepers and Interpretive Park Rangers are a potential short-term residential exposure scenario.

Visitors

The islands of APIS are open to visitors year round. However, the historic light stations and associated buildings may be entered only at such times when the structures are open to the public and only under the supervision of an NPS employee or designated park volunteer (NPS, 2013).

Most visitors to APIS are adults; fifty-nine percent (59%) of the visitors were ages 36 to 60 years and 11 percent (%) were 15 years or younger (Littlejohn and Hollenhorst, 2005). Forty-four percent of visitor groups spent less than 24 hours at the park including on the water near park islands, while 56% spent 24 or more hours. For the visitor groups who spent 24 or more hours on this visit, most (70%) spent two to four days. Seventeen percent spent seven or more days (Littlejohn and Hollenhorst, 2005). While access to the public is assumed to be unrestricted, the general public's occupancy of the light stations is expected to be intermittent and significantly less in frequency and duration relative to the Maintenance Worker/Interpretive Park Ranger working at the light stations. Therefore, visitors were not evaluated further because evaluation of the other receptor groups will be protective of the visitor receptor group.

3.1.2.2 Quantification of Exposure

Since elevated levels of lead were detected in surface soil samples, direct contact with soil is a potentially complete exposure pathway. The EPA evaluates direct exposure with lead in soil by using blood lead (PbB) modeling, such as the Integrated Exposure-Uptake Biokinetic Model (IEUBK) for Lead in Children and the Adult Lead Model (ALM). The EPA has recommended that the IEUBK model and the ALM be applied to exposures that exceed a minimum frequency of one day per week and duration of three consecutive months (EPA, 2003b). Three months is considered to be the minimum exposure to produce a quasi-steady-state PbB concentration. The IEUBK model should only be used to assess risks to children from 0 to 84 months of age. When older children (>84 months) are expected to be exposed, the ALM should be used with appropriate consideration given to the inputs (EPA, 2003b).

The ALM was used to evaluate the Maintenance Worker, the Interpretive Park Ranger, the adult Volunteer Lighthouse Keeper, and the adolescent (7 to 16 years) Volunteer Lighthouse Keeper exposure scenarios. The intake rate of soil is assumed to be 50 mg/day for the Volunteer Lighthouse Keeper (adult and adolescent) and Interpretive Park Ranger; an intake rate of 100 grams/day is assumed for the Maintenance Worker. The EPA recommends 50 mg/day as the default ingestion rate for indoor workers (EPA, 2013a). The reasonable default central tendency estimate for contact-intensive adult scenarios (such as an agricultural or construction worker) is 100 mg/day (EPA, 2013a). EPA (2009) recommended values for baseline blood lead level of 1 microgram per deciliter (µg/dL) and geometric standard deviation (GSD) of 1.8 were applied for all exposure scenarios. For the adolescent Volunteer Lighthouse Keeper, EPA recommends an absorption fraction range of 12-30% because adolescence is a time of active growth. The mid-point of this range (21%) was applied. All other parameters for an adult were applied for the adolescent, though there is uncertainty associated with applying the adult values to an adolescent (EPA, 2013a).

The exposure frequency (i.e., days of exposure during the averaging period) for contact with soils and/or dust is based on the average time spent at work by both full-time and part-time workers. The averaging time is the total period during which soil contact may occur and is typically taken as days per year for continuing, long term exposures (e.g., 365 days/year) (EPA, 2003a). The islands are not occupied year-round. The exposure frequency (EF) and averaging time for each receptor group may differ by island. Proposed current exposure frequencies and averaging times are:

- Raspberry Island
  - Interpretive Park Rangers may be present in the lighthouse area up to five days per week for 6 months (183 days per year), with an exposure frequency of up to 131 days (5 days/7 days * 183 days).
  - Maintenance Workers are assumed to be in the lighthouse area up to five days per week for 6 month construction season (183 days per year), with an exposure frequency of 131 days (5 days/7 days*183 days).
- Michigan and Devils Islands

- Volunteer Lighthouse Keepers may be present in the lighthouse areas up to seven days per week from mid-June to end of September (107 days per year), with an exposure frequency of 107 days.
- Maintenance Workers are assumed to be in the lighthouse area up to five days per week for 6 month construction season (183 days per year), with an exposure frequency of 131 days (5 days/7 days*183 days).

§ Outer Island and Long Island

- Interpretive Park Rangers are assumed to be in the lighthouse areas 1 day per week from mid-June to the end of September, for an exposure frequency of 26 days (1 day/7 days * 183 days/yr)).
- Maintenance Workers are assumed to be in the lighthouse area up to five days per week for 6 month construction season (183 days per year), with an exposure frequency of 131 days (5 days/7 days*183 days).
- Volunteer Lighthouse Keepers may be present in the lighthouse areas up to seven days per week up to three months (90 days), should refurbishment of the keeper's quarters be performed in the future.

It is assumed that future exposure frequencies will be the same as current conditions.

There are important methodology constraints on exposure frequency and duration that must be considered in evaluating infrequent contact at a site (EPA, 2003a). The biokinetic slope factor (BKSF) used to evaluate lead exposure and risk applies to exposures that result in a quasi-steady state for blood lead concentration; that is, an intake over a sufficient duration for the blood lead concentration to become nearly constant over time (EPA, 2003a). Based on estimates of the first order elimination half-time for lead in blood of approximately 30 days, a constant lead intake rate over duration of 90 days would be expected to achieve a blood lead concentration that is sufficiently close to the quasi-steady state. This is the minimum exposure duration to which this methodology should be applied (EPA, 2003a). Due to these constraints, the short-term exposure (< 90 days) of a site visitor is not evaluated in the HHRA. An evaluation of risks to the long-term receptor group is considered to be a conservative evaluation of risk to the short-term receptor groups.

3.1.2.3 Exposure Point Concentration

Exposure to lead is assumed to be predominantly to the top layers of the soil which gives rise to transportable soil-derived dust in both outdoor and indoor environments, the latter occurring where soil-derived dust has been transported indoors (EPA, 2003a). An exposure point concentration (EPC) for a chemical is intended to represent a reasonable maximum estimate of the concentration a receptor is likely to be exposed to over time. Because of the uncertainty associated with any estimate of the EPC, the 95th percentile upper confidence limit (95% UCL) on the arithmetic mean is generally used as the reasonable maximum exposure concentration in CERCLA risk assessments.

The arithmetic mean should be entered for soil lead concentration data in the ALM model (EPA, 2013a). The models can use an upper confidence limit (UCL); however the model result could be interpreted as a more conservative estimate of the risk of an elevated blood lead level (EPA, 2013a).

Because the light stations are larger than a typical residential lot, and a receptor may spend most of their time closer to one structure than another, the RA evaluated risk based on both the maximum concentration and site-wide 95UCL concentration for each island. The maximum concentration was also used so that potential hotspots of contamination are not overlooked. The 95UCL was calculated with EPA's ProUCL version 5.0 statistical program (EPA, 2013c). Input data and ProUCL output is provided in **Appendix B**. To aid in risk management decision making, a 95UCL was also calculated for each structure on each island; these concentrations are compared to the preliminary remediation goals (PRGs) developed in **Section 3.1.5**.

3.1.3 Toxicity Assessment

Toxicity assessment involves a review of the EPA hierarchy of toxicity literature sources and the subsequent compilation of cancer and non-cancer toxicity values (e.g., cancer slope factors) and non-cancer references doses [RfDs]) used to estimate cancer risk and non-cancer hazard index (HI). However, neither EPA nor WDNR publishes toxicity values for lead, a COPC known as toxic. EPA's risk assessment for lead is unique because an RfD value for lead is not available (EPA, 2013b). An RfD is typically derived from a concentration below which no adverse effects have been observed. Existing evidence indicates adverse health effects occur even at very low lead exposures (e.g., subtle neurological effects in children have been observed at low doses).

The EPA identifies a blood lead concentration level of 10 µg/dL as the level of concern above which significant health risks occur (EPA, 2013b). The EPA risk reduction goal for contaminated sites is to limit the probability of a child's blood lead concentration exceeding 10 µg/dL (the P10) to 5% or less after cleanup (EPA, 2013b). In 2009, the Adult Blood Level Epidemiology and Surveillance (ABLES) program updated its case definition for an Elevated Blood Lead Level to a blood lead concentration ≥ 10 µg/dL. The U.S. Department of Health and Human Services recommends that blood lead levels among all adults (age 16 or older) be reduced to <10 µg/dL.(http://www.cdc.gov/niosh/topics/ ABLES/description.html; last updated October 30, 2013).

3.1.4 Risk Characterization

Risk characterization typically estimates the potential excess lifetime cancer risk and potential for non-cancer adverse health effects for human receptors exposed to COPCs in environmental media. Estimates of cancer and non-cancer risk are not calculated for lead in soil at APIS due to the lack of standard toxicity values for lead. The most frequently used biomarker for lead exposure is the concentration of lead in blood (EPA, 2002). Thus, risk from exposure to lead in soil is evaluated using blood lead modeling. The EPA's ALM focuses on estimating fetal blood lead concentration in women exposed to lead contaminated soils and also provides tools that can be used for evaluating risks of elevated blood lead concentrations among exposed adults (EPA, 2003a). These models assume all entries represent chronic exposure and use a biokinetic component that considers the transfer of lead between blood and other body tissues, or elimination of lead from the body in determining a blood lead concentration (EPA, 2002).

The ALM was used to evaluate lead exposure by calculating a blood lead concentration of a Maintenance Worker, Interpretive Park Ranger, and Volunteer Lighthouse Keeper (adult [>16 years old] and adolescent [7 to 16 years old]) and estimating the probability of fetal blood lead concentration of a pregnant female worker exceeding 10 µg/dL. Both 95UCL and maximum soil concentrations were used in the evaluation of risk so that potential hotspots of contamination were not overlooked. At the maximum lead concentrations at all light stations, the ALM calculated blood lead levels exceeding 10 µg/dL (ranging from 3.6 to 64.3 µg/dL) and predicted that there would be greater than a 5 % chance that the fetus of a pregnant adult worker would have a blood lead level above 10 µg/dL for all receptor groups except for the short-term Maintenance Worker (i.e., 1 day per week) on Long Island and Outer Island (**Table 3-1**). At the 95UCL lead concentrations at all light stations, the ALM calculated blood lead levels that did not exceed 10 µg/dL (ranging from 1.2 µg/dL to 8.8 µg/dL), though the ALM predicted that there would be greater than a 5 % chance that the fetus of a pregnant adult worker would have a blood lead level above 10 µg/dL for all receptors on Michigan Island, the adolescent Volunteer Lighthouse Keeper on Long Island, and the Maintenance Worker and the adolescent Volunteer Lighthouse Keeper on Devils Island (**Table 3-2**). Thus, lead concentrations in the soil pose risk to potential receptors at these light stations.

3.1.4.1 Vegetable Garden on Raspberry Island

While 400 mg/kg lead in soil is generally considered an appropriate screening level for soil lead under unrestricted residential contact to soil, EPA recommends building raised beds with clean (no greater than 50 mg/kg lead) topsoil for gardening (EPA, 2013a). The average concentration of soil samples collected in the garden on Raspberry Island (51 mg/kg) is equivalent to the recommended threshold concentration for clean topsoil. The garden soil concentrations ranged from 36 mg/kg to 65.9 mg/kg lead. EPA (2013d) guidance on gardening states that soil concentrations less than 100 mg/kg present low risk. No specific remediation is needed and there are no restrictions on crop type. Good gardening and housekeeping practices (i.e., wash hands, clothes, and produce) are recommended.

3.1.5 Preliminary Remediation Goals

The ALM can also be used to calculate a PRG for a non-residential setting. This PRG is intended to protect a fetus carried by a pregnant female worker. It also assumes a cleanup goal protective of a fetus also affords protection for male or female adult workers (EPA, 2013a). PRGs were developed for each receptor group using the ALM (**Table 3-3**). Exposure frequencies of five days per week and an averaging time of mid-April through mid-October (183 days) were used for the Maintenance Worker. An exposure frequency of five days per week for an Interpretive Park Ranger and seven days per week for a Volunteer Lighthouse Keeper were used for an averaging time of mid-June through September (107 days). Continuous exposure for three months was also considered for a Volunteer Lighthouse Keeper. PRGs were calculated as follows (**Table 3-3**):

- Maintenance Worker – Mid-April through Mid-October: 939 mg/kg;
- Interpretive Park Ranger – Mid-April through Mid-October: 9,458 mg/kg;
- Interpretive Park Ranger – Mid-June through End September: 1,881 mg/kg;
- Volunteer Lighthouse Keeper – Mid-June through End September - Adult: 1,344 mg/kg; and
- Volunteer Lighthouse Keeper – Mid-June through End September - Adolescent: 768 mg/kg.

Based on the infrequent use of the sites by young children, this receptor group is not evaluated in the HHRA. The EPA's IEUBK predicts plausible distributions of blood lead levels in children zero to seven years of age. Based on this model, EPA (1994) and WDNR (2013) have established a residential cleanup level of 400 mg/kg. This cleanup level is recommended for the light stations if a young child would be in residence in the keeper's quarters.

The 95UCL lead concentration at each structure is compared to the PRGs in **Table 3-4** through **Table 3-8**. An overall UCL (0 to 1 ft below ground surface [bgs]), a surface soil UCL (0 to 0.5 ft bgs), and a subsurface UCL (>0.5 to 1 ft bgs) were calculated for each structure.

On Raspberry Island (**Table 3-4**), the 95UCL concentration exceeded the PRGs for the Maintenance Worker and the adolescent Volunteer Lighthouse Keeper at the Fog Signal Building and the Volunteer Lighthouse Keeper's Quarters. The 95UCL exceeded the PRG for the adult Volunteer Lighthouse Keeper only at the Volunteer Lighthouse Keeper's Quarters. The 95UCL concentration exceeded the PRG for the child Volunteer Lighthouse Keeper at the Fog

Signal Building, the Volunteer Lighthouse Keeper's Quarters, the Oil Storage Building, the Outhouse, and the Shed.

On Michigan Island (**Table 3-5**), the 95UCL concentration at the Lighthouse exceeded the PRGs for all receptors. The 95UCL exceeded the PRG for the child Volunteer Lighthouse Keeper and the adolescent Volunteer Lighthouse Keeper at the Outhouse.

On Devils Island (**Table 3-6**), the 95UCL concentration exceeded the PRGs for all receptors except the short-term Interpretive Park Ranger at the East Oil Storage Building, the Fog Signal Building, the Lighthouse, the Tramway Engine Building, the West Keeper's Quarters, and the West Oil Storage Building.

On Outer Island (**Table 3-7**), the 95UCL concentration exceeded the PRGs for all receptors except the short-term Interpretive Park Ranger at the Fog Signal Building. The 95UCL concentration exceeded the PRG for the Maintenance Worker, adolescent Volunteer Lighthouse Keeper, and Child Volunteer Lighthouse Keeper at the Oil Storage Building. The 95UCL concentration exceeded the PRG for only the child Volunteer Lighthouse Keeper at the Outhouse. Currently, no inhabited keeper's quarters are present on Outer Island; nor are they planned for refurbishment. However, this receptor was evaluated should the keeper's quarters be refurbished in the future.

On Long Island (**Table 3-8**), the 95UCL concentration exceeded the PRGs for all receptors except the short-term Interpretive Park Ranger at the Fog Signal Building and the LaPointe Lighthouse. The 95UCL concentration exceeded the PRG for the Maintenance Worker and the Volunteer Lighthouse Keeper (adult and adolescent) at the Original LaPointe Keeper's Quarters. The 95UCL concentration exceeded the PRG for the child Volunteer Lighthouse Keeper at the Aboveground Storage Tank, the Fog Signal Building, the Keeper's Quarters, the LaPointe Lighthouse, the Oil Storage Shed, and the Original LaPointe Keeper's Quarters. Currently, no inhabited keeper's quarters are present on Long Island; nor are they planned for refurbishment. However, this receptor was evaluated should the keeper's quarters be refurbished in the future.

3.2 ECOLOGICAL RISK ASSESSMENT

The EPA (1997) ecological risk assessment (ERA) guidance defines an ERA as a "process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors." A SLERA was conducted to evaluate the risk to wildlife based on direct contact exposures of organisms to affected media, and the potential exposure of wildlife through the ingestion of other organisms as food sources. This SLERA has been prepared in accordance with CERCLA and has been conducted according to federal guidance (EPA, 1997; EPA, 1998).

3.2.1 Scope and Objective

The goal of this SLERA was to determine whether available data indicate the potential for ecological impacts from lead in soil at the Sites. The objectives of the SLERA include the following:

§ Describe potential exposure pathways;

§ Screen media concentrations (soil) against applicable ecologically-based benchmarks to identify potential chemicals of ecological concern (COPEC); and

§ Determine which receptors and geographic portions of the Sites are potentially at risk based on the screening evaluation, and which may be dropped from further consideration.

A SLERA consists of the first two steps of EPA's eight-step ERA process (EPA, 1997) which are:

§ Step 1 – Screening Level Problem Formulation and Ecological Effects Evaluation

§ Step 2 – Screening Level Exposure Estimation and Risk Characterization

The outcome of the SLERA is Step 3 (Problem Formulation) in the ERA process, and in which complete exposure pathways identified in the SLERA are summarized, with recommendations for future action if warranted. Future action may take the form of a baseline ecological risk assessment (BERA) or remedial action. Step 3a of the Problem Formulation, known as Refining Preliminary Contaminants of Ecological Concern, was performed to provide a refinement of the conservative intake parameter and screening ecotoxicity values to consider how the risk estimates would change if more realistic assumptions were used (EPA, 2001b).

This SLERA includes the following sections:

Section 3.2.1 presents the scope and objectives of the SLERA and provides an overview of the ERA process at APIS.

Section 3.2.2 consists of Steps 1 and 2 of the SLERA process, including a description of the site, potential exposure pathways, and potential receptors, and results of the screening of the analytical results against conservative ecological benchmarks.

Section 3.2.3 presents Step 3a (Refinement of COPECSs), including a refinement of conservative intake factors and ecotoxicity values. An uncertainty analysis is also presented.

Section 3.2.4 presents the conclusion and recommendations of this SLERA, summarizing which receptors and geographic portions of the Sites are potentially at risk based on the screening evaluation and the refinement of COPECs and which may be dropped from further consideration.

3.2.2 Step 1 and 2: SLERA

This subsection presents the SLERA, which consists of Steps 1 and 2 of the ERA process, including a description of the site, potential exposure pathways, and potential receptors, and results of the screening of the analytical results against conservative ecological benchmarks. Risk to ecological receptors from exposure to lead in soil was identified for locations that exceed conservative EPA ecological soil screening levels (EcoSSLs) for lead (EPA, 2005). The EcoSSLs for lead are:

- Plant – 120 mg/kg
- Soil Invertebrate -1,700 mg/kg
- Avian ground insectivore – 11 mg/kg
- Avian herbivore – 46 mg/kg
- Avian carnivore – 510 mg/kg

- Mammalian herbivore – 1,200 mg/kg
- Mammalian ground insectivore – 56 mg/kg
- Mammalian carnivore – 460 mg/kg

3.2.2.1 Site Description

Refer to **Subsection 3.1.2.1** for a description of the Site. The total acreage of each island, and the area cleared around the light stations are:

- Raspberry Island – 288 acres/3.1 acres light station
- Devils Island – 311 acres/3 acres light station
- Long Island- 309 acres/1.5 acres light station
- Michigan Island – 1539 acres/1.6 acres light station
- Outer Island – 1322 acres/1.6 acres light station

The 21 islands that comprise APIS provide regionally diverse and unique plant communities. Over 800 plant species occur within the lakeshore, including Wisconsin State listed endangered and threatened species. Most of the islands have a history of logging; however; a few of the islands (North Twin, Devils, Raspberry, Long, Eagle, and Gull) have never been commercially logged and have old growth remnant forests. Old growth forests are also present on Oak, Outer and Sand Islands. Today, maturing second growth forest exists throughout the islands (http://www.nps.gov/apis/naturescience/plants.htm).

The naturally isolated island environments provide important habitat for numerous bird species, mammals, plants, amphibians and aquatic species. Wildlife species are characteristic of the southern limits of the boreal and northern limits of the hardwood/hemlock forests. Game species include whitetail deer, black bear, snowshoe hare, waterfowl, woodcock, and ruffed grouse. Other fur-bearers include the red fox, coyote, beaver, and otter. Small mammals are an important component of the lakeshore's terrestrial fauna and include: shrews, mice, voles, red squirrels and chipmunks (http://www.nps.gov/apis/naturescience/animals.htm).

The islands within APIS provide important habitat for resident breeding birds as well as neotropical migrants. The great majority of nesting forest bird species in APIS are migratory. The lakeshore includes important migratory bird concentration points during spring and fall migration (http://www.nps.gov/apis/naturescience/animals.htm).

3.2.2.2 Ecological Exposure Pathways and Ecological Receptors

Potential onsite exposure pathways include direct contact with soil contaminants and dietary exposure via consumption of soil-inhabiting organisms. The ecological receptors evaluated in the SLERA include the representative species used by EPA in their development of EcoSSLs for plants, soil invertebrates, birds and mammals. Exposure pathways and receptor considered for each receptor group (EPA, 2003) include:

- Plants
  - Direct contact of contaminants in soils
  - Soil Invertebrates
  - Ingestion of soil
  - Direct contact exposures with a preference for conditions of high bioavailability
- Birds and Mammals
  - Incidental ingestion of soils during feeding at the soil surface, grooming and preening
  - Ingestion of food (plants and soil invertebrates) contaminated as a result of the uptake of soil contaminants

The six vertebrate species (three birds and three mammals) used for EcoSSL development are chosen as representative receptors for food-chain analysis to evaluate risk from lead contamination in soil to passerine birds, raptors, small mammals, and large mammals at APIS. The surrogate species used in EcoSSL development are mourning dove, American woodcock, red-tailed hawk, meadow vole, short-tailed shrew, and long-tailed weasel.

3.2.2.3 SLERA Risk Characterization

The risk to ecological receptors was evaluated by comparing maximum concentrations to the species-specific Eco-SSLs (**Table 3-9**). The HQ for each receptor group at each light station exceeded the threshold of one, indicating potential for adverse ecological impacts from maximum lead concentrations in soil at all the light stations.

3.2.3 Step 3a: Refining Preliminary Contaminants of Ecological Concern

The outcome of the SLERA is Step 3 (Problem Formulation) in the ERA process, and in which complete exposure pathways identified in the SLERA are summarized, with recommendations for future action if warranted. Step 3a of the Problem Formulation, known as Refining Preliminary COPEC, provides a refinement of the conservative intake parameter and screening ecotoxicity values to consider how the risk estimates would change if more realistic assumptions were used (EPA, 2001b). Risk to ecological receptors from exposure to lead was identified for locations that exceed conservative EPA EcoSSLs. A refined analysis of ecological risk was performed for upper trophic level birds and mammals using site-specific species, a representative average EPC and alternative ecotoxicity values and natural background. The uncertainty associated with this risk analysis is also discussed.

3.2.3.1 Refinement of Receptor Species

Because toxic responses for the same contaminant could differ among wildlife taxa, surrogate species were selected for both mammals and birds (EPA, 2003) in the development of EcoSSLs. The selected surrogate species provide a conservative representation of the three primary trophic groups (herbivores, insectivores, carnivores) (EPA, 2003). The choice of surrogate species used in EcoSSL development was based on a consideration of body weight (a low body weight is associated with high food intake per unit body weight) and behavior (dietary sources, amount of soil ingested) (EPA, 2007). To refine the analysis of risk, site-specific species were evaluated. These receptors were:

- American Robin

- The American robin (*Turdus migratorius*) was selected for assessment of potential food-chain bioaccumulation from soils into herbivorous (granivorous) passerine birds. This species regularly breeds in the Chequamegon Bay Area in varying numbers (Brady and Verch, 2007) and occurs at APIS.

§ American Woodcock

- The American woodcock (*Scolopax minor*) was selected for assessment of potential food-chain bioaccumulation from soils into insectivorous passerine birds. This species regularly breeds in the Chequamegon Bay Area in varying numbers (Brady and Verch, 2007) and occurs at APIS.

§ Broad-winged Hawk

- The broad-winged hawk (*Buteo platypterus*) was selected for assessment of potential food-chain bioaccumulation from soils into carnivorous raptors. This species regularly breeds in the Chequamegon Bay Area in varying numbers (Brady and Verch, 2007) and occurs at APIS.

§ Southern Red-Back Vole

- The southern red-back vole (*Clethrionomys gapperi*) was selected for assessment of potential food-chain bioaccumulation from soils into herbivorous small mammals. The southern red-back vole's distribution is scattered throughout the entire state of Wisconsin (UWSP, 2012) and occurs at APIS. Small mammals, including voles, are an important component of the lakeshore's terrestrial fauna.

§ Masked Shrew

- The masked shrew (*Sorax cinereus*) was selected for assessment of potential food-chain bioaccumulation from soils into insectivorous small mammals. Masked shrews can be found throughout Wisconsin (UWSP, 2012) and occurs at APIS. Small mammals, including shrews, are an important component of the lakeshore's terrestrial fauna.

§ Short-tailed Weasel

- The short-tailed weasel (*Mustela erminea*) was selected for assessment of potential food-chain bioaccumulation from soils into carnivorous medium-sized mammals. This species ranges throughout Wisconsin (UWSP, 2012) and occurs at APIS.

3.2.3.2 Refinement of EPC

An EPC for a chemical is intended to represent a reasonable maximum estimate of the concentration a receptor is likely to be exposed. Because of the uncertainty associated with any estimate of the EPC, the 95UCL on the arithmetic mean is generally used as the reasonable maximum exposure concentration in CERCLA risk assessments. The 95UCL was calculated using EPA's ProUCL (Version 5.0) software (EPA, 2010). A site-wide UCL was calculated for each light station.

3.2.3.3 Refinement of Toxicity Value

The EPA generated nationally-accepted toxicity reference values (TRVs) through EcoSSL methodology and these toxicity values are considered to have high confidence compared to other sources. The EcoSSL TRV represents a receptor-class specific estimate of a no observed adverse effect level (NOAEL) for the respective contaminant for chronic exposure. The NOAEL-based TRV is protective of wildlife populations and sensitive individuals because it represents an exposure that is not associated with adverse impacts of low-level, long-term chemical effects (i.e., adverse effects on ability of individuals to develop into viable organisms, search for mates, breed successfully, and produce live and equally viable offspring) (EPA, 2005a). An alternative TRV based on the lowest observed adverse effect level (LOAEL) was used in the refining risk estimates. A LOAEL-based TRV represents the lowest dose at which an adverse population effect is expected. The lower of the geometric mean of LOAEL data for growth and reproduction and the geometric means of LOAEL data for growth, reproduction and survival presented in the EcoSSL guidance document was used as the alternative TRV.

3.2.3.4 Risk Characterization

The generic food-chain model used in the EcoSSL calculations was used to refine the risk based exposure to lead via the incidental ingestion of soil while feeding and ingestion of food items that have become contaminated due to uptake from soil exposure pathways. The general equation used is:

$$HQj = [FIR \times (Soilj \times Ps + Bij)] / TRVj$$

where:

HQj = Hazard Quotient for contaminant (j) (unitless)

Soilj = Concentration of contaminant (j) in soil (mg/kg dry weight)

FIR = Food intake rate (kg of food [dry weight] per kg body weight per day)

Ps = Proportion of total food intake that is soil (kg soil/kg food)

Bij = Concentration of contaminant 'j" in biota type "i" (mg/kg dry weight)

TRVj = Toxicity Reference Value for contaminant (j) (mg chemical/kg body weight per day)

For each group of receptors, the food intake rate was estimated using predicted equations based on body weight developed by Nagy (2001). For all birds, the ingestion rate (IR grams [g] dry/day) = 0.638(g BW^0.0.685) and for all mammals the IR (g dry/day) =0.323(g BW)^0.744). Mean body weight for the American robin (77.3 g) was obtained from the EPA Wildlife Exposure Factors Handbook (EPA, 1993); mean body weights of masked shrew (4.5 g) and Southern red-backed vole (28 g) were obtained from the University of Wisconsin-Steven's Point (UWSP) Mammals of Wisconsin (UWSP, 2012); mean body weight for the broad winged hawk (413 g) was obtained from the University of Michigan Animal Diversity Web (UMich, 2012). The food intake rate applied for the American woodcock is the value presented in the EcoSSL guidance (EPA, 2005). The proportion of soil in the diet for each feeding group presented in the EcoSSL guidance documents was applied (EPA 2005). The concentration of lead in biota or food type (i.e., earthworms, terrestrial plants, and small mammals) was related to the concentration in soil by the uptake model as presented in the EPA EcoSSL guidance document (EPA, 2005).

Risk estimates were refined using the site-specific species, the 95UCL concentration as the EPC, and the alternative LOAEL-based TRV to evaluate a dose which is expected to produce adverse population effects. The refined risk calculations for wildlife are provided in **Table 3-10**. To provide a range of ecological hazard from COPEC exposure, HQs were calculated using both the NOAEL-based TRV and the LOAEL-based TRV.

For Michigan Island, the HQ for the NOAEL-based TRV exceeded one for all receptor groups; the HQ for the LOAEL-based TRV exceeded the threshold of one for the woodcock (HQ=3) and equaled the threshold of one for the robin (1). For Outer Island, the HQ for the NOAEL-based TRV exceeded one for the woodcock, robin, hawk, and shrew and equaled the threshold of one for the vole and weasel; the HQ for the LOAEL-based TRV equaled the threshold of one for the woodcock. For Raspberry Island, the HQ for the NOAEL-based TRV exceeded one for the woodcock, robin, hawk, and shrew and equaled the threshold of one for the vole; the HQ for the LOAEL-based TRV equaled the threshold of one for the woodcock. For Devils Island, the HQ for the NOAEL-based TRV exceeded one for the woodcock, robin, hawk, shrew, and vole and equaled the threshold of one for the weasel; the HQ for the LOAEL-based TRV exceeded the threshold of one for the woodcock. For Long Island, the HQ for the NOAEL-based TRV exceeded one for the woodcock, robin, hawk, and shrew and equaled the threshold of one for the vole and weasel; the HQ for the LOAEL-based TRV exceeded the threshold of one for the woodcock.

3.2.3.5 Uncertainty Analysis

Uncertainty analysis assists in the evaluation of the level of confidence in the results of the SLERA and the refinement of COPECs. General and site-specific uncertainties in this SLERA include:

§ Site use and dietary composition factors were conservatively assumed to be 100% for all receptors. Migratory patterns, behavioral differences, and seasonal distributions of species are not considered in food web model calculations. The use of 100% for these factors assumes that the target wildlife species forage year round and obtains all of its food (i.e., plants, insects, small mammals) from the light stations. These assumptions are conservative considering the home ranges estimated for some of the target wildlife species (e.g., 10 hectares [24.7 acres] for the short-tailed weasel) (UMich, 2012), and up to 7 to 98 acres for the woodcock (EPA, 1993). Though the home range size of broad-winged hawks has not been studied, the home range of red-tailed hawk is 1.3 to 5.2 square kilometers (UMich, 2012). As a result, use of 100% for the aforementioned factors will contribute to an overestimation of risk for the wide ranging species. The home range of the vole is about ¼ acre (UWSP, 2012), home range size has been estimated at 5,549 square meters (1.4 acres) for the masked shrew (UWSP, 2012), and the foraging home range of a robin is 0.15 to 0.81 hectare (0.37 to 2 acres) (EPA, 1993).

§ The NOAEL-based TRVs and LOAEL-based TRVs are not specific to the ecological receptors at the site; therefore, in the absence of site-specific data, the extrapolation of the effect data to the receptors was necessary. Most toxicity data were obtained from laboratory studies (e.g., rat, mouse, quail, chicken, and turkey). NOAELs and LOAELs for potential effects on reproduction and growth were used to derive TRVs. This results in conservative TRVs whose relationship to potential population effects is uncertain. The NOAEL-based TRVs are designed not to underestimate risk so that the risks at the site may actually be overestimated.

§ The SLERA and the refinement of risk estimates were conducted with the simplifying assumption that the protection of the receptor species selected on the basis of their role within the ecosystem will protect the ecosystem as a whole. The use of individual metrics, such as hazard quotients, overstates risks to the primary ecological units of concern, local populations. The use of individual metrics, such as hazard quotients, could understate the risk for especially sensitive receptors. There are no known sensitive species at the light stations.

3.2.4 Ecological Risk Summary

In accordance with EPA ecological risk guidelines, the SLERA included conservative assumptions to ensure ecological receptors and risks are not prematurely eliminated from consideration. The SLERA found that there is potential risk to plants, soil invertebrates, small mammals, passerine birds and carnivorous bird and mammals from exposure to lead in soil at all light stations. Under more realistic site use conditions (e.g., 95UCL concentrations and species common to APIS), the risk to site-specific individual organisms would be reduced. Risk estimates were also refined using the LOAEL-based alternative TRV to evaluate a dose which is expected to produce adverse population effects. At the 95UCL soil concentrations on Michigan Island, Devils Island, and Long Island, the LOAEL-based HQs exceeded one for the American woodcock, indicating potential risk to upper trophic level populations of avian insectivores. However, the risk evaluation assumes that woodcock feeds entirely within the light stations, which encompass 1.6 to 3 acres, while the home range of a woodcock is from 7 to 98 acres (EPA, 1993).

There is widespread lead in soil at the light stations at concentrations above natural background and conservative ecological screening levels. These concentrations have been delineated to 250 mg/kg (ECC/SAIC, 2012) and were found to be localized around the buildings/structures. At 250 mg/kg lead, the LOAEL-based HQ for all receptor groups does not exceed the threshold of one.

The light stations are not included in the wilderness area; the habitat near the building/structures consists of maintained lawns (see the ECC/SAIC 2012 report for site photographs). Some of the buildings are open for guided tours and the grounds are also open to the public for hiking and recreational use (ECC/SAIC 2012). Human use of the area will limit use by wildlife. Lead does not biomagnify in the food chain or significantly bioaccumulate. Therefore, remediation of lead in site soils for human use is anticipated to result in protection of ecological receptors that may inhabit the developed areas around the light stations.

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

The results of the previous investigations at the Sites determined that contaminant concentrations exceeding human health action levels were present at each light station making them subject to processes and rules promulgated under CERCLA and the NCP. This RA was developed as part of the response activities to address exposure to lead at the Sites, and to develop site-specific human health PRGs for use in evaluating remedial options in the EE/CA.

The ALM was used to evaluate lead exposure by calculating a blood lead concentration of a Maintenance Worker, Interpretive Park Ranger, and Volunteer Lighthouse Keeper (adult [>16 years old] and adolescent [7 to 16 years old]) and estimating the probability of fetal blood lead concentration of a pregnant female worker exceeding 10 µg/dL. Both 95UCL on the arithmetic mean and maximum soil concentrations were used in the evaluation of risk so that potential hotspots of contamination were not overlooked.

PRGs were developed for each receptor group using the ALM. Exposure frequencies of five days per week and an averaging time of mid-April through mid-October (183 days) were used for the Maintenance Worker. An exposure frequency of one and five days per week for an Interpretive Park Ranger and seven days per week for a Volunteer Lighthouse Keeper were used for an averaging time of mid-June through September (107 days). Continuous exposure for three months was also considered for a Volunteer Lighthouse Keeper. PRGs were calculated as follows:

- Maintenance Worker – Mid-April through Mid-October: 939 mg/kg;
- Interpretive Park Ranger (one day/week) – Mid-April through Mid-October: 9,458 mg/kg;
- Interpretive Park Ranger (five days/week) – Mid-June through End September: 1,881 mg/kg;
- Volunteer Lighthouse Keeper – Mid-June through End September - Adult: 1,344 mg/kg; and,

- Volunteer Lighthouse Keeper – Mid-June through End September - Adolescent: 768 mg/kg.

Based on the infrequent use of the Sites by young children, this receptor group is not evaluated in the HHRA. The EPA's IEUBK predicts plausible distributions of blood lead levels in children zero to seven years of age. Based on this model, EPA (1994) and WDNR (2013) have established a residential cleanup level of 400 mg/kg. This cleanup level is recommended for the light stations if a young child would be in residence in the keeper's quarters.

The garden soil concentrations on Raspberry Island ranged from 36 mg/kg to 65.9 mg/kg lead. EPA (2013d) guidance on gardening states that soil concentrations less than 100 mg/kg present low risk. No specific remediation is needed and there are no restrictions on crop type. Good gardening and housekeeping practices (i.e., wash hands, clothes, and produce) are recommended

In accordance with EPA ecological risk guidelines, the SLERA included conservative assumptions to ensure ecological receptors and risks are not prematurely eliminated from consideration. The SLERA found that there is potential risk to plants, soil invertebrates, small mammals, passerine birds and carnivorous bird and mammals from exposure to lead in soil at all light stations. Under more realistic site use conditions (e.g., 95UCL concentrations and species common to APIS), the risk to site-specific individual organisms would be reduced. Risk estimates were also refined using the LOAEL-based alternative toxicity reference values to evaluate a dose which is expected to produce adverse population effects. At the 95UCL soil concentrations on Michigan Island, Devils Island, and Long Island, the LOAEL-based hazard quotient exceeded one for the American woodcock, indicating potential risk to upper trophic level populations of avian insectivores. However, the risk evaluation assumes that woodcock feeds entirely within the light stations, which encompass 1.6 to 3 acres, while the home range of a woodcock is from 7 to 98 acres (EPA, 1993).

There is widespread lead in soil at the Sites at concentrations above natural background and conservative ecological screening levels. These concentrations have been delineated to 250 mg/kg (ECC/SAIC, 2012) and were found to be localized around the buildings/structures. At 250 mg/kg lead, the LOAEL-based HQ for all receptor groups does not exceed the threshold of one.

The light stations are not included in the wilderness area; the habitat near the building/structures consists of maintained lawns. Some of the buildings are open for guided tours and the grounds are also open to the public for hiking and recreational use (ECC/SAIC, 2012). Human use of the area will limit use by wildlife. Lead does not biomagnify in the food chain or significantly bioaccumulate. Therefore, remediation of lead in site soils for human use is anticipated to result in protection of ecological receptors that may inhabit the developed areas around the light stations.

It is anticipated that completion of a removal action at each of the Sites will be a final action necessary to address soil contamination related to deterioration of lead-based paint at the subject facilities. Further, achievement of the Remedial Action Objectives at each of the Sites will eliminate threats to human health and the environment while eliminating the need for long-term management of the impacted areas and preserving the mission of the NPS.

SECTION 5

REFERENCED REPORTS

The sources of Site-specific data, information, or conclusions that are discussed or referenced within this RA Report and its attachments are listed below in alphabetical order.

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FIGURES

Figure 2-1

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

N W E S

0 2.25 4.5 Miles

Prepared for:
NATIONAL PARK SERVICE
415 Washington Avenue
Bayfield WI, 54814

Prepared by:
WESTON SOLUTIONS, INC
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Houghton, MI 49931

APOSTLE ISLANDS NATIONAL LAKESHORE SITE LOCATION MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

Figure 2-2

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

N W E S

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MICHIGAN ISLAND PROJECT
SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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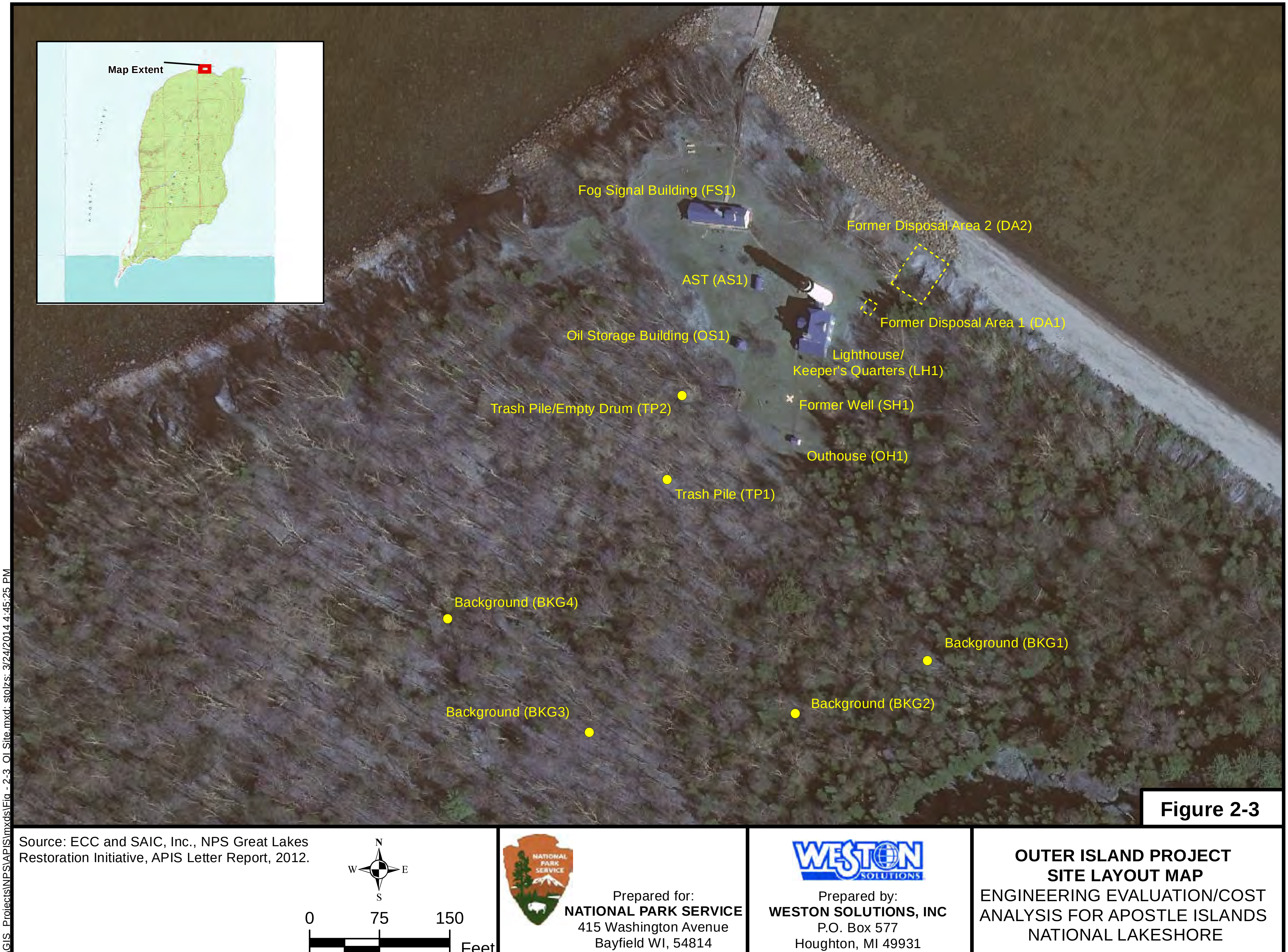

Figure 2-3

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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OUTER ISLAND PROJECT
SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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Figure 2-4

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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RASPBERRY ISLAND PROJECT
SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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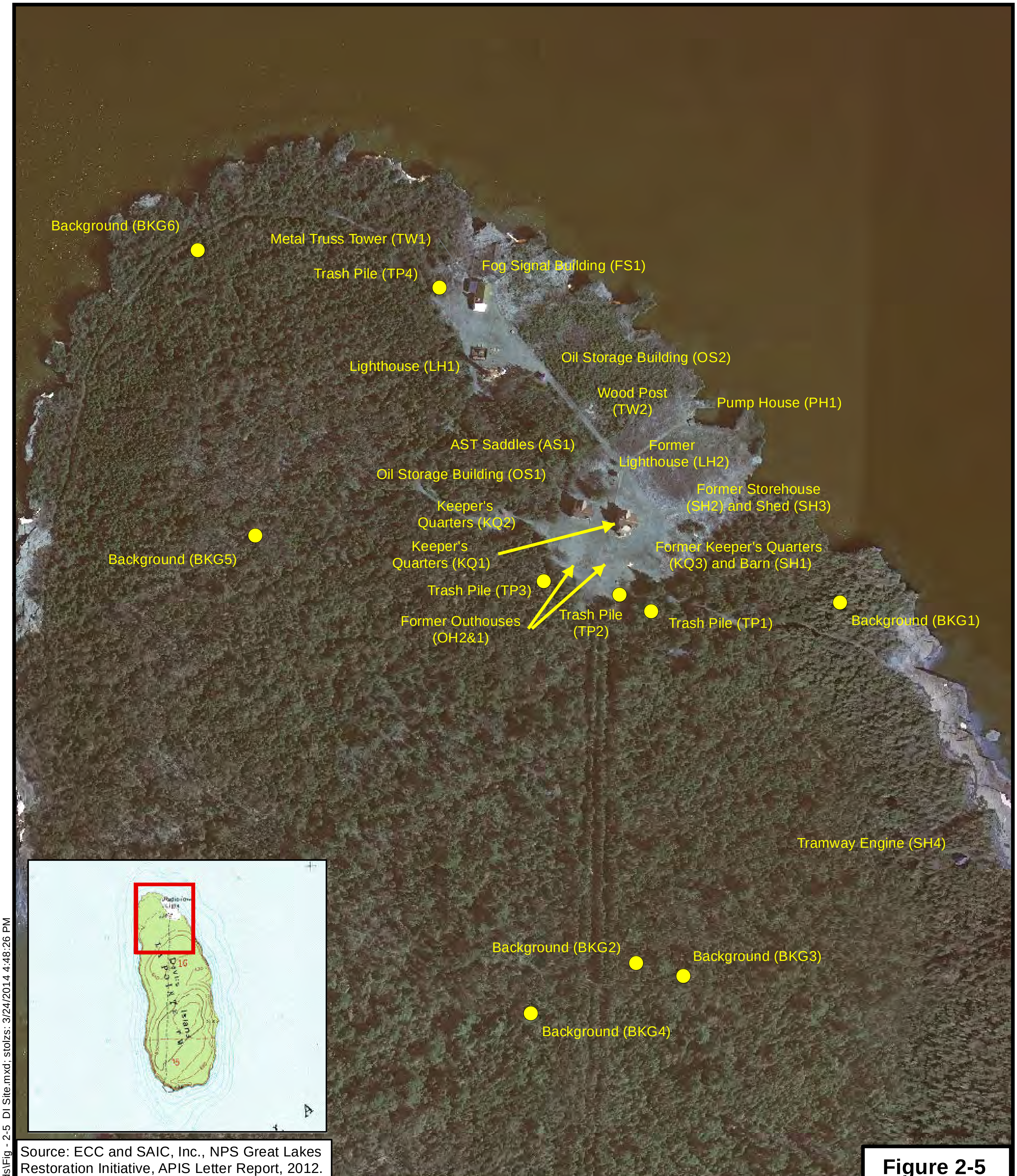

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

Figure 2-5

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DEVILS ISLAND PROJECT
SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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Figure 2-6

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

N W E S

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LONG ISLAND - LAPOINTE LIGHT STATION PROJECT SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE

Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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Figure 2-7

Source: ECC and SAIC, Inc., NPS Great Lakes Restoration Initiative, APIS Letter Report, 2012.

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Coordinate System: NAD 1983 StatePlane Wisconsin North FIPS 4801 Feet

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LONG ISLAND - ORIGINAL LAPOINTE LIGHT STATION PROJECT
SITE LAYOUT MAP
ENGINEERING EVALUATION/COST ANALYSIS FOR APOSTLE ISLANDS NATIONAL LAKESHORE

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TABLES

Table 3-1

Calculations of Blood Lead Concentrations (PbBs) - Maximum Lead Concentrations

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Asult Lead Model (ALM) Version date 6/21/09

Variable	Description of Variable	Units	Source	Long Island				Outer Island				Michigan Island			Devils Island			Raspberry Island	
				Maintenance Worker	Interpretive Park Ranger	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Maintenance Worker	Interpretive Park Ranger	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Maintenance Worker	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Maintenance Worker	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Maintenance Worker	Interpretive Park Ranger
				5 d/wk for 6 mo	1 d/wk for 6 mo	7 d/wk for 90 day season	7 d/wk for 90 day season	5 d/wk for 6 mo	1 d/wk for 6 mo	7 d/wk for 90 day season	7 d/wk for 90 day season	5 d/wk for 6 mo	7 d/wk for season	7 d/wk for season	5 d/wk for 6 mo	7 d/wk for season	7 d/wk for season	5 d/wk for 6 mo	1 d/wk for 6 mo
PbS	Soil lead concentration	ug/g or ppm	Maximum XRF/Lab Concentration	8662	8662	8662	8662	7610	7610	7610	7610	15078	15078	15078	6382	6382	15078	4877	4877
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	EPA 2009	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	EPA 2009	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	GSDi and PbBo from Analysis of NHANES 1999-2004	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
PbB_0	Baseline PbB	ug/dL	GSDi and PbBo from Analysis of NHANES 1999-2004	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	ALM default	0.100	0.050	0.050	0.050	0.100	0.050	0.050	0.050	0.100	0.050	0.050	0.100	0.050	0.050	0.100	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	ALM default	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	ALM default	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	ALM default	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	ALM default	0.12	0.12	0.12	0.21	0.12	0.12	0.12	0.21	0.12	0.12	0.21	0.12	0.12	0.21	0.12	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	1-7 days per week	131	26	90	90	131	26	90	90	131	107	107	131	107	107	131	131
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	site specific	183	183	90	90	183	183	90	90	183	107	107	183	107	107	183	183
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**calculated**	**30.8**	**4.0**	**21.8**	**37.4**	**27.1**	**3.6**	**19.3**	**33.0**	**52.8**	**37.2**	**64.3**	**22.9**	**16.3**	**64.3**	**17.8**	**9.4**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	calculated	72.8	9.4	51.6	88.5	64.3	8.5	45.6	78.0	125.0	88.0	152.3	54.3	38.6	152.3	42.0	22.2
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**ALM default**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**calculated**	**95.8%**	**3.9%**	**87.4%**	**98.0%**	**93.6%**	**2.7%**	**82.5%**	**96.8%**	**99.6%**	**98.0%**	**99.9%**	**89.1%**	**74.3%**	**99.9%**	**78.7%**	**38.7%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 3-2

Calculations of Blood Lead Concentrations (PbBs) - 95UCL Lead Concentrations

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Asult Lead Model (ALM) Version date 6/21/09

Variable	Description of Variable	Units	Source	Long Island				Outer Island				Michigan Island			Devils Island			Raspberry Island	
				Maintenance Worker	Interpretive Park Ranger	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Maintenance Worker	Interpretive Park Ranger	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Maintenance Worker	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Maintenance Worker	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Maintenance Worker	Interpretive Park Ranger
				5 d/wk for 6 mo	1 d/wk for 6 mo	7 d/wk for 90 day season	7 d/wk for 90 day season	5 d/wk for 6 mo	1 d/wk for 6 mo	7 d/wk for 90 day season	7 d/wk for 90 day season	5 d/wk for 6 mo	7 d/wk for season	7 d/wk for season	5 d/wk for 6 mo	7 d/wk for season	7 d/wk for season	5 d/wk for 6 mo	1 d/wk for 6 mo
PbS	Soil lead concentration	ug/g or ppm	95UCL XRF	820.9	820.9	820.9	820.9	637.5	637.5	637.5	637.5	1874	1874	1856	1081	1081	1081	556.6	556.6
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	EPA 2009	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	EPA 2009	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	GSDi and PbBo from Analysis of NHANES 1999-2004	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
PbB_0	Baseline PbB	ug/dL	GSDi and PbBo from Analysis of NHANES 1999-2004	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	ALM default	0.100	0.050	0.050	0.050	0.100	0.050	0.050	0.050	0.100	0.050	0.050	0.100	0.050	0.050	0.100	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	ALM default	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	ALM default	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	ALM default	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	ALM default	0.12	0.12	0.12	0.21	0.12	0.12	0.12	0.21	0.12	0.12	0.21	0.12	0.12	0.21	0.12	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	1-7 days per week	131	26	90	90	131	26	90	90	131	107	107	131	107	107	131	131
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	site specific	183	183	90	90	183	183	90	90	183	107	107	183	107	107	183	183
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**calculated**	**3.8**	**1.3**	**3.0**	**4.4**	**3.2**	**1.2**	**2.5**	**3.7**	**7.4**	**5.5**	**8.8**	**4.7**	**3.6**	**5.5**	**2.9**	**2.0**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	calculated	9.0	3.0	7.0	10.5	7.6	2.9	6.0	8.7	17.6	13.0	20.8	11.2	8.5	13.1	6.9	4.6
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**ALM default**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**calculated**	**3.5%**	**0.01%**	**1.2%**	**6.0%**	**1.7%**	**0.01%**	**0.6%**	**3.0%**	**24.7%**	**11.6%**	**34.5%**	**7.2%**	**2.7%**	**11.8%**	**1.1%**	**0.2%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 3-3

Calculations of Preliminary Remediation Goals (PRGs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Asult Lead Model (ALM) Version date 6/21/09

Variable	Description of Variable	Units	Source	Maintenance Worker - Mid-April through Mid-October	Interpretive Park Ranger - Mid-April through Mid-October	Interpretive Park Ranger- Mid-June through End September	Volunteer Lighthouse Keeper - Mid-June through End September-Adult	Volunteer Lighthouse Keeper - Mid-June through End September-Adolescent	Volunteer Lighthouse Keeper - 3 Months-Adult	Volunteer Lighthouse Keeper -3 Months-Adolescent
				5 days per week	1 day per week	5 days per week	7 days per week	7 days per week	7 days per week	7 days per week
$PbB_{fetal, 0.95}$	95th percentile PbB in fetus	ug/dL	ALM default	10	10	10	10	10	10	10
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	ALM default	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	ALM default	0.4	0.4	0.4	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	EPA 2009	1.8	1.8	1.8	1.8	1.8	1.8	1.8
PbB_0	Baseline PbB	ug/dL	EPA 2009	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	ALM default	0.10	0.05	0.05	0.05	0.05	0.05	0.05
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	ALM default	0.12	0.12	0.12	0.12	0.21	0.12	0.21
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	1-7 days per week	131	26	76	107	107	90	90
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	site specific	183	183	107	107	107	90	90
PRG		**ppm**		**939**	**9,458**	**1,881**	**1,344**	**768**	**1,344**	**768**

Table 3-4
Comparison of 95UCL Concentrations to Preliminary Remediation Goals (PRG)
Raspberry Island, APIS

				Exceed PRG?					
				Maintenance Worker	Interpretive Park Ranger (1 day/wk)	Interpretive Park Ranger	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Volunteer Lighthouse Keeper-Child
Raspberry Island	Depth	UCL	Basis	939	9458	1881	1344	768	400
Raspberry Island	Overall	556.6	95% H-UCL	--	--	--	--	--	Yes
Raspberry Island	Surface	615.2	95% H-UCL	--	--	--	--	--	Yes
Raspberry Island	Subsurface	465	95% Approximate Gamma UCL	--	--	--	--	--	Yes
Drainage Swale	Overall	266.6	95% Student's-t UCL	--	--	--	--	--	--
Drainage Swale	Surface	266.6	95% Student's-t UCL	--	--	--	--	--	--
Drainage Swale	Subsurface	NA							
Fog Signal Building	Overall	764	95% Student's-t UCL	--	--	--	--	--	Yes
Fog Signal Building	Surface	943	95% Student's-t UCL	Yes	--	--	--	Yes	Yes
Fog Signal Building	Subsurface	657.1	95% Student's-t UCL	--	--	--	--	--	Yes
Garden	Overall	50.95	average	--	--	--	--	--	--
Garden	Surface	50.95	average	--	--	--	--	--	--
Garden	Subsurface	NA							
Lighthouse/Keeper's Quarters	Overall	1189	95% Chebyshev (Mean, Sd) UCL	Yes	--	--	--	Yes	Yes
Lighthouse/Keeper's Quarters	Surface	1460	95% Chebyshev (Mean, Sd) UCL	Yes	--	--	Yes	Yes	Yes
Lighthouse/Keeper's Quarters	Subsurface	902.1	95% Adjusted Gamma UCL	--	--	--	--	Yes	Yes
Oil Storage Building	Overall	366.9	95% Student's-t UCL	--	--	--	--	--	--
Oil Storage Building	Surface	448.6	95% Student's-t UCL	--	--	--	--	--	Yes
Oil Storage Building	Subsurface	253	95% Student's-t UCL	--	--	--	--	--	--
Outhouse	Overall	555.5	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
Outhouse	Surface	616.2	95% Student's-t UCL	--	--	--	--	--	Yes
Outhouse	Subsurface	530	95% Student's-t UCL	--	--	--	--	--	Yes
Shed	Overall	621.2	95% Approximate Gamma UCL	--	--	--	--	--	Yes
Shed	Surface	729.9	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
Shed	Subsurface	594.8	95% Adjusted Gamma UCL	--	--	--	--	--	Yes

Table 3-5
Comparison of 95UCL Concentrations to Preliminary Remediation Goals (PRG)
Michigan Island, APIS

				Exceed PRG?					
				Maintenance Worker	Interpretive Park Ranger (1 day/wk)	Interpretive Park Ranger	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Volunteer Lighthouse Keeper-Child
Michigan Island	Depth	UCL	Basis	939	9458	1881	1344	768	400
Michigan Island	Overall	1874	95% Chebyshev (Mean, Sd) UCL	Yes	--	--	Yes	Yes	Yes
Michigan Island	Surface	2510	95% Chebyshev (Mean, Sd) UCL	Yes	--	Yes	Yes	Yes	Yes
Michigan Island	Subsurface	412	95% H-UCL	--	--	--	--	--	Yes
Assistant Keeper's Quarters	Overall	417.6	95% Student's-t UCL	--	--	--	--	--	Yes
Assistant Keeper's Quarters	Surface	468.9	95% Student's-t UCL	--	--	--	--	--	Yes
Assistant Keeper's Quarters	Subsurface	216.8	95% Student's-t UCL	--	--	--	--	--	--
Fog Signal Building	Overall	265.7	95% Student's-t UCL	--	--	--	--	--	--
Fog Signal Building	Surface	326.6	95% Student's-t UCL	--	--	--	--	--	--
Fog Signal Building	Subsurface	260.1	95% Student's-t UCL	--	--	--	--	--	--
Keeper's Quarters	Overall	248.2	95% Adjusted Gamma UCL	--	--	--	--	--	--
Keeper's Quarters	Surface	280.8	95% Student's-t UCL	--	--	--	--	--	--
Keeper's Quarters	Subsurface	113.7	95% Student's-t UCL	--	--	--	--	--	--
Lighthouse	Overall	7534	95% Adjusted Gamma UCL	Yes	--	Yes	Yes	Yes	Yes
Lighthouse	Surface	11614	95% Adjusted Gamma UCL	Yes	Yes	Yes	Yes	Yes	Yes
Lighthouse	Subsurface	1739	95% Student's-t UCL	Yes	--	--	Yes	Yes	Yes
Lighthouse/Keeper's Quarters	Overall	188.4	95% Student's-t UCL	--	--	--	--	--	--
Lighthouse/Keeper's Quarters	Surface	208.7	95% Student's-t UCL	--	--	--	--	--	--
Lighthouse/Keeper's Quarters	Subsurface	213.6	95% Student's-t UCL	--	--	--	--	--	--
Oil Storage Building	Overall	129.6	95% Student's-t UCL	--	--	--	--	--	--
Oil Storage Building	Surface	166.2	95% Student's-t UCL	--	--	--	--	--	--
Oil Storage Building	Subsurface	122	95% Student's-t UCL	--	--	--	--	--	--
Outhouse	Overall	685.4	95% Student's-t UCL	--	--	--	--	--	Yes
Outhouse	Surface	830.6	95% Student's-t UCL	--	--	--	--	Yes	Yes
Outhouse	Subsurface	622.2	95% Student's-t UCL	--	--	--	--	--	Yes
Shed	Overall	587.8	95% Student's-t UCL	--	--	--	--	--	Yes
Shed	Surface	741.1	95% Student's-t UCL	--	--	--	--	--	Yes
Shed	Subsurface	330.1	95% Student's-t UCL	--	--	--	--	--	--

Table 3-6
Comparison of 95UCL Concentrations to Preliminary Remediation Goals (PRG)
Devils Island, APIS

				Exceed PRG?					
				Maintenance Worker	Interpretive Park Ranger (1 day/wk)	Interpretive Park Ranger	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Volunteer Lighthouse Keeper-Child
Devils Island	Depth	UCL	Basis	939	9458	1881	1344	768	400
Devils Island	Overall	1081	95% Chebyshev (Mean, Sd) UCL	Yes	--	--	--	Yes	Yes
Devils Island	Surface	1225	95% Chebyshev (Mean, Sd) UCL	Yes	--	--	--	Yes	Yes
Devils Island	Subsurface	658.4	95% H-UCL	--	--	--	--	--	Yes
Assistant Keeper's Quarters	Overall	502.3	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
Assistant Keeper's Quarters	Surface	506.5	95% Student's-t UCL	--	--	--	--	--	Yes
Assistant Keeper's Quarters	Subsurface	525.8	95% Student's-t UCL	--	--	--	--	--	Yes
East Keeper's Quarters	Overall	400.2	95% Chebyshev (Mean, Sd) UCL	--	--	--	--	--	Yes
East Keeper's Quarters	Surface	464.8	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
East Keeper's Quarters	Subsurface	153.4	95% Student's-t UCL	--	--	--	--	--	--
East Oil Storage Building	Overall	2218	95% Adjusted Gamma UCL	Yes	--	Yes	Yes	Yes	Yes
East Oil Storage Building	Surface	2345	95% Adjusted Gamma UCL	Yes	--	Yes	Yes	Yes	Yes
East Oil Storage Building	Subsurface	26	Maximum	--	--	--	--	--	--
East Outhouse	Overall	303.1	95% Student's-t UCL	--	--	--	--	--	--
East Outhouse	Surface	302.7	95% Student's-t UCL	--	--	--	--	--	--
East Outhouse	Subsurface	304	Maximum	--	--	--	--	--	--
Fog Signal Building	Overall	1024	95% Adjusted Gamma UCL	Yes	--	--	--	Yes	Yes
Fog Signal Building	Surface	1115	95% Adjusted Gamma UCL	Yes	--	--	--	Yes	Yes
Fog Signal Building	Subsurface	614.6	95% Student's-t UCL	--	--	--	--	--	Yes
Lighthouse	Overall	1768	95% Approximate Gamma UCL	Yes	--	--	Yes	Yes	Yes
Lighthouse	Surface	1766	95% Adjusted Gamma UCL	Yes	--	--	Yes	Yes	Yes
Lighthouse	Subsurface	3426	95% Student's-t UCL	Yes	--	Yes	Yes	Yes	Yes
Storehouse	Overall	691.6	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
Storehouse	Surface	691.6	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
Storehouse	Subsurface	NA							
Tramway Engine Building	Overall	2641	95% Adjusted Gamma UCL	Yes	--	Yes	Yes	Yes	Yes
Tramway Engine Building	Surface	2653	95% Student's-t UCL	Yes	--	Yes	Yes	Yes	Yes
Tramway Engine Building	Subsurface	641.4	95% Student's-t UCL	--	--	--	--	--	Yes
West Keeper's Quarters	Overall	492	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
West Keeper's Quarters	Surface	343.8	95% Student's-t UCL	--	--	--	--	--	--
West Keeper's Quarters	Subsurface	991.9	95% Adjusted Gamma UCL	Yes	--	--	--	Yes	Yes
West Oil Storage Building	Overall	3058	95% Adjusted Gamma UCL	Yes	--	Yes	Yes	Yes	Yes
West Oil Storage Building	Surface	4602	95% Chebyshev (Mean, Sd) UCL	Yes	--	Yes	Yes	Yes	Yes
West Oil Storage Building	Subsurface	216.8	Average	--	--	--	--	--	--
West Outhouse	Overall	279.1	95% Student's-t UCL	--	--	--	--	--	--
West Outhouse	Surface	279.1	95% Student's-t UCL	--	--	--	--	--	--
West Outhouse	Subsurface	NA							

NA = not available

Table 3-7
Comparison of 95UCL Concentrations to Preliminary Remediation Goals (PRG)
Outer Island, APIS

				Exceed PRG?					
				Maintenance Worker	Interpretive Park Ranger (1 day/wk)	Interpretive Park Ranger	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Volunteer Lighthouse Keeper-Child
Outer Island	Depth	UCL	Basis	939	9458	1881	1344	768	400
Outer Island	Overall	637.5	95% H-UCL	--	--	--	--	--	Yes
Outer Island	Surface	1140	95% Chebyshev (Mean, Sd) UCL	Yes	--	--	--	Yes	Yes
Outer Island	Subsurface	425.3	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
Above Ground Storage Tank	Overall	463.8	95% Student's-t UCL	--	--	--	--	--	Yes
Above Ground Storage Tank	Surface	627.9	95% Student's-t UCL	--	--	--	--	--	Yes
Above Ground Storage Tank	Subsurface	374.2	95% Student's-t UCL	--	--	--	--	--	--
Fog Signal Building	Overall	1732	95% H-UCL	Yes	--	--	Yes	Yes	Yes
Fog Signal Building	Surface	2330	95% Chebyshev (Mean, Sd) UCL	Yes	--	Yes	Yes	Yes	Yes
Fog Signal Building	Subsurface	1278	95% Adjusted Gamma UCL	Yes	--	--	--	Yes	Yes
Lighthouse/Keeper's Quarters	Overall	404.1	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
Lighthouse/Keeper's Quarters	Surface	462.1	95% Student's-t UCL	--	--	--	--	--	Yes
Lighthouse/Keeper's Quarters	Subsurface	375.5	95% Adjusted Gamma UCL	--	--	--	--	--	--
Oil Storage Building	Overall	962.2	95% Adjusted Gamma UCL	Yes	--	--	--	Yes	Yes
Oil Storage Building	Surface	978.4	95% Student's-t UCL	Yes	--	--	--	Yes	Yes
Oil Storage Building	Subsurface	317.2	95% Student's-t UCL	--	--	--	--	--	--
Outhouse	Overall	460.2	95% Student's-t UCL	--	--	--	--	--	Yes
Outhouse	Surface	575.6	95% Student's-t UCL	--	--	--	--	--	Yes
Outhouse	Subsurface	590.8	95% Student's-t UCL	--	--	--	--	--	Yes

Currently, no inhabited keeper’s quarters are present on Outer Island; nor are they planned for refurbishment. The mainland is close to this island, so overnight stays are not envisioned for this island.

Table 3-8
Comparison of 95UCL Concentrations to Preliminary Remediation Goals (PRG)
Long Island, APIS

				Exceed PRG?					
				Maintenance Worker	Interpretive Park Ranger (1 day/wk)	Interpretive Park Ranger	Volunteer Lighthouse Keeper-Adult	Volunteer Lighthouse Keeper-Adolescent	Volunteer Lighthouse Keeper-Child
Long Island	Depth	UCL	Basis	939	9458	1881	1344	768	400
Area 1	Overall	641.5	95% H-UCL	--	--	--	--	--	Yes
Area 1	Surface	741.6	95% H-UCL	--	--	--	--	--	Yes
Area 1	Subsurface	674.6	95% Chebyshev (Mean, Sd) UCL	--	--	--	--	--	Yes
Above Ground Storage Tank	Overall	403.5	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
Above Ground Storage Tank	Surface	760.5	95% Chebyshev (Mean, Sd) UCL	--	--	--	--	--	Yes
Above Ground Storage Tank	Subsurface	287.2	95% Student's-t UCL	--	--	--	--	--	--
Fog Signal Building	Overall	2387	95% Chebyshev (Mean, Sd) UCL	Yes	--	Yes	Yes	Yes	Yes
Fog Signal Building	Surface	1851	95% H-UCL	Yes	--	--	Yes	Yes	Yes
Fog Signal Building	Subsurface	1244	95% Adjusted Gamma UCL	Yes	--	--	--	Yes	Yes
Former Radio Tower Footers	Overall	101.2	95% Student's-t UCL	--	--	--	--	--	--
Former Radio Tower Footers	Surface	163.8	95% Student's-t UCL	--	--	--	--	--	--
Former Radio Tower Footers	Subsurface	27.62	95% Student's-t UCL	--	--	--	--	--	--
Keeper's Quarters	Overall	372.5	95% Student's-t UCL	--	--	--	--	--	--
Keeper's Quarters	Surface	471.7	95% Student's-t UCL	--	--	--	--	--	Yes
Keeper's Quarters	Subsurface	170.2	95% Student's-t UCL	--	--	--	--	--	--
LaPointe Cistern	Overall	183.2	95% Student's-t UCL	--	--	--	--	--	--
LaPointe Cistern	Surface	259.7	95% Student's-t UCL	--	--	--	--	--	--
LaPointe Cistern	Subsurface	215.1	95% Student's-t UCL	--	--	--	--	--	--
LaPointe East Shed	Overall	221.9	95% Adjusted Gamma UCL	--	--	--	--	--	--
LaPointe East Shed	Surface	252	95% Student's-t UCL	--	--	--	--	--	--
LaPointe East Shed	Subsurface	270.1	95% Adjusted Gamma UCL	--	--	--	--	--	--
LaPointe Lighthouse	Overall	1994	95% Adjusted Gamma UCL	Yes	--	Yes	Yes	Yes	Yes
LaPointe Lighthouse	Surface	2452	95% Adjusted Gamma UCL	Yes	--	Yes	Yes	Yes	Yes
LaPointe Lighthouse	Subsurface	1907	95% Student's-t UCL	Yes	--	Yes	Yes	Yes	Yes
Oil Storage Shed	Overall	634.5	95% Adjusted Gamma UCL	--	--	--	--	--	Yes
Oil Storage Shed	Surface	711.4	95% Student's-t UCL	--	--	--	--	--	Yes
Oil Storage Shed	Subsurface	108.9	95% Student's-t UCL	--	--	--	--	--	--
Area 2	Overall	1482	95% H-UCL	Yes	--	--	Yes	Yes	Yes
Area 2	Surface	1265	95% Adjusted Gamma UCL	Yes	--	--	--	Yes	Yes
Area 2	Subsurface	800.9	95% Chebyshev (Mean, Sd) UCL	--	--	--	--	Yes	Yes
Chequamegon Lighthouse	Overall	18	Maximum	--	--	--	--	--	--
Chequamegon Lighthouse	Surface	18	Maximum	--	--	--	--	--	--
Chequamegon Lighthouse	Subsurface	18	Maximum	--	--	--	--	--	--
LaPointe Radio Beacon	Overall	39.29	95% Chebyshev (Mean, Sd) UCL	--	--	--	--	--	--
LaPointe Radio Beacon	Surface	44.4	95% Student's-t UCL	--	--	--	--	--	--
LaPointe Radio Beacon	Subsurface	9.096	95% Student's-t UCL	--	--	--	--	--	--
Old Chequamegon Lighthouse	Overall	27.01	95% Student's-t UCL	--	--	--	--	--	--
Old Chequamegon Lighthouse	Surface	19.82	95% Student's-t UCL	--	--	--	--	--	--
Old Chequamegon Lighthouse	Subsurface	40.1	95% Student's-t UCL	--	--	--	--	--	--
Original LaPointe Keeper's Quarters	Overall	1437	95% H-UCL	Yes	--	--	Yes	Yes	Yes
Original LaPointe Keeper's Quarters	Surface	1658	95% Adjusted Gamma UCL	Yes	--	--	Yes	Yes	Yes
Original LaPointe Keeper's Quarters	Subsurface	1003	95% Chebyshev (Mean, Sd) UCL	Yes	--	--	--	Yes	Yes

Area 1 includes Above Ground Storage Tank, Fog Signal Building, Former Radio Tower Footers, LaPointe East Shed, Keepers' Quarters, LaPointe Cistern, LaPointe Lighthouse, and Oil Storage Shed.

Area 2 includes Chequamegon Lighthouse, LaPointe Radio Beacon, Old Chequamegon Lighthouse, and Original LaPointe Keeper's Quarters

Currently, no inhabited keeper’s quarters are present on Long Island; nor are they planned for refurbishment. The mainland is close to this island, so overnight stays are not envisioned for this island.

Table 3-9
Comparison of Maximum Lead Concentrations to Ecological Screening Levels
APIS, Wisconsin

Light Station	Maximum Lead Concentration (mg/kg)	Ecological Soil Screening Levels (EcoSSL)															
						Avian Receptors						Mammalian Receptor					
		Invertebrates	HQ	Plants	HQ	Herbivore	HQ	Insectivore	HQ	Carnivore	HQ	Herbivore	HQ	Insectivore	HQ	Carnivore	HQ
Michigan Island	15,078	1700	**9**	120	**126**	46	**328**	11	**1371**	510	**30**	1200	**13**	56	**269**	460	**33**
Outer Island	7,610	1700	**4**	120	**63**	46	**165**	11	**692**	510	**15**	1200	**6**	56	**136**	460	**17**
Raspberry Island	4,877	1700	**3**	120	**41**	46	**106**	11	**443**	510	**10**	1200	**4**	56	**87**	460	**11**
Devils Island	6,382	1700	**4**	120	**53**	46	**139**	11	**580**	510	**13**	1200	**5**	56	**114**	460	**14**
Long Island	8,662	1700	**5**	120	**72**	46	**188**	11	**787**	510	**17**	1200	**7**	56	**155**	460	**19**

HQ = Hazard quotient, equal maximum concentration divided by EcoSSL
mg/kg = milligram per kilogram

Table 3-10
Lead Ecological Risk Characterization for 95UCL Concentrations at the Light Stations
APIS, Wisconsin

HQ_j = [FIR x ($Soil_j$ x P_s + B_{ij})} / TRV_j (Equation 4-2, U.S. EPA, 2005a)

Exposure Concentration	95UCL $Soil_j$ (mg/kg)	Avian ground insectivore American woodcock TRV-NOAEL = 1.63[a] HQ -NOAEL	TRV-LOAEL = 44.6[b] HQ - LOAEL	Avian herbivore American Robin TRV-NOAEL = 1.63[a] HQ -NOAEL	TRV-LOAEL = 44.6[b] HQ - LOAEL	Avian carnivore Broad-winged Hawk TRV-NOAEL = 1.63[a] HQ -NOAEL	TRV-LOAEL = 44.6[b] HQ - LOAEL	Mammalian ground insectivore Masked shrew TRV-NOAEL = 4.7[c] HQ -NOAEL	TRV-LOAEL = 166[d] HQ - LOAEL	Mammalian ground herbivore Southern red-backed vole TRV-NOAEL = 4.7[c] HQ -NOAEL	TRV-LOAEL = 166[d] HQ - LOAEL	Mammalian carnivore Short-tailed weasel TRV-NOAEL = 4.7[c] HQ -NOAEL	TRV-LOAEL = 166[d] HQ - LOAEL
Michigan Island	1,874	89	3	29	1	8	0.3	20	0.6	3	0.08	2	0.07
Outer Island	638	34	1	11	0.4	3	0.1	8	0.2	1	0.03	1	0.03
Raspberry Island	557	30	1	9	0.3	3	0.1	7	0.2	1	0.03	0.9	0.02
Devils Island	1,081	54	2	17	0.6	5	0.2	13	0.4	2	0.05	1	0.04
Long Island	821	42	2	13	0.5	4	0.1	10	0.3	1	0.04	1	0.03

Input Parameters

HQ_j Hazard quotient for contaminant (j) (unitless)
$Soil_j$ Concentration of contaminant (j) in soil (mg/kg [dry weight])
FIR Food ingestion rate (kg food [dry weight]/kg bw [wet weight]/d)
P_s Proportion of diet that is soil
TRV_j Toxicity reference value for contaminant (j) (mg{dry weight]/kg bw [wet weight]/d)
B_{ij} Concentration of contaminant (j) in food type (i) mg/kg [dry weight]
ln(Bi) = 0.807 x ln(Soil) - 0.218 where I = earthworms
ln(Bi) = 0.561 x ln(Soij) - 1.328 where I = plants
ln(Bi) = 0.4422 x ln(Soilj) + 0.0761 where I = mammals

	FIR = IR/BW	Ps	IR (g dry/day)[e]	Mean BW (g)	Source
Avian ground Insectivore (woodcock)	0.214	0.164	NA	NA	EcoSSL
Avian herbivore (American robin)	0.162	0.139	12.54	77.3	WEFH
Avian carnivore (broad-winged hawk)	0.096	0.057	39.48	413	UWSP
Mammalian ground insectivore (masked shrew)	0.220	0.03	0.99	4.5	UWSP
Mammalian ground herbivore (Southern red-backed vole)	0.138	0.032	3.85	28	UWSP
Mammalian carnivore (short-tailed weasel)	0.101	0.043	9.47	94	UMICH

[a]The avian wildlife TRV-NOAEL for lead is equal to 1.63 mg lead/kg bw/day which is the highest bounded NOAEL below the lowest bounded LOAEL for effects on growth, reproduction, and survival (U.S. EPA, 2005).

[b]The avian wildlife TRV-LOAEL is the geometric mean of LOAELs within the reproduction and growth effect groups (presented in Table 5-1 of U.S. EPA, 2005b).

[c]The mammalian wildlife TRV-NOAEL for lead is equal to 4.70 mg lead/kg bw/day which is the highest bounded NOAEL below the lowest bounded LOAEL for results in the growth, reproduction, and survival effect groups (U.S. EPA, 2005).

[d]The mammalian avian wildlife TRV-LOAEL is the geometric mean of LOAELs within the reproduction, growth, and survival effect groups (presented in Table 6-1 of U.S. EPA, 2005).

[e] Ingestion rate (IR) based on mean body weight using Nagy (2001) equation for all birds which is IR (g dry/day) = 0.638(gBW^0.638) and all mammals which is IR (g dry/day) =0.323(g BW)^0.744)

NOAEL = no observable adverse effect level; LOAEL = lowest observable adverse effect level

UWSP = University of Wisconsin-Stevens Point (UWSP). 2012. Mammals of Wisconsin. (http://www.uwsp.edu/biology/VertebrateCollection/Pages/default.aspx).

UMICH = University of Michigan, Museum of Zoology, Animal Diversity Web. 2012. http://animaldiversity.ummz.umich.edu/accounts/Buteo_platypterus/

WEFH = EPA. 1993. Wildlife Exposure Factors Handbook. EPA/600/R-93/187a.

EPA, 2005. Ecological Soil Screening Levels for Lead. Interim Final. OSWER Directive 9285.7-70. March 2005.

Nagy KA (2001) Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews, Series B71, 21R-31R.

APPENDIX A

Analytical Results and Sample Location Map Excerpts

Table 4-2. Michigan Island Background Soil - Metals

Station Sample ID Collection Date Depth (ft bgs)	MI-BKG-SB001 APISSB0630 6/22/2012 0-0.5	MI-BKG-SB001 APISSB0631 6/22/2012 0.5-1	MI-BKG-SB002 APISSB0632 6/22/2012 0-0.5	MI-BKG-SB002 APISSB0633 6/22/2012 0.5-1	MI-BKG-SB003 APISSB0634 6/22/2012 0-0.5	MI-BKG-SB003 APISSB0635 6/22/2012 0.5-1	MI-BKG-SB004 APISSB0636 6/22/2012 0-0.5	MI-BKG-SB004 APISSB0637 6/22/2012 0.5-1	BSV[a]	
Metals (mg/kg)										
Aluminum	8,380	7,920	3,450	8,450	4,380	10,800	6,320	10,200	14,218	b
Antimony	1.39 UJ	1.305 U	1.645 U	0.648 J	1.205 U	0.632 J	1.515 U	0.757 J	1.494	c
Arsenic	2.18	2.04	1.13 J	2.4	1.37	2.12	1.62	1.73	2.95	b
Barium	64.8 J	62.2	24	45.7	27	60.3	39.6	48.8	86.93	b
Beryllium	0.272 J	0.259 J	0.176 J	0.283 J	0.178 J	0.338	0.231 J	0.329	0.416	b
Cadmium	0.422	0.354	0.224 J	0.28 J	0.188 J	0.291 J	0.241 J	0.266 J	0.476	b
Calcium	1870	1630	643	1000	813	1630	638	949	2,410	b
Chromium	17.7	18.7	7.39	18.3	10.9	23.9	14.4	21.7	30.76	b
Cobalt	10.6	9.56	2.45	5.18	3.43	7.24	11.3	6.79	15.51	b
Copper	9.92	11.9	4.18	8.74	4.79	15.1	5.57	8.72	18.28	b
Iron	12,400	12,100	8,210	16,300	8,130	14,600	11,600	14,900	20,008	b
Lead	11.4	11.2	8.55	8.01	13.3	9.8	11.9	9.04	15.15	b
Magnesium	2850	2750	905	2300	1630	3700	1970	3400	4,834	b
Manganese	794	760	253	218	101	167	796	204	796	c
Mercury	0.044 J	0.039 J	0.041 J	0.032 J	0.04 J	0.026 J	0.035 J	0.018 J	0.0569	b
Nickel	11.5	12.3	4.12	9.86	6.54	16.1	7.8	13.3	20.27	b
Potassium	873	811	344	767	507	1,060	617	990	1,374	b
Selenium	0.484 J	0.52 U	0.66 U	0.5 U	0.482 U	0.515 U	0.605 U	0.49 U		d
Silver	0.278 U	0.261 U	0.33 U	0.25 U	0.24 U	0.258 U	0.302 U	0.245 U		d
Sodium	23.6 J	52 U	66 U	50 U	36.3 J	7.69 J	38 J	12.7 J	55.08	e
Thallium	1.11 U	0.291 J	1.32 U	1 U	0.965 U	1.035 U	1.21 U	0.98 U		d
Vanadium	26.4	25.6	17.6	38.8	18	30.5	29.2	34.7	46.73	b
Zinc	39.6	33.7	22	24.8	24.8	34.1	30.3	33.3	45.78	b

a Background Screening Value (BSV) is the 95% Upper Tolerance Limit (UTL) calculated using ProUCL version 4.1.01 (USEPA 2011)
b Data are normally distributed, 95% UTL calculated assuming normal distribution
c Data are not normally distributed, 95% UTL calculated using non-parametric Kaplan-Meier method for data with non-detect values and multiple detection limits.
d BSV cannot be calculated because analyte was not detected or was detected in only 1 sample.
e Data are not normally distributed, 95% UTL calculated using non-parametric statistics
ft bgs = feet below ground surface

Table 4-4. Outer Island Background Soil - Metals

Station Sample ID Collection Date Depth (ft bgs)	OI-BKG-SB001 APISSB0638 6/22/2012 0-0.5	OI-BKG-SB001 APISSB0639 6/22/2012 0.5-1	OI-BKG-SB002 APISSB0640 6/22/2012 0-0.5	OI-BKG-SB002 APISSB0641 6/22/2012 0.5-1	OI-BKG-SB003 APISSB0642 6/22/2012 0-0.5	OI-BKG-SB003 APISSB0643 6/22/2012 0.5-1	OI-BKG-SB004 APISSB0644 6/22/2012 0-0.5	OI-BKG-SB004 APISSB0645 6/22/2012 0.5-1	BSV[a]	
Metals (mg/kg)										
Aluminum	1,650	2,550	3,350	3,440	1,030	1,750	248	256	5,030	b
Antimony	1.065 U	1.09 U	1.33 U	1.125 U	1.565 U	1.375 U	1.265 U	1.275 U		c
Arsenic	0.657 J	0.81 J	1.28	0.651 J	0.596 J	0.581 J	0.379 J	0.417 J	1.398	b
Barium	23.2	15.3	37.4	15.2	11.9	7.58	5.48	4.32 J	43.31	b
Beryllium	0.128 U	0.13 U	0.08 J	0.086 J	0.188 U	0.165 U	0.152 U	0.153 U	0.0907	d
Cadmium	0.175 J	0.15 J	0.245 J	0.148 J	0.188 U	0.165 U	0.063 J	0.153 U	0.286	d
Calcium	632	373	845	214	250	147	116	111	1,030	b
Chromium	5.83	5.88	8.52	6.57	2.05	3.35	1.48	2.72	11	b
Cobalt	2.56	1.75	2.57	1.75	0.94 U	0.711 J	0.76 U	0.765 U	3.444	d
Copper	3.4	3.3	7.52	2.39	1.95	1.85	2.19	1.38	7.52	e
Iron	5,030	4,680	8,190	6,180	1,390	1,810	1,160	1,600	10,571	b
Lead	8.23	4.43	9.94	3.56	3.97	2.63	3.55	2.24	11.95	b
Magnesium	959	442	740	298	103 J	287	34.7 J	25.1 J	1,236	e
Manganese	194	89.1	187	98.9	9.57	14.9	8.8	10.6	194	e
Mercury	0.032 J	0.022 J	0.042 J	0.024 J	0.038 J	0.018 J	0.007 J	0.004 J	0.0587	b
Nickel	5.61	2.79	5.18	2.7	1.14 J	1.95 J	0.741 J	1.12 J	7.429	b
Potassium	120	93.9	301	132	151	105 J	69.7 J	44.4 J	328.6	b
Selenium	0.426 U	0.436 U	0.57 J	0.45 U	0.625 U	0.55 U	0.505 U	0.51 U		c
Silver	0.213 U	0.218 U	0.266 U	0.225 U	0.313 U	0.275 U	0.254 U	0.255 U		c
Sodium	14.7 J	12 J	21 J	39 J	78.1 J	50.5 J	26.6 J	7.49 J	92.6	b
Thallium	0.85 U	0.87 U	1.065 U	0.9 U	1.25 U	1.1 U	1.015 U	1.02 U		c
Vanadium	14.2	11.4	24.1	17.5	4.3	5.57	2.7	4.27	30.29	b
Zinc	15.2	11.9	21.4	11.2	8.1	6.9	6.88	6.54	24.42	b

a Background Screening Value (BSV) is the 95% Upper Tolerance Limit (UTL) calculated using ProUCL version 4.1.01 (USEPA 2011)
b Data are normally distributed, 95% UTL calculated assuming normal distribution
c BSV cannot be calculated because analyte was not detected or was detected in only 1 sample.
d Data are not normally distributed, 95% UTL calculated using non-parametric Kaplan-Meier method for data with non-detect values and multiple detection limits.
e Data are not normally distributed, 95% UTL calculated using non-parametric statistics
ft bgs = feet below ground surface

Table 4-5. Raspberry Island Background Soil - Metals

Station Sample ID Collection Date Depth (ft bgs)	RI-BKG-SB001 APISSB0646 6/22/2012 0-0.5	RI-BKG-SB001 APISSB0647 6/22/2012 0.5-1	RI-BKG-SB002 APISSB0648 6/22/2012 0-0.5	RI-BKG-SB002 APISSB0649 6/22/2012 0.5-1	RI-BKG-SB003 APISSB0650 6/22/2012 0-0.5	RI-BKG-SB003 APISSB0651 6/22/2012 0.5-1	RI-BKG-SB004 APISSB0652 6/22/2012 0-0.5	RI-BKG-SB004 APISSB0653 6/22/2012 0.5-1	BSV[a]	
Metals (mg/kg)										
Aluminum	3,720	4,410	7,330	13,100	17,500	22,800	4,850	7,340	28,152	b
Antimony	1.385 U	1.295 U	0.561 J	0.792 J	1.01 J	1.08 J	1.12 U	0.599 J	1.35	c
Arsenic	1.09 J	1.11	2.03	2.6	2.5	2.95	1.27	1.4	3.793	b
Barium	49.4	41.3	66.5	89.4	93.5	132	23	38.4	160.1	b
Beryllium	0.157 J	0.164 J	0.241 J	0.483	0.635	0.839	0.191 J	0.289	1.026	b
Cadmium	0.163 J	0.215 J	0.374	0.413	0.505	0.486	0.22 J	0.242 J	0.672	b
Calcium	868	710	1,440	1,690	1,700	2,300	550	1,110	2,828	b
Chromium	9.2	12.4	15.3	25.8	28.6	35.6	9.04	14.9	44.36	b
Cobalt	4.44	4.64	10	7.97	13.6	12.8	3.46	5.57	17.98	b
Copper	4.81	4.91	11.4	18.1	17.2	27	4.91	6.39	33.07	b
Iron	6,870	8,330	13,400	21,000	25,200	28,800	9,500	12,100	37,007	b
Lead	7.38	6.78	11.9	11	13.2	13.1	7.53	7.31	16.99	b
Magnesium	1,110	1,530	3,000	5,090	6,370	7,960	1,280	2,670	10,244	b
Manganese	236	175	890	209	791	362	89.3	129	890	d
Mercury	0.03 J	0.018 J	0.021 J	0.02 J	0.047	0.023	0.032	0.02	0.047	d
Nickel	7.53	12.9	12.5	18.3	22.6	27.7	5.46	10.6	34.36	b
Potassium	332	373	854	1,310	2,210	2,580	400	842	3,338	b
Selenium	0.555 U	0.515 U	0.5 U	0.525 U	0.515 U	0.505 U	0.449 U	0.418 U		e
Silver	0.276 U	0.258 U	0.25 U	0.262 U	0.258 U	0.252 U	0.224 U	0.208 U		e
Sodium	27 J	54 J	50 U	52.5 U	51.5 U	21.2 J	44.9 U	41.75 U	54.31	c
Thallium	1.105 U	1.035 U	1 U	1.05 U	1.03 U	1.01 U	0.9 U	0.835 U		e
Vanadium	17.7	20.3	30.8	43.2	50.6	60.7	23.2	29.7	74.4	b
Zinc	21.9	24	39.7	37.9	48.5	46.7	17.1	22.7	64.03	b

a Background Screening Value (BSV) is the 95% Upper Tolerance Limit (UTL) calculated using ProUCL version 4.1.01 (USEPA 2011)
b Data are normally distributed, 95% UTL calculated assuming normal distribution
c Data are not normally distributed, 95% UTL calculated using non-parametric Kaplan-Meier method for data with non-detect values and multiple detection limits.
d Data are not normally distributed, 95% UTL calculated using non-parametric statistics
e BSV cannot be calculated because analyte was not detected or was detected in only 1 sample.
ft bgs = feet below ground surface

Table 4-6. Devil's Island Background Soil - Metals

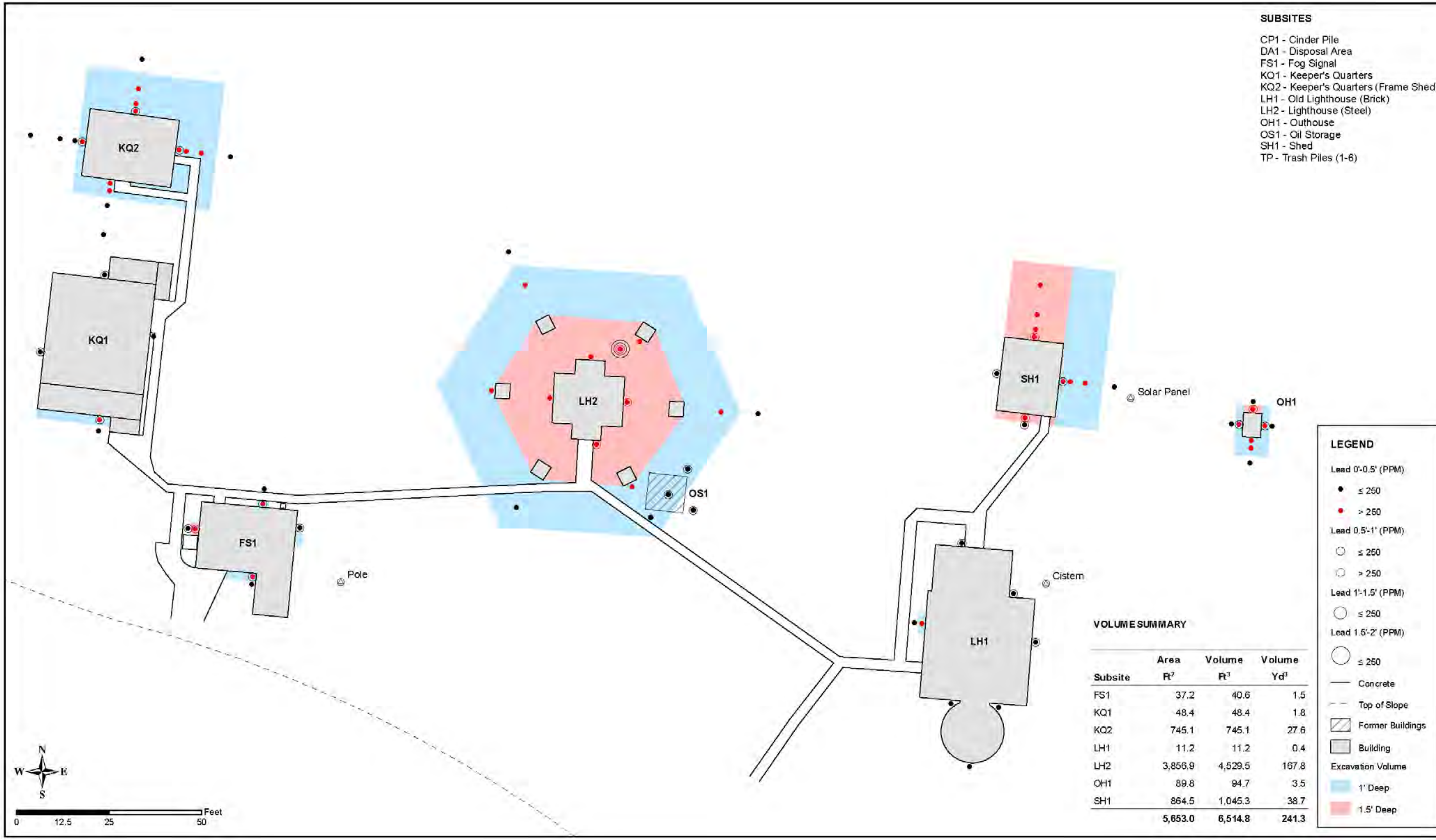
Station Sample ID Collection Date Depth (ft bgs)	DI-BKG-SB001 APISSB0622 6/24/2012 0-0.5	DI-BKG-SB001 APISSB0623 6/24/2012 0.5-1	DI-BKG-SB002 APISSB0624 6/24/2012 0-0.5	DI-BKG-SB003 APISSB0625 6/24/2012 0-0.5	DI-BKG-SB004 APISSB0626 6/24/2012 0-0.5	DI-BKG-SB005 APISSB0627 6/24/2012 0-0.5	DI-BKG-SB005 APISSB0628 6/24/2012 0.5-1	DI-BKG-SB006 APISSB0629 6/24/2012 0-0.5	BSV[a]	
Metals (mg/kg)										
Aluminum	626	388	234 J	1,930	1110 J	2,810	4,510	282	5,414	b
Antimony	1.6 U	1.435 U	1.06 U	1.61 U	1.595 U	1.515 U	1.56 U	1.495 U		c
Arsenic	0.571 J	0.418 J	0.308 J	0.913 J	1.2 J	2.16	2.65	0.456 J	3.343	b
Barium	11.2	9.07	4.8	16.5	16.1	12.2	10.4	5.58 J	21.82	b
Beryllium	0.192 U	0.172 U	0.127 U	0.194 U	0.192 U	0.182 U	0.187 U	0.18 U		c
Cadmium	0.148 J	0.106 J	0.067 J	0.114 J	0.299 J	0.288 J	0.274 J	0.111 J	0.421	b
Calcium	776	623	127 J	408	700	354	268	293	1,038	b
Chromium	8.16	6.23	4.93	5.38	3.52	17.1	12.9	3.13	20.36	b
Cobalt	0.96 U	0.86 U	0.635 U	0.965 U	0.955 U	1.21 J	1.36 J	0.895 U	1.357	d
Copper	4.21	3.81	1.97	4.36	5.33	8.6	8.96	5.97	11.58	b
Iron	1,110	535	1,340	1,580	1,960	8,490	10,400	527	10,400	e
Lead	8.08	5.98	3.29	6.66	16.9	12.3	9.79	3.18	20.29	b
Magnesium	128 J	75.5 J	30.3 J	201	147	296	358	46.6 J	464.9	b
Manganese	11.9	6.76	9.2	13.4	14.9	28.8	24.6	9.61	35.02	b
Mercury	0.052	0.021	0.022	0.067	0.107	0.081	0.118	0.021	0.162	b
Nickel	4.17	2.3	2.25	2.55 J	1.82 J	5.16	3.93	1.49 J	6.313	b
Potassium	166 J	81 J	73.5 J	194	254	298	275	91 J	413.8	b
Selenium	0.64 U	0.575 U	0.424 U	0.645 U	0.559 J	0.605 U	0.612 J	0.6 U	0.619	d
Silver	0.32 U	0.288 U	0.212 U	0.322 U	0.319 U	0.303 U	0.312 U	0.299 U		c
Sodium	28 J	30.9 J	8.41 J	23.7 J	21.4 J	11 J	62.5 U	16.7 J	40.13	d
Thallium	1.28 U	1.15 U	0.845 U	1.29 U	1.275 U	1.215 U	1.245 U	1.195 U		c
Vanadium	2.31 J	1.17 J	2.71	4.43	3.84	26.7	35.7	0.893 J	35.7	e
Zinc	15.2	18.2	5.24	11.5	16.6 J	15.1	16.1	8.68	24.84	b

a Background Screening Value (BSV) is the 95% Upper Tolerance Limit (UTL) calculated using ProUCL version 4.1.01 (USEPA 2011)
b Data are normally distributed, 95% UTL calculated assuming normal distribution
c BSV cannot be calculated because analyte was not detected or was detected in only 1 sample.
d Data are not normally distributed, 95% UTL calculated using non-parametric Kaplan-Meier method for data with non-detect values and multiple detection limits.
e Data are not normally distributed, 95% UTL calculated using non-parametric statistics
ft bgs = feet below ground surface

Table 4-7. Long Island Background Soil - Metals

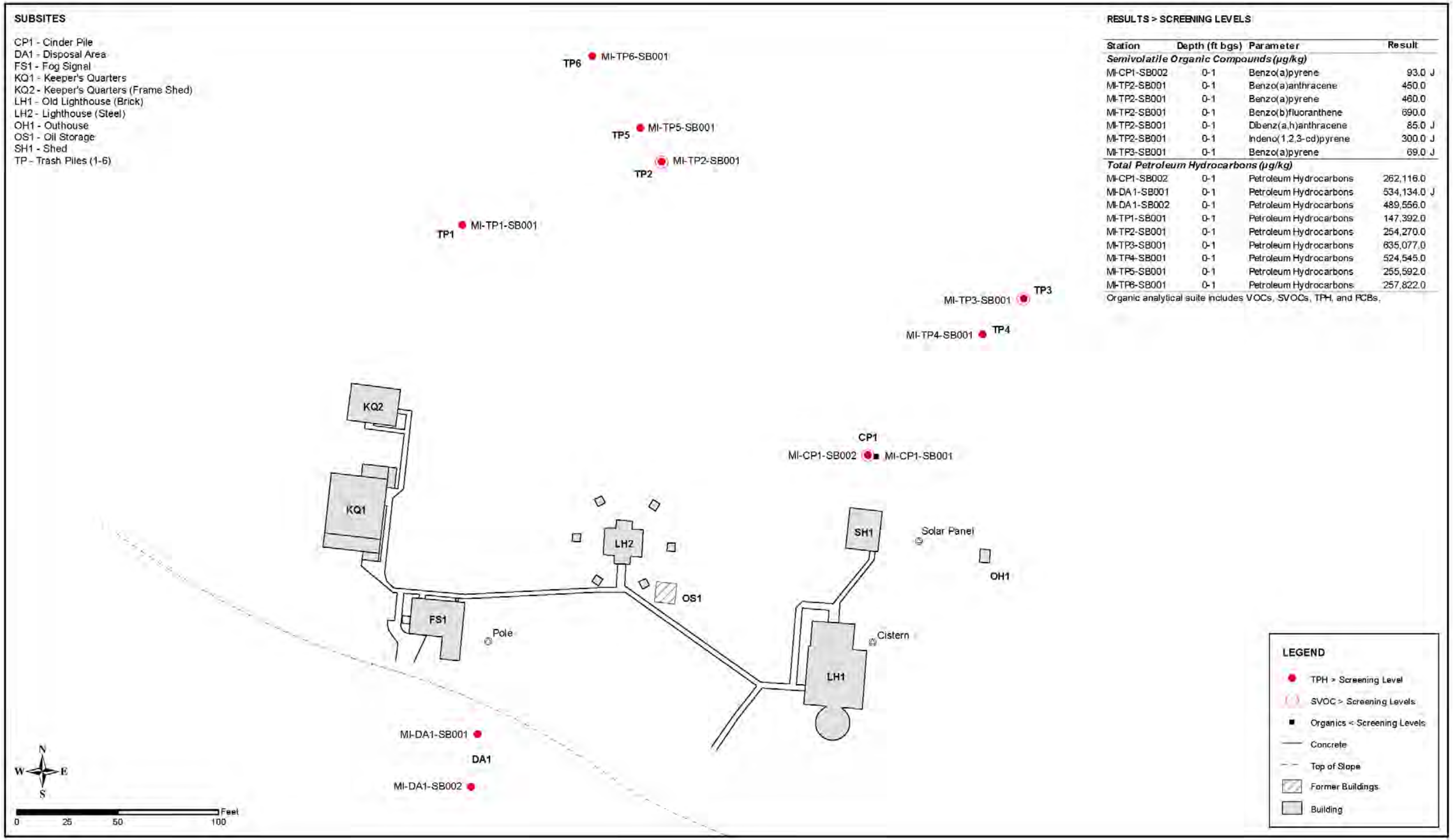
Station Sample ID Collection Date Depth (ft bgs)	LI-BKG-SB001 APISSB0614 6/26/2012 0-0.5	LI-BKG-SB001 APISSB0615 6/26/2012 0.5-1	LI-BKG-SB002 APISSB0616 6/26/2012 0-0.5	LI-BKG-SB002 APISSB0617 6/26/2012 0.5-1	LI-BKG-SB003 APISSB0618 6/26/2012 0-0.5	LI-BKG-SB003 APISSB0619 6/26/2012 0.5-1	LI-BKG-SB004 APISSB0620 6/26/2012 0-0.5	LI-BKG-SB004 APISSB0621 6/26/2012 0.5-1	BSV[a]	
Metals (mg/kg)										
Aluminum	1,150	1,030	947	1,020	1,110	1,030	965	967	1,212	b
Antimony	0.592 J	0.463 J	0.512 J	0.606 J	0.482 J	1.005 U	0.489 J	0.975 U	0.666	c
Arsenic	1.24	0.974	1.07	1.08	1.08	1.11	1.33	0.886	1.456	b
Barium	5.76	4.67	5.64	6.22	4.58	4.26	6.56	5.57	7.532	b
Beryllium	0.108 J	0.105 J	0.106 J	0.097 J	0.098 J	0.083 J	0.137 J	0.087 J	0.145	b
Cadmium	0.214 J	0.355	0.271	0.801	0.201 J	0.134 J	0.24 J	0.172 J	0.801	d
Calcium	781	696	564	604	779	782	684	597	917.9	b
Chromium	7.8	5.86	7.09	7.67	5.96	5.81	7.13	6.35	8.814	b
Cobalt	2.46	1.96	2.16	2.24	2.2	1.93	2.18	1.87	2.628	b
Copper	1.65 J	1.15 J	1.27 J	1.09 J	1.45 J	1.44 J	1.18 J	1.11 J	1.811	b
Iron	9,570	6,660	9,670	9,400	7,280	5,870	9,150	7,520	11927	b
Lead	5.65	3.28	5.51	5.79	5.47	3.62	4.95	3.7	7.431	b
Magnesium	496	457	343	329	471	461	393	419	579.6	b
Manganese	56	43.5	47.1	47.2	45.5	41.8	49.2	41.2	58.73	b
Mercury	0.008 J	0.004 J	0.009 J	0.015	0.009	0.005 J	0.006 J	0.004 J	0.017	b
Nickel	3.22	2.71	2.52	2.81	2.66	2.85	2.87	2.65	3.33	b
Potassium	75.2 J	73.2 J	58 J	76.3 J	65 J	71.9 J	57.5 J	72 J	88.03	b
Selenium	0.406 U	0.395 U	0.432 U	0.416 U	0.391 U	0.402 U	0.427 U	0.391 U		e
Silver	0.203 U	0.198 U	0.216 U	0.208 U	0.196 U	0.201 U	0.214 U	0.196 U		e
Sodium	40.65 U	15.5 J	43.25 U	41.65 U	39.1 U	40.2 U	42.7 U	39.1 U		e
Thallium	0.815 U	0.79 U	0.865 U	0.835 U	0.78 U	0.805 U	0.855 U	0.78 U		e
Vanadium	33	20.6	32.9	33.5	25.4	18.2	31.9	24.7	43.29	b
Zinc	11.1	13.1	11.9	12.3	9.87	7.33	11.5	8.93	15.7	b

a Background Screening Value (BSV) is the 95% Upper Tolerance Limit (UTL) calculated using ProUCL version 4.1.01 (USEPA 2011)
b Data are normally distributed, 95% UTL calculated assuming normal distribution
c Data are not normally distributed, 95% UTL calculated using non-parametric Kaplan-Meier method for data with non-detect values and multiple detection limits.
d Data are not normally distributed, 95% UTL calculated using non-parametric statistics
e BSV cannot be calculated because analyte was not detected or was detected in only 1 sample.
ft bgs = feet below ground surface



Subsite	Area Ft^2	Volume Ft^3	Volume Yd^3
FS1	37.2	40.6	1.5
KQ1	48.4	48.4	1.8
KQ2	745.1	745.1	27.6
LH1	11.2	11.2	0.4
LH2	3,856.9	4,529.5	167.8
OH1	89.8	94.7	3.5
SH1	864.5	1,045.3	38.7
	5,653.0	**6,514.8**	**241.3**

Figure 4-1. Michigan Island XRF Results and Excavation Volumes

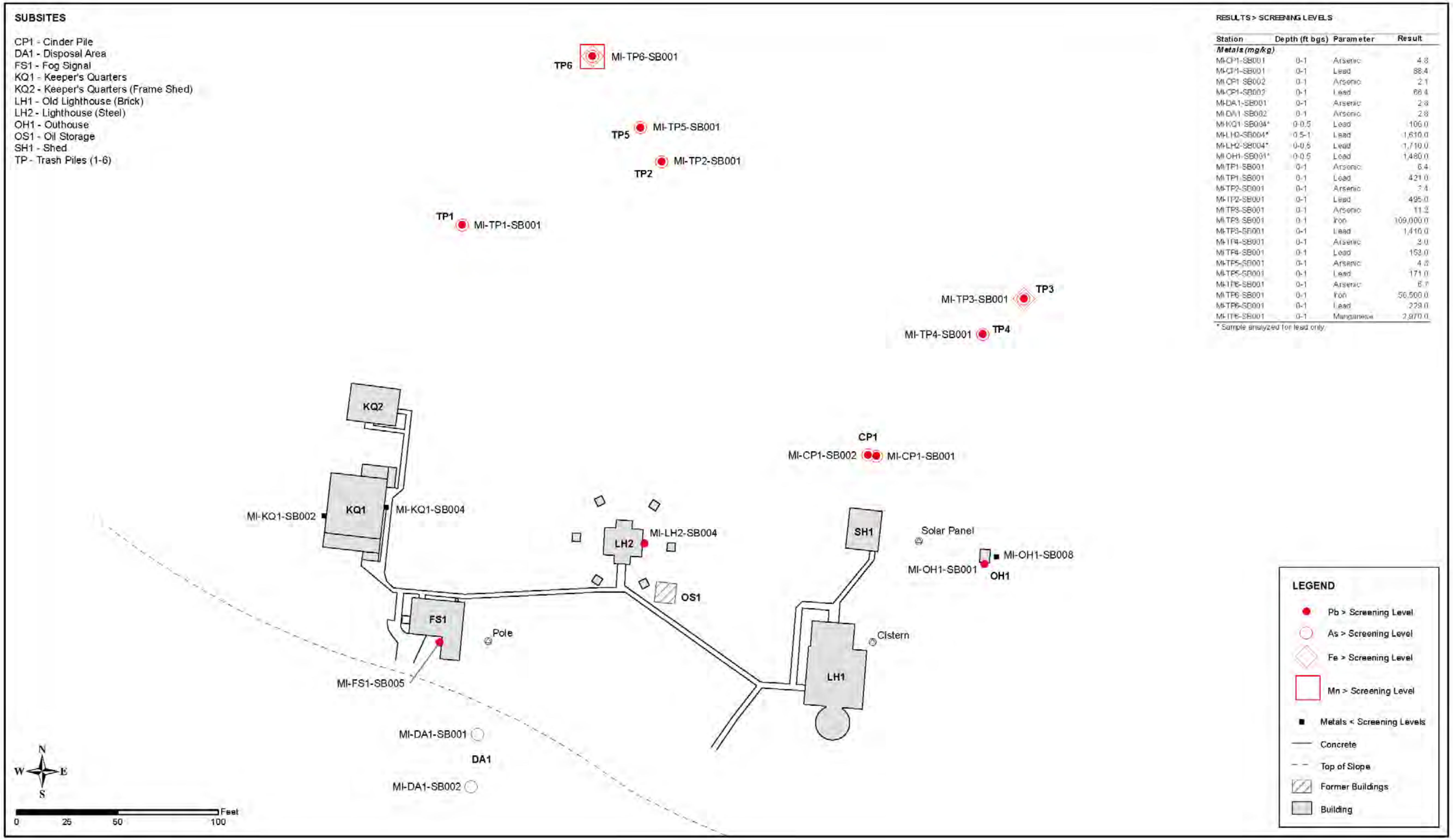


RESULTS > SCREENING LEVELS

Station	Depth (ft bgs)	Parameter	Result
Semivolatile Organic Compounds (μg/kg)			
MI-CP1-SB002	0-1	Benzo(a)pyrene	93.0 J
MI-TP2-SB001	0-1	Benzo(a)anthracene	450.0
MI-TP2-SB001	0-1	Benzo(a)pyrene	460.0
MI-TP2-SB001	0-1	Benzo(b)fluoranthene	690.0
MI-TP2-SB001	0-1	Dibenz(a,h)anthracene	85.0 J
MI-TP2-SB001	0-1	Indeno(1,2,3-cd)pyrene	300.0 J
MI-TP3-SB001	0-1	Benzo(a)pyrene	69.0 J
Total Petroleum Hydrocarbons (μg/kg)			
MI-CP1-SB002	0-1	Petroleum Hydrocarbons	262,116.0
MI-DA1-SB001	0-1	Petroleum Hydrocarbons	534,134.0 J
MI-DA1-SB002	0-1	Petroleum Hydrocarbons	489,556.0
MI-TP1-SB001	0-1	Petroleum Hydrocarbons	147,392.0
MI-TP2-SB001	0-1	Petroleum Hydrocarbons	254,270.0
MI-TP3-SB001	0-1	Petroleum Hydrocarbons	635,077.0
MI-TP4-SB001	0-1	Petroleum Hydrocarbons	524,545.0
MI-TP5-SB001	0-1	Petroleum Hydrocarbons	255,592.0
MI-TP6-SB001	0-1	Petroleum Hydrocarbons	257,822.0

Organic analytical suite includes VOCs, SVOCs, TPH, and PCBs.

Figure 4-2. Michigan Island Organic Analytical Results

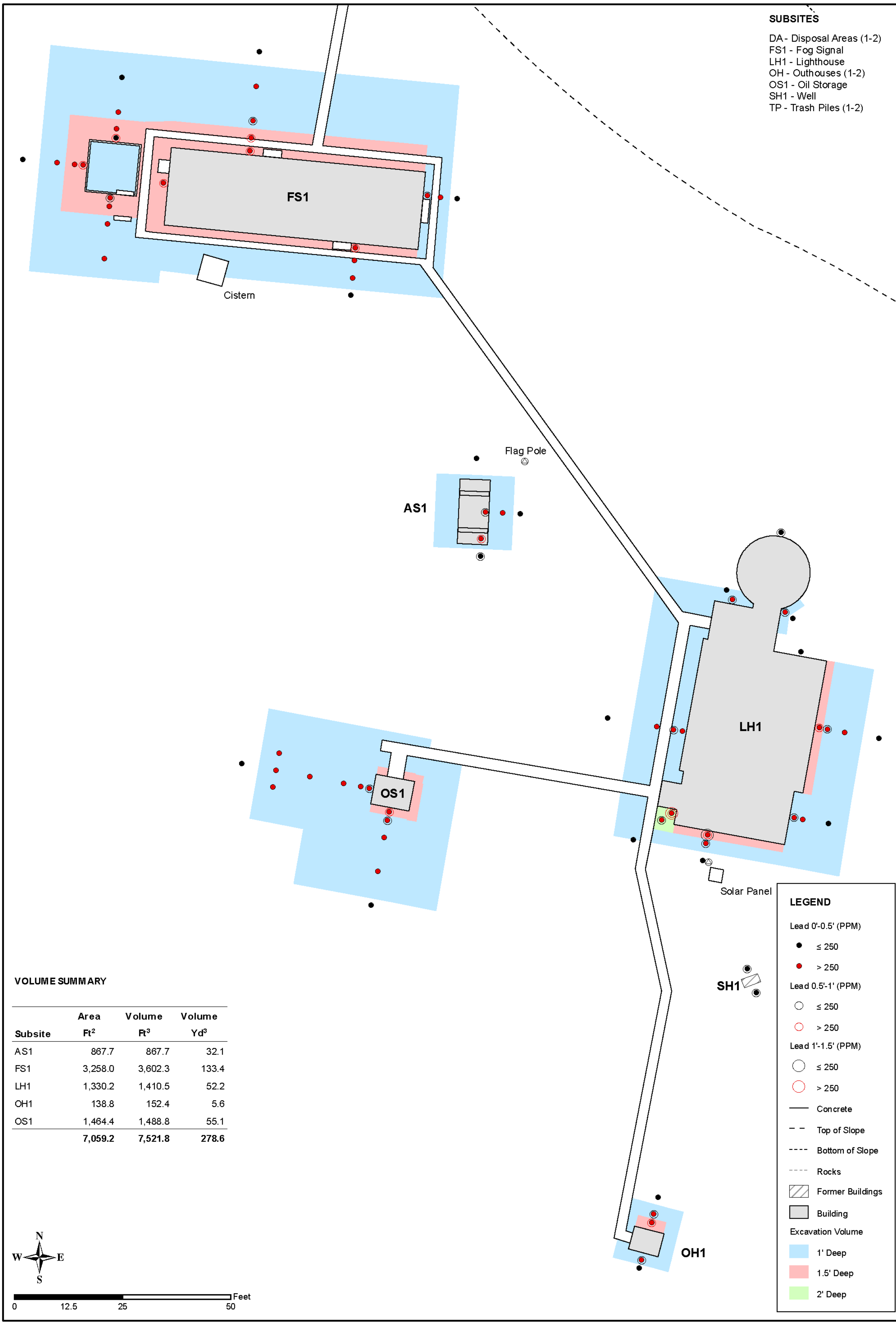


RESULTS > SCREENING LEVELS

Station	Depth (ft bgs)	Parameter	Result
Metals (mg/kg)			
MI-CP1-SB001	0-1	Arsenic	4.8
MI-CP1-SB001	0-1	Lead	88.4
MI-CP1-SB002	0-1	Arsenic	2.1
MI-CP1-SB002	0-1	Lead	66.4
MI-DA1-SB001	0-1	Arsenic	2.8
MI-DA1-SB002	0-1	Arsenic	2.8
MI-KQ1-SB004*	0-0.5	Lead	106.0
MI-LH2-SB004*	0.5-1	Lead	1,610.0
MI-LH2-SB004*	0-0.5	Lead	1,710.0
MI-OH1-SB001*	0-0.5	Lead	1,480.0
MI-TP1-SB001	0-1	Arsenic	6.4
MI-TP1-SB001	0-1	Lead	421.0
MI-TP2-SB001	0-1	Arsenic	7.4
MI-TP2-SB001	0-1	Lead	495.0
MI-TP3-SB001	0-1	Arsenic	11.2
MI-TP3-SB001	0-1	Iron	109,000.0
MI-TP3-SB001	0-1	Lead	1,410.0
MI-TP4-SB001	0-1	Arsenic	3.0
MI-TP4-SB001	0-1	Lead	153.0
MI-TP5-SB001	0-1	Arsenic	4.8
MI-TP5-SB001	0-1	Lead	171.0
MI-TP6-SB001	0-1	Arsenic	6.7
MI-TP6-SB001	0-1	Iron	56,500.0
MI-TP6-SB001	0-1	Lead	229.0
MI-TP6-SB001	0-1	Manganese	2,970.0

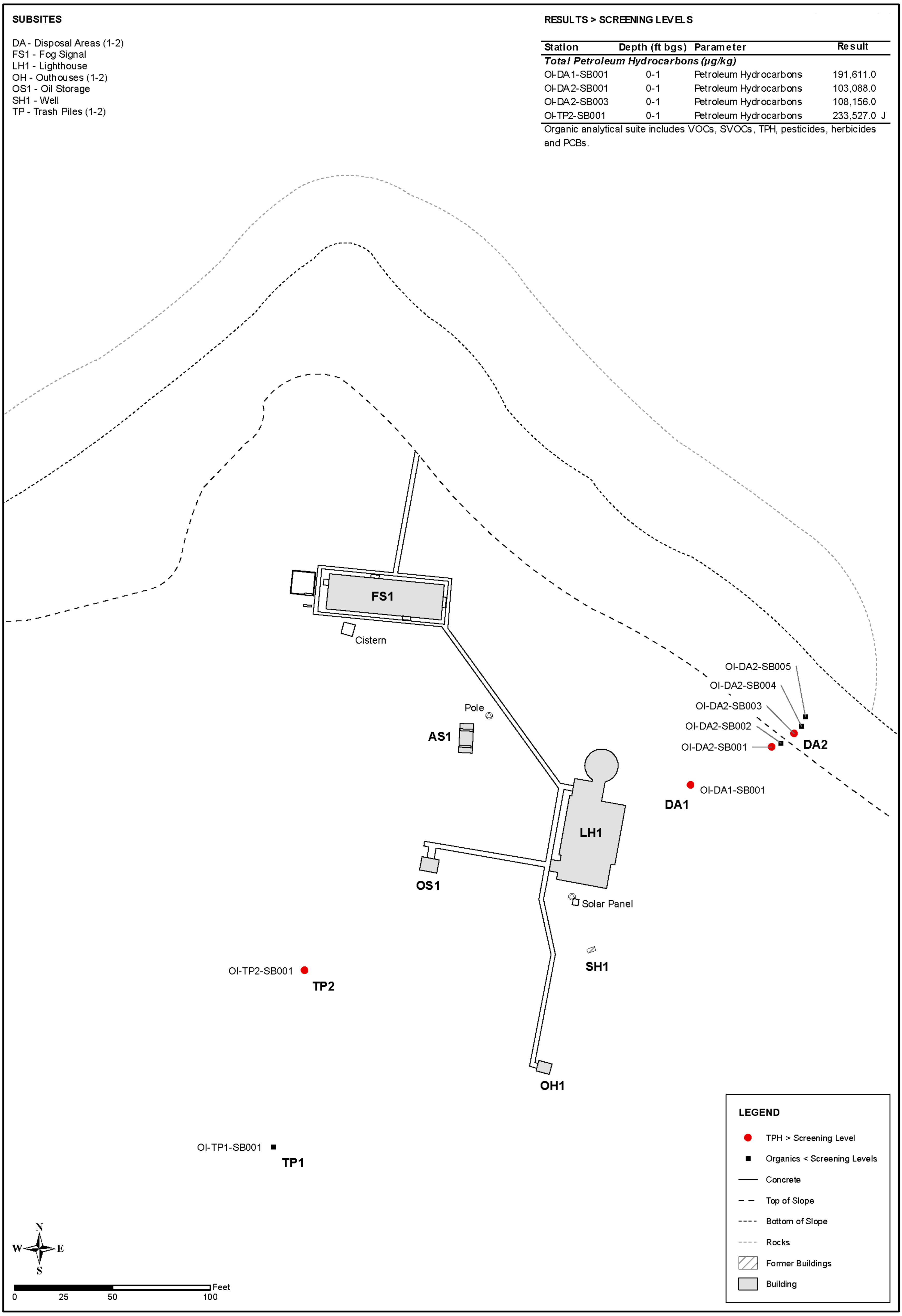
* Sample analyzed for lead only

Figure 4-3. Michigan Island Metal Analytical Results



Subsite	Area Ft²	Volume Ft³	Volume Yd³
AS1	867.7	867.7	32.1
FS1	3,258.0	3,602.3	133.4
LH1	1,330.2	1,410.5	52.2
OH1	138.8	152.4	5.6
OS1	1,464.4	1,488.8	55.1
	7,059.2	**7,521.8**	**278.6**

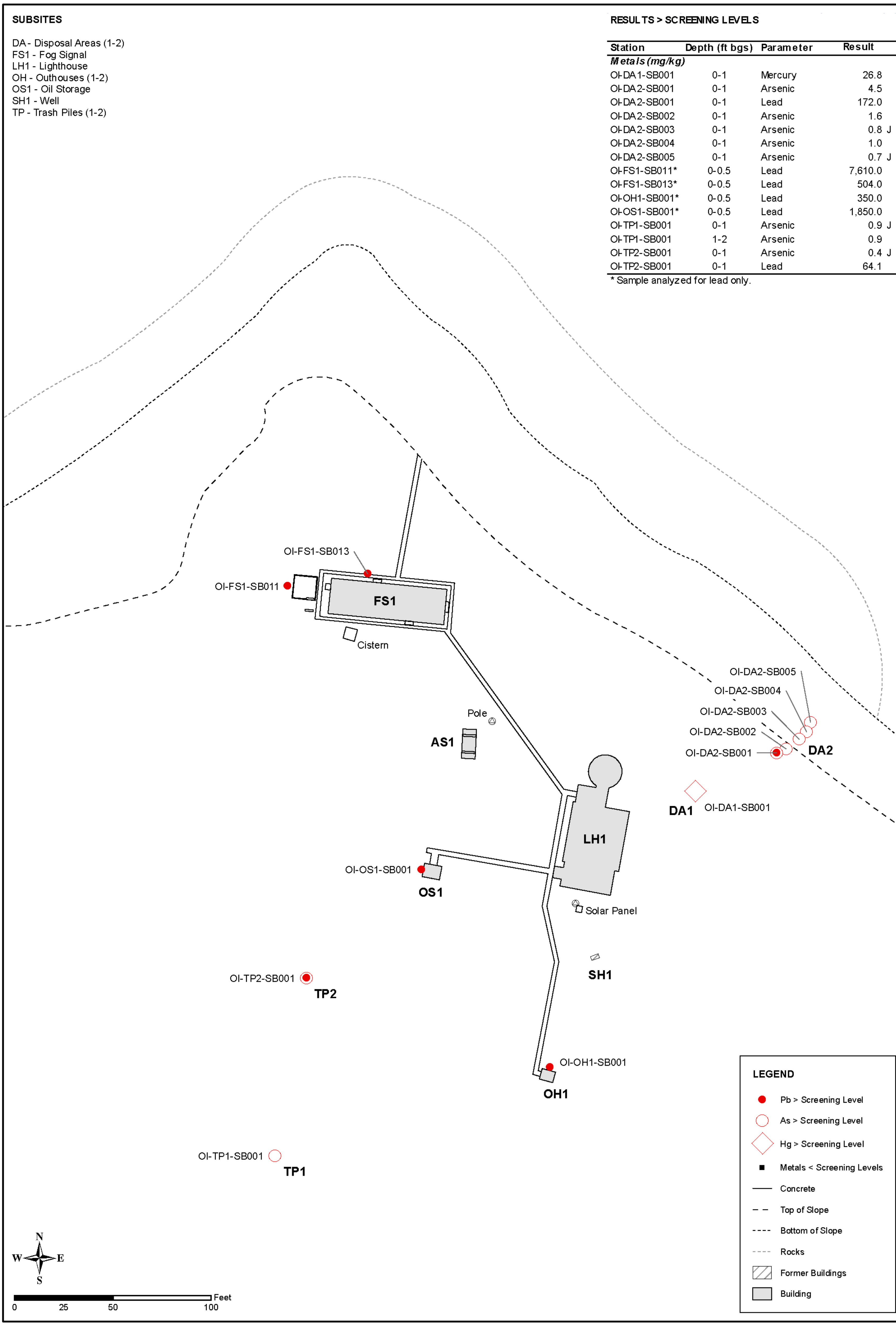
Figure 4-4. Outer Island XRF Results and Excavation Volumes



Station	Depth (ft bgs)	Parameter	Result
Total Petroleum Hydrocarbons (µg/kg)			
OI-DA1-SB001	0-1	Petroleum Hydrocarbons	191,611.0
OI-DA2-SB001	0-1	Petroleum Hydrocarbons	103,088.0
OI-DA2-SB003	0-1	Petroleum Hydrocarbons	108,156.0
OI-TP2-SB001	0-1	Petroleum Hydrocarbons	233,527.0 J

Organic analytical suite includes VOCs, SVOCs, TPH, pesticides, herbicides and PCBs.

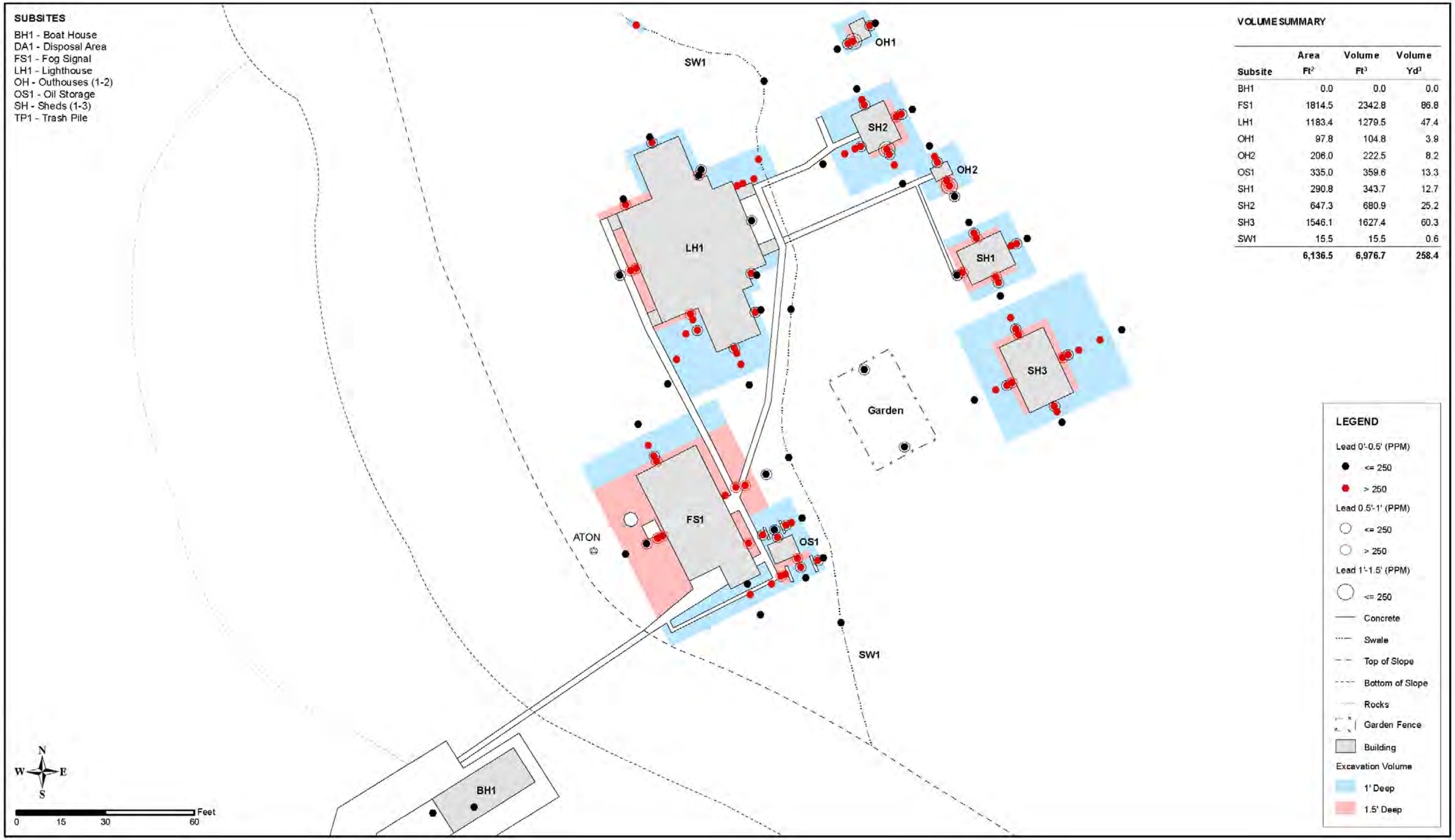
Figure 4-5. Outer Island Organic Analytical Results



Station	Depth (ft bgs)	Parameter	Result
Metals (mg/kg)			
OI-DA1-SB001	0-1	Mercury	26.8
OI-DA2-SB001	0-1	Arsenic	4.5
OI-DA2-SB001	0-1	Lead	172.0
OI-DA2-SB002	0-1	Arsenic	1.6
OI-DA2-SB003	0-1	Arsenic	0.8 J
OI-DA2-SB004	0-1	Arsenic	1.0
OI-DA2-SB005	0-1	Arsenic	0.7 J
OI-FS1-SB011*	0-0.5	Lead	7,610.0
OI-FS1-SB013*	0-0.5	Lead	504.0
OI-OH1-SB001*	0-0.5	Lead	350.0
OI-OS1-SB001*	0-0.5	Lead	1,850.0
OI-TP1-SB001	0-1	Arsenic	0.9 J
OI-TP1-SB001	1-2	Arsenic	0.9
OI-TP2-SB001	0-1	Arsenic	0.4 J
OI-TP2-SB001	0-1	Lead	64.1

* Sample analyzed for lead only.

Figure 4-6. Outer Island Metal Analytical Results



VOLUME SUMMARY

Subsite	Area Ft^2	Volume Ft^3	Volume Yd^3
BH1	0.0	0.0	0.0
FS1	1814.5	2342.8	86.8
LH1	1183.4	1279.5	47.4
OH1	97.8	104.8	3.9
OH2	206.0	222.5	8.2
OS1	335.0	359.6	13.3
SH1	290.8	343.7	12.7
SH2	647.3	680.9	25.2
SH3	1546.1	1627.4	60.3
SW1	15.5	15.5	0.6
	6,136.5	**6,976.7**	**258.4**

Figure 4-7. Raspberry Island XRF Results and Excavation Volumes

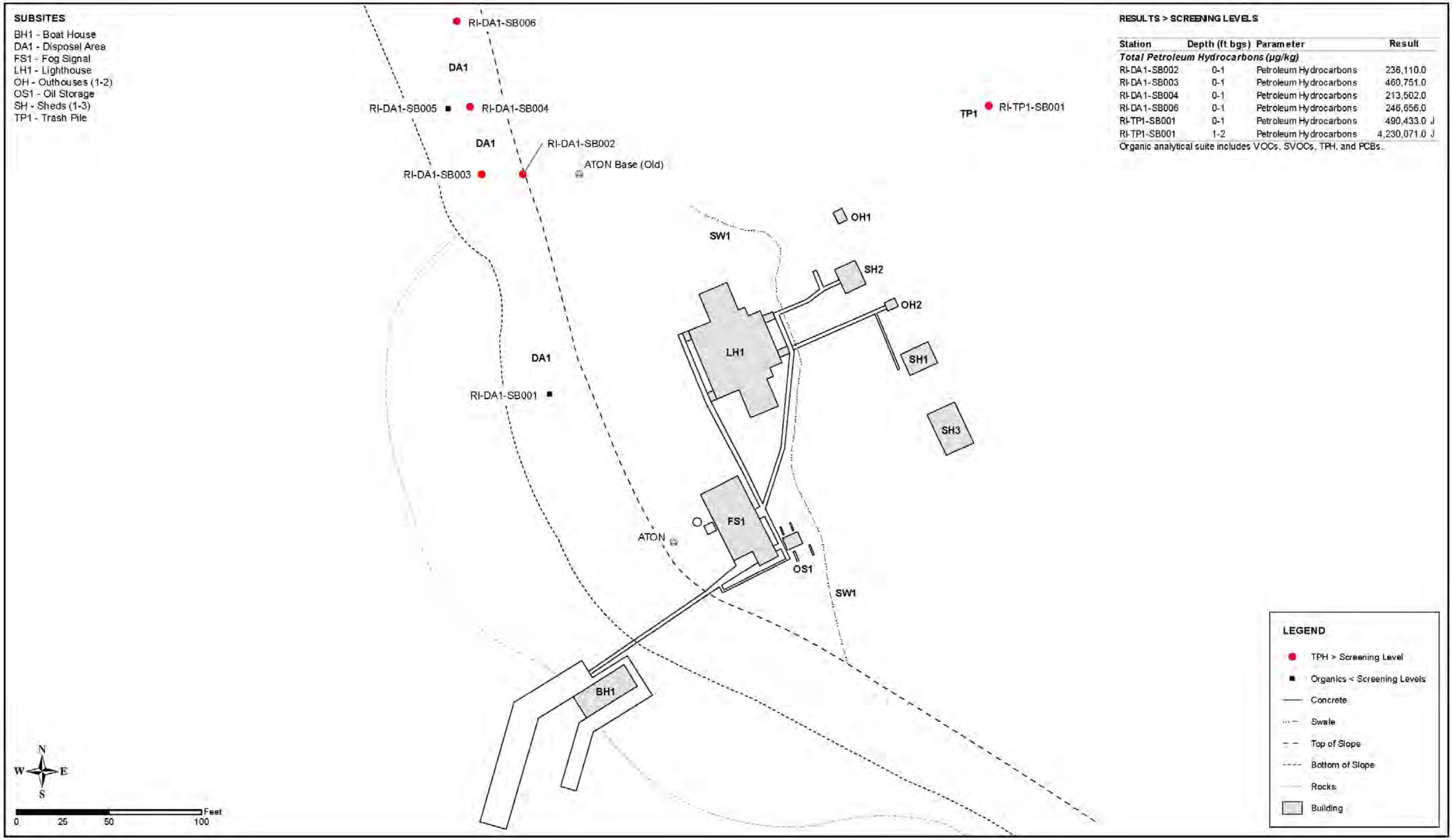
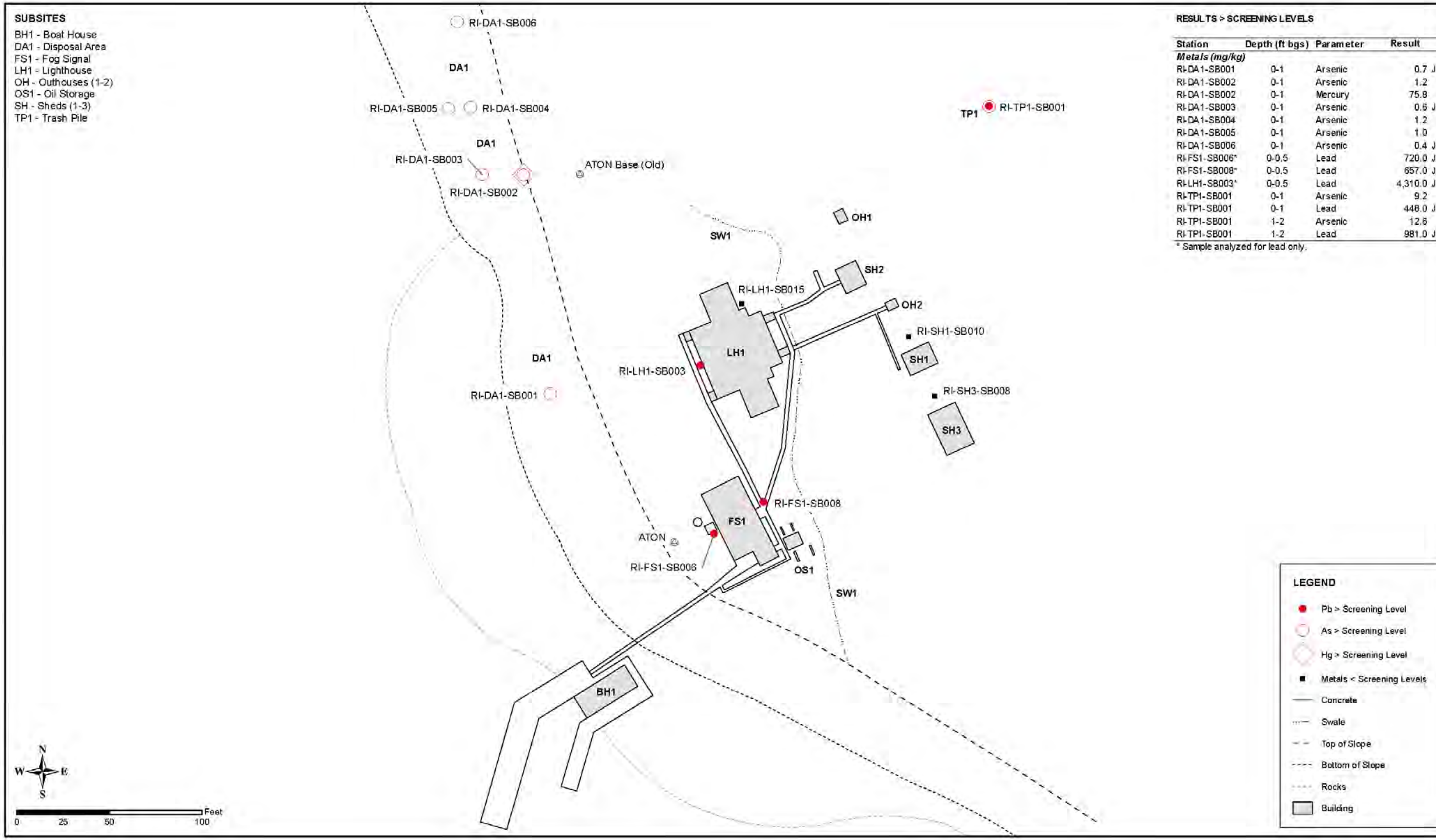


Figure 4-8. Raspberry Island Organic Analytical Results

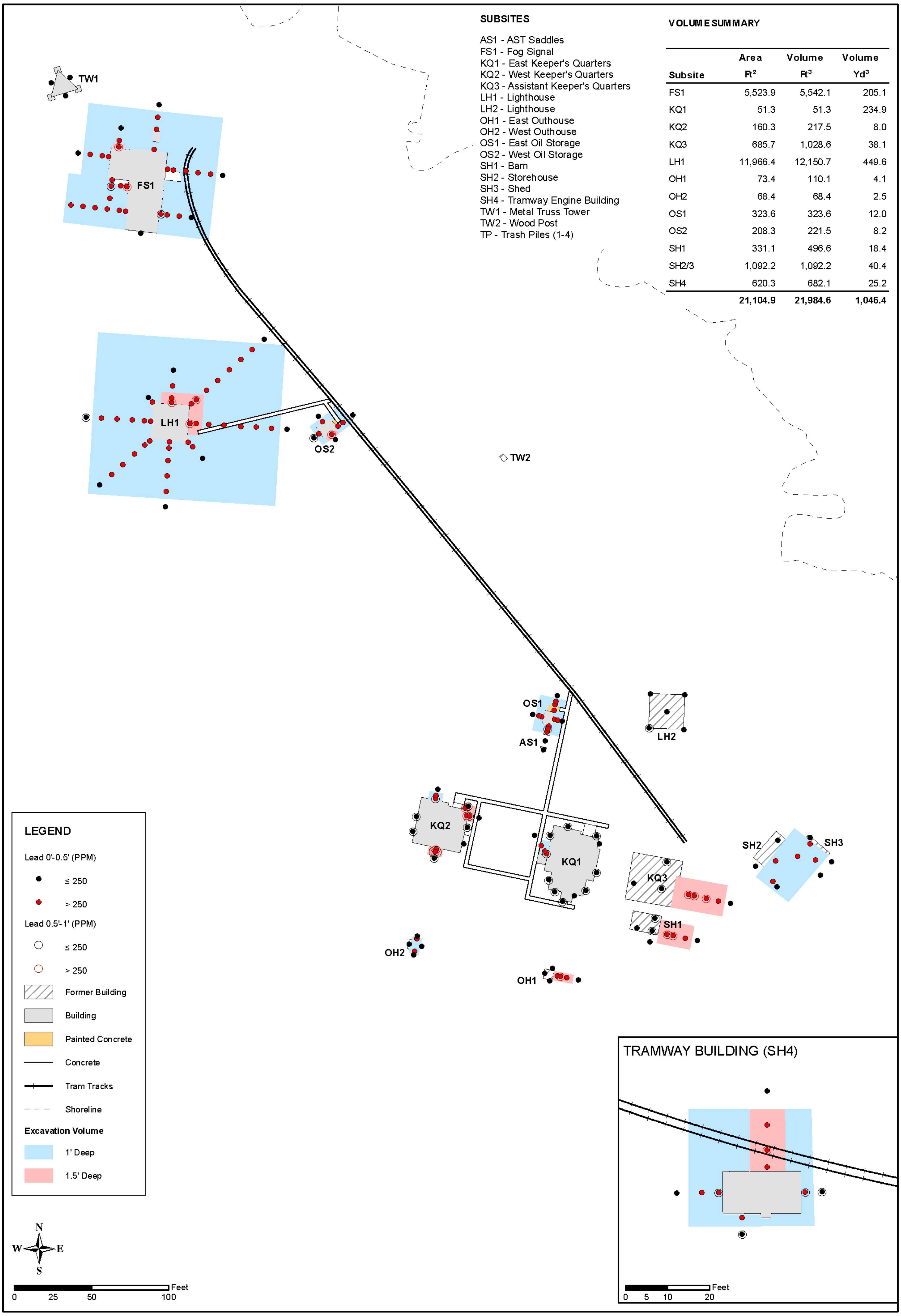


RESULTS > SCREENING LEVELS

Station	Depth (ft bgs)	Parameter	Result
Metals (mg/kg)			
RI-DA1-SB001	0-1	Arsenic	0.7 J
RI-DA1-SB002	0-1	Arsenic	1.2
RI-DA1-SB002	0-1	Mercury	75.8
RI-DA1-SB003	0-1	Arsenic	0.6 J
RI-DA1-SB004	0-1	Arsenic	1.2
RI-DA1-SB005	0-1	Arsenic	1.0
RI-DA1-SB006	0-1	Arsenic	0.4 J
RI-FS1-SB006*	0-0.5	Lead	720.0 J
RI-FS1-SB008*	0-0.5	Lead	657.0 J
RI-LH1-SB003*	0-0.5	Lead	4,310.0 J
RI-TP1-SB001	0-1	Arsenic	9.2
RI-TP1-SB001	0-1	Lead	448.0 J
RI-TP1-SB001	1-2	Arsenic	12.6
RI-TP1-SB001	1-2	Lead	981.0 J

* Sample analyzed for lead only.

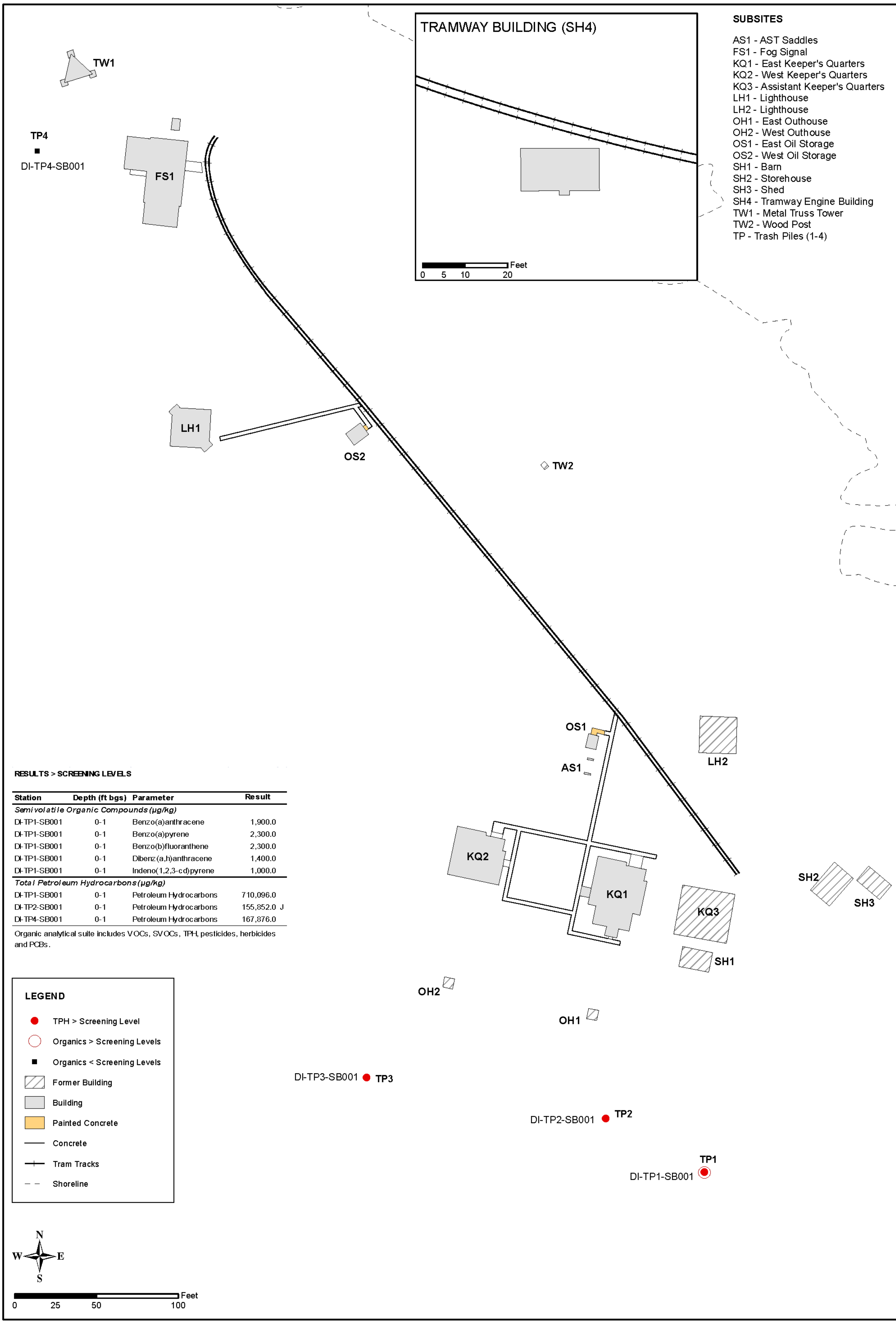
Figure 4-9. Raspberry Island Metal Analytical Results



VOLUME SUMMARY

Subsite	Area Ft²	Volume Ft³	Volume Yd³
FS1	5,523.9	5,542.1	205.1
KQ1	51.3	51.3	234.9
KQ2	160.3	217.5	8.0
KQ3	685.7	1,028.6	38.1
LH1	11,966.4	12,150.7	449.6
OH1	73.4	110.1	4.1
OH2	68.4	68.4	2.5
OS1	323.6	323.6	12.0
OS2	208.3	221.5	8.2
SH1	331.1	496.6	18.4
SH2/3	1,092.2	1,092.2	40.4
SH4	620.3	682.1	25.2
	21,104.9	**21,984.6**	**1,046.4**

Figure 4-10. Devil's Island XRF Results and Excavation Volumes

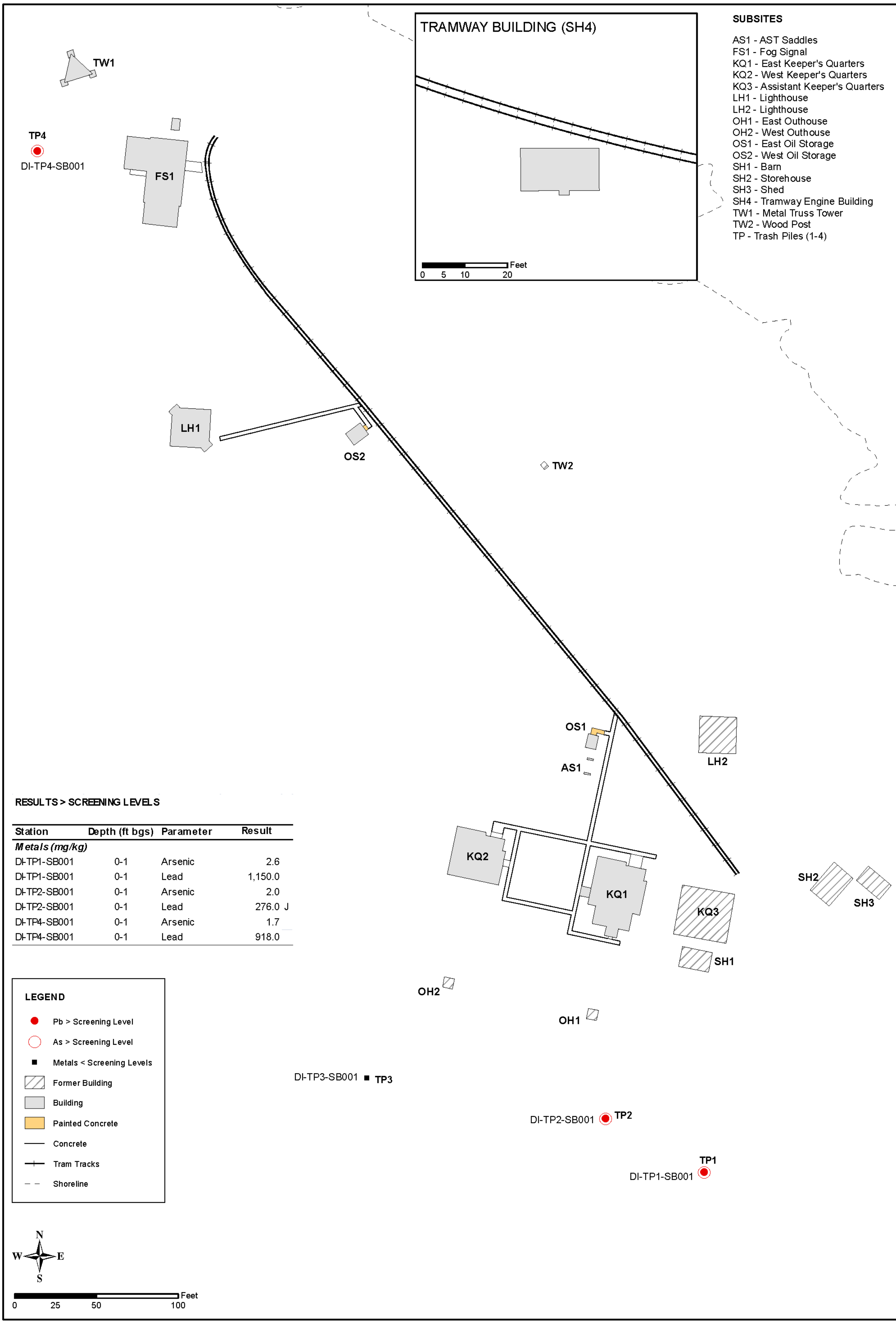


RESULTS > SCREENING LEVELS

Station	Depth (ft bgs)	Parameter	Result
Semivolatile Organic Compounds (µg/kg)			
DI-TP1-SB001	0-1	Benzo(a)anthracene	1,900.0
DI-TP1-SB001	0-1	Benzo(a)pyrene	2,300.0
DI-TP1-SB001	0-1	Benzo(b)fluoranthene	2,300.0
DI-TP1-SB001	0-1	Dibenz(a,h)anthracene	1,400.0
DI-TP1-SB001	0-1	Indeno(1,2,3-cd)pyrene	1,000.0
Total Petroleum Hydrocarbons (µg/kg)			
DI-TP1-SB001	0-1	Petroleum Hydrocarbons	710,096.0
DI-TP2-SB001	0-1	Petroleum Hydrocarbons	155,852.0 J
DI-TP4-SB001	0-1	Petroleum Hydrocarbons	167,876.0

Organic analytical suite includes VOCs, SVOCs, TPH, pesticides, herbicides and PCBs.

Figure 4-11. Devil's Island Organic Analytical Results



RESULTS > SCREENING LEVELS

Station	Depth (ft bgs)	Parameter	Result
Metals (mg/kg)			
DI-TP1-SB001	0-1	Arsenic	2.6
DI-TP1-SB001	0-1	Lead	1,150.0
DI-TP2-SB001	0-1	Arsenic	2.0
DI-TP2-SB001	0-1	Lead	276.0 J
DI-TP4-SB001	0-1	Arsenic	1.7
DI-TP4-SB001	0-1	Lead	918.0

Figure 4-12. Devil's Island Metal Analytical Results

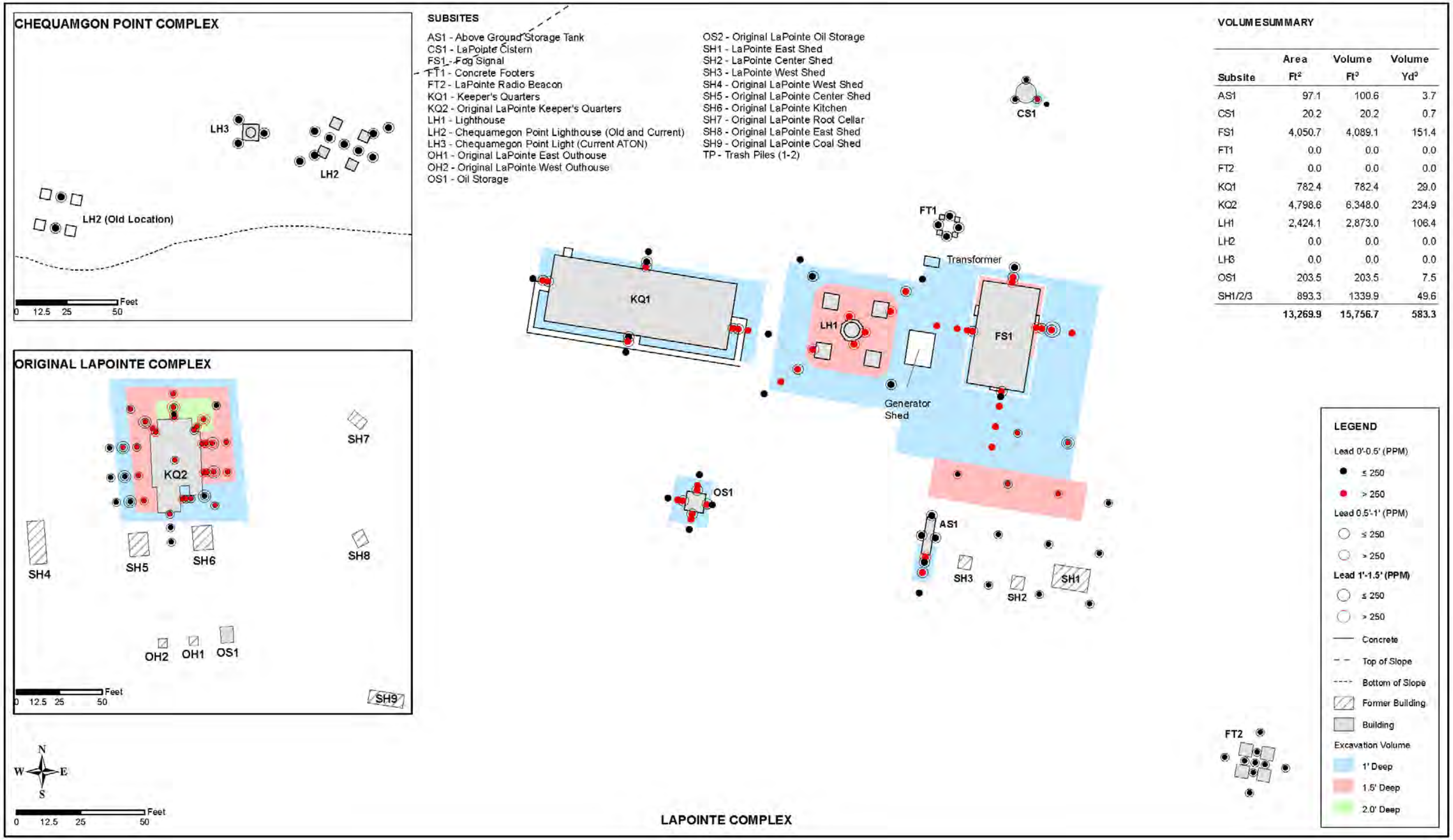
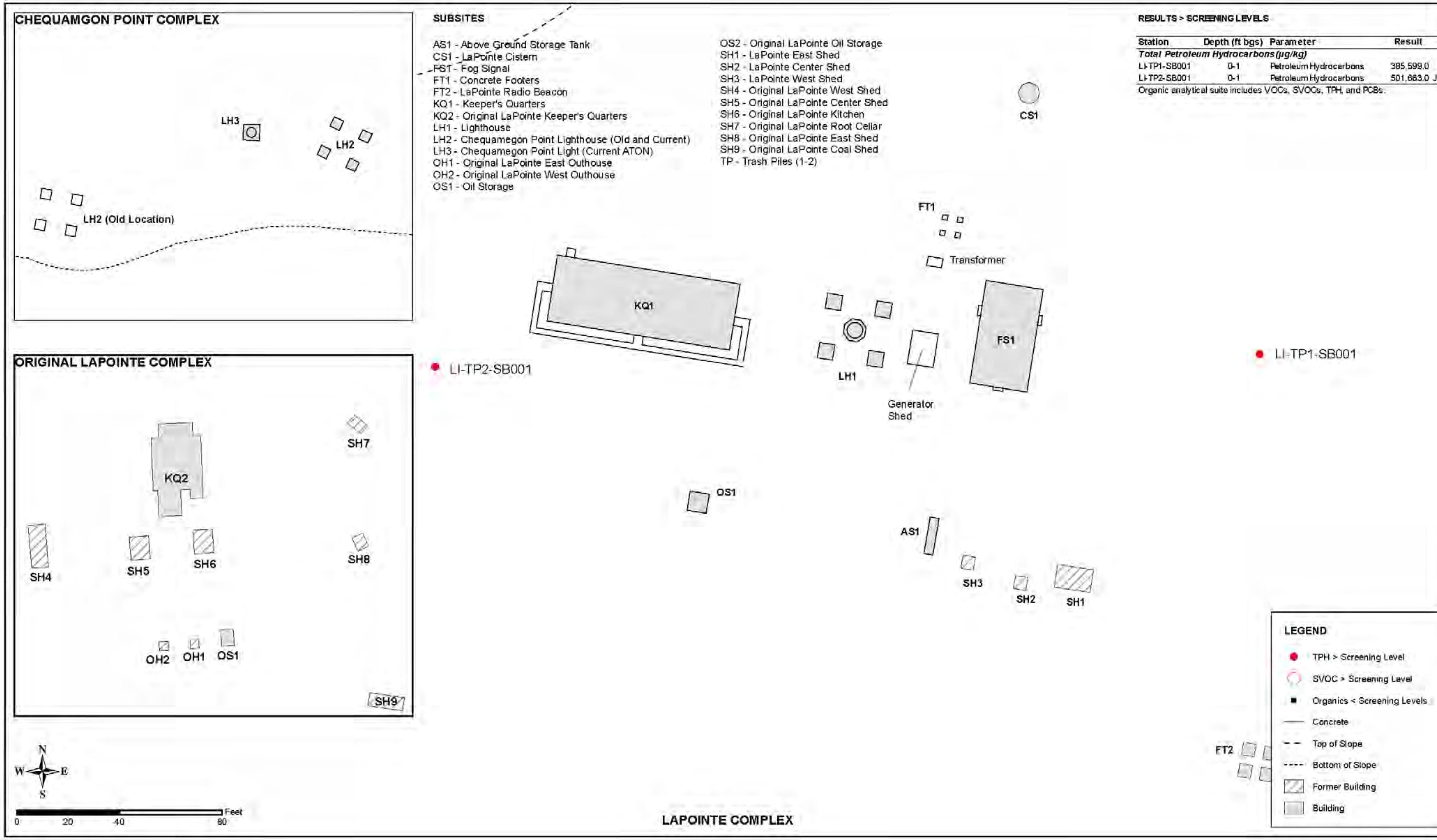


Figure 4-13. Long Island XRF Results and Excavation Volumes



Station	Depth (ft bgs)	Parameter	Result
Total Petroleum Hydrocarbons (µg/kg)			
LI-TP1-SB001	0-1	Petroleum Hydrocarbons	385,599.0
LI-TP2-SB001	0-1	Petroleum Hydrocarbons	501,663.0 J

Organic analytical suite includes VOCs, SVOCs, TPH, and PCBs.

Figure 4-14. Long Island Organic Analytical Results

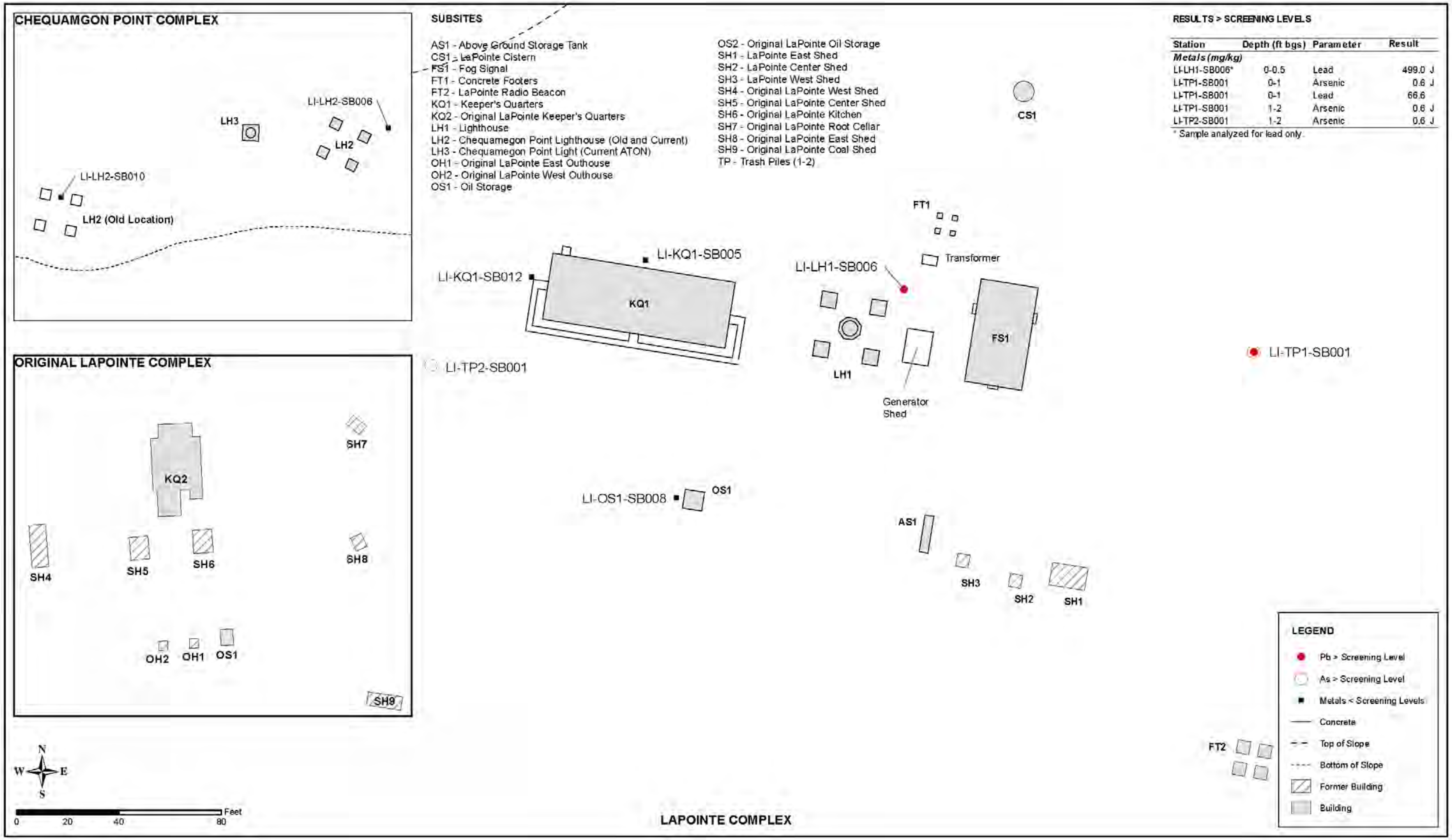


Figure 4-15. Long Island Metal Analytical Results

APPENDIX B

ProUCL INPUT AND OUTPUT

Station	Group1	Group2	Long Island Lead (mg/kg)	Lab or XRF?
LI-AS1-SB001	Above Ground Storage Tank	surface	160	XRF
LI-AS1-SB001	Above Ground Storage Tank	subsurface	107	XRF
LI-AS1-SB002	Above Ground Storage Tank	surface	99	XRF
LI-AS1-SB003	Above Ground Storage Tank	surface	**261**	XRF
LI-AS1-SB003	Above Ground Storage Tank	subsurface	**413**	XRF
LI-AS1-SB004	Above Ground Storage Tank	surface	141	XRF
LI-AS1-SB004	Above Ground Storage Tank	subsurface	20	XRF
LI-AS1-SB005	Above Ground Storage Tank	surface	105	XRF
LI-AS1-SB005	Above Ground Storage Tank	subsurface	42	XRF
LI-AS1-SB006	Above Ground Storage Tank	surface	**936**	XRF
LI-AS1-SB006	Above Ground Storage Tank	subsurface	94	XRF
LI-AS1-SB007	Above Ground Storage Tank	surface	156	XRF
LI-CS1-SB001	LaPointe Cistern	surface	32.7	XRF
LI-CS1-SB001	LaPointe Cistern	subsurface	46.1	XRF
LI-CS1-SB002	LaPointe Cistern	surface	**282**	XRF
LI-CS1-SB002	LaPointe Cistern	subsurface	170	XRF
LI-CS1-SB003	LaPointe Cistern	surface	136	XRF
LI-CS1-SB003	LaPointe Cistern	subsurface	115.2	XRF
LI-CS1-SB004	LaPointe Cistern	surface	32.2	XRF
LI-FS1-SB001	Fog Signal Building	surface	**2,275**	XRF
LI-FS1-SB001	Fog Signal Building	subsurface	**1,492**	XRF
LI-FS1-SB002	Fog Signal Building	surface	**8,662**	XRF
LI-FS1-SB002	Fog Signal Building	subsurface	**456**	XRF
LI-FS1-SB003	Fog Signal Building	surface	**825**	XRF
LI-FS1-SB003	Fog Signal Building	subsurface	118	XRF
LI-FS1-SB004	Fog Signal Building	surface	**615**	XRF
LI-FS1-SB004	Fog Signal Building	subsurface	102	XRF
LI-FS1-SB005	Fog Signal Building	surface	**368**	XRF
LI-FS1-SB005	Fog Signal Building	subsurface	14	XRF
LI-FS1-SB006	Fog Signal Building	surface	146	XRF
LI-FS1-SB006	Fog Signal Building	subsurface	41	XRF
LI-FS1-SB007	Fog Signal Building	surface	**839**	XRF
LI-FS1-SB007	Fog Signal Building	subsurface	111	XRF
LI-FS1-SB008	Fog Signal Building	surface	**629**	XRF
LI-FS1-SB008	Fog Signal Building	subsurface	41	XRF
LI-FS1-SB009	Fog Signal Building	surface	196	XRF
LI-FS1-SB010	Fog Signal Building	surface	**330**	XRF
LI-FS1-SB011	Fog Signal Building	surface	**815**	XRF
LI-FS1-SB012	Fog Signal Building	surface	**420**	XRF
LI-FS1-SB013	Fog Signal Building	surface	**253**	XRF
LI-FS1-SB014	Fog Signal Building	surface	**705**	XRF
LI-FS1-SB015	Fog Signal Building	surface	**325**	XRF
LI-FS1-SB016	Fog Signal Building	surface	**262**	XRF
LI-FT1-SB001	Former Radio Tower Footers	surface	65	XRF
LI-FT1-SB001	Former Radio Tower Footers	subsurface	25	XRF
LI-FT1-SB002	Former Radio Tower Footers	surface	117	XRF
LI-FT1-SB002	Former Radio Tower Footers	subsurface	26	XRF
LI-FT1-SB003	Former Radio Tower Footers	surface	171	XRF
LI-FT1-SB003	Former Radio Tower Footers	subsurface	21	XRF
LI-FT1-SB004	Former Radio Tower Footers	surface	72	XRF

Station	Group1	Group2	Long Island Lead (mg/kg)	Lab or XRF?
LI-FT1-SB004	Former Radio Tower Footers	subsurface	15	XRF
LI-KQ1-SB001	Keeper's Quarters	surface	**414**	XRF
LI-KQ1-SB002	Keeper's Quarters	surface	**679**	XRF
LI-KQ1-SB002	Keeper's Quarters	subsurface	83	XRF
LI-KQ1-SB003	Keeper's Quarters	surface	144	XRF
LI-KQ1-SB003	Keeper's Quarters	subsurface	19	XRF
LI-KQ1-SB004	Keeper's Quarters	surface	**295**	XRF
LI-KQ1-SB005	Keeper's Quarters	surface	141	XRF
LI-KQ1-SB006	Keeper's Quarters	surface	**1,021**	XRF
LI-KQ1-SB006	Keeper's Quarters	subsurface	245	XRF
LI-KQ1-SB007	Keeper's Quarters	surface	**291**	XRF
LI-KQ1-SB007	Keeper's Quarters	subsurface	13	XRF
LI-KQ1-SB008	Keeper's Quarters	surface	**478**	XRF
LI-KQ1-SB008	Keeper's Quarters	subsurface	22	XRF
LI-KQ1-SB009	Keeper's Quarters	surface	46	XRF
LI-KQ1-SB010	Keeper's Quarters	surface	**382**	XRF
LI-KQ1-SB011	Keeper's Quarters	surface	242	XRF
LI-KQ1-SB012	Keeper's Quarters	surface	56	XRF
LI-KQ1-SB013	Keeper's Quarters	surface	199	XRF
LI-LH1-SB001	LaPointe Lighthouse	surface	**3,733**	XRF
LI-LH1-SB001	LaPointe Lighthouse	subsurface	**636**	XRF
LI-LH1-SB002	LaPointe Lighthouse	surface	**3,271**	XRF
LI-LH1-SB002	LaPointe Lighthouse	subsurface	**3,359**	XRF
LI-LH1-SB003	LaPointe Lighthouse	surface	**2,198**	XRF
LI-LH1-SB003	LaPointe Lighthouse	subsurface	**2,573**	XRF
LI-LH1-SB004	LaPointe Lighthouse	surface	**811**	XRF
LI-LH1-SB004	LaPointe Lighthouse	subsurface	**585**	XRF
LI-LH1-SB005	LaPointe Lighthouse	surface	**3,030**	XRF
LI-LH1-SB005	LaPointe Lighthouse	subsurface	**1,213**	XRF
LI-LH1-SB006*	LaPointe Lighthouse	surface	**499**	Lab
LI-LH1-SB006	LaPointe Lighthouse	subsurface	111	XRF
LI-LH1-SB007	LaPointe Lighthouse	surface	156	XRF
LI-LH1-SB007	LaPointe Lighthouse	subsurface	17	XRF
LI-LH1-SB008	LaPointe Lighthouse	surface	**417**	XRF
LI-LH1-SB008	LaPointe Lighthouse	subsurface	16	XRF
LI-LH1-SB009	LaPointe Lighthouse	surface	236	XRF
LI-LH1-SB010	LaPointe Lighthouse	surface	233	XRF
LI-LH1-SB011	LaPointe Lighthouse	surface	126	XRF
LI-LH1-SB012	LaPointe Lighthouse	surface	**384**	XRF
LI-LH1-SB013	LaPointe Lighthouse	surface	211	XRF
LI-OS1-SB001	Oil Storage Shed	surface	**688**	XRF
LI-OS1-SB001	Oil Storage Shed	subsurface	95	XRF
LI-OS1-SB002	Oil Storage Shed	surface	**487**	XRF
LI-OS1-SB002	Oil Storage Shed	subsurface	74	XRF
LI-OS1-SB003	Oil Storage Shed	surface	**1,686**	XRF
LI-OS1-SB003	Oil Storage Shed	subsurface	103	XRF
LI-OS1-SB004	Oil Storage Shed	surface	**715**	XRF
LI-OS1-SB004	Oil Storage Shed	subsurface	48	XRF
LI-OS1-SB005	Oil Storage Shed	surface	**262**	XRF
LI-OS1-SB006	Oil Storage Shed	surface	166	XRF

Station	Group1	Group2	Long Island Lead (mg/kg)	Lab or XRF?
LI-OS1-SB007	Oil Storage Shed	surface	**392**	XRF
LI-OS1-SB008*	Oil Storage Shed	surface	**322**	XRF
LI-OS1-SB009	Oil Storage Shed	surface	143	XRF
LI-OS1-SB010	Oil Storage Shed	surface	125	XRF
LI-OS1-SB011	Oil Storage Shed	surface	54	XRF
LI-SH1-SB001	LaPointe East Shed	surface	106.4	XRF
LI-SH1-SB001	LaPointe East Shed	subsurface	97.2	XRF
LI-SH1-SB002	LaPointe East Shed	surface	**272**	XRF
LI-SH1-SB002	LaPointe East Shed	subsurface	**572**	XRF
LI-SH1-SB003	LaPointe East Shed	surface	**253**	XRF
LI-SH1-SB003	LaPointe East Shed	subsurface	98.5	XRF
LI-SH1-SB004	LaPointe East Shed	surface	78.7	XRF
LI-SH1-SB004	LaPointe East Shed	subsurface	48.4	XRF
LI-SH1-SB005	LaPointe East Shed	surface	27.7	XRF
LI-SH1-SB005	LaPointe East Shed	subsurface	20.7	XRF
LI-SH1-SB006	LaPointe East Shed	surface	17.5	XRF
LI-SH1-SB006	LaPointe East Shed	subsurface	19.9	XRF
LI-SH1-SB007	LaPointe East Shed	surface	135	XRF
LI-SH1-SB007	LaPointe East Shed	subsurface	68.1	XRF
LI-SH1-SB008	LaPointe East Shed	surface	58.2	XRF
LI-SH1-SB008	LaPointe East Shed	subsurface	10.1	XRF
LI-SH1-SB009	LaPointe East Shed	surface	103.7	XRF
LI-SH1-SB009	LaPointe East Shed	subsurface	6.9	XRF
LI-SH1-SB010	LaPointe East Shed	surface	**596**	XRF
LI-SH1-SB010	LaPointe East Shed	subsurface	101.4	XRF
LI-SH1-SB011	LaPointe East Shed	surface	**288**	XRF
LI-SH1-SB011	LaPointe East Shed	subsurface	223	XRF
LI-SH1-SB011	LaPointe East Shed	subsurface	163	XRF
LI-SH1-SB012	LaPointe East Shed	surface	64.6	XRF
LI-SH1-SB012	LaPointe East Shed	subsurface	**265**	XRF
LI-KQ2-SB001	Original LaPointe Keeper's Quarters	surface	**1,629**	XRF
LI-KQ2-SB001	Original LaPointe Keeper's Quarters	subsurface	**1,045**	XRF
LI-KQ2-SB002	Original LaPointe Keeper's Quarters	surface	**1,455**	XRF
LI-KQ2-SB002	Original LaPointe Keeper's Quarters	subsurface	**436**	XRF
LI-KQ2-SB003	Original LaPointe Keeper's Quarters	surface	**266**	XRF
LI-KQ2-SB003	Original LaPointe Keeper's Quarters	subsurface	156	XRF
LI-KQ2-SB004	Original LaPointe Keeper's Quarters	surface	**2,033**	XRF
LI-KQ2-SB004	Original LaPointe Keeper's Quarters	subsurface	**1,950**	XRF
LI-KQ2-SB005	Original LaPointe Keeper's Quarters	surface	**724**	XRF
LI-KQ2-SB005	Original LaPointe Keeper's Quarters	subsurface	**419**	XRF
LI-KQ2-SB007	Original LaPointe Keeper's Quarters	surface	**2,137**	XRF
LI-KQ2-SB007	Original LaPointe Keeper's Quarters	subsurface	**1,692**	XRF
LI-KQ2-SB008	Original LaPointe Keeper's Quarters	surface	**299**	XRF
LI-KQ2-SB008	Original LaPointe Keeper's Quarters	subsurface	73.4	XRF
LI-KQ2-SB009	Original LaPointe Keeper's Quarters	surface	**1,636**	XRF
LI-KQ2-SB009	Original LaPointe Keeper's Quarters	subsurface	**383**	XRF
LI-KQ2-SB010	Original LaPointe Keeper's Quarters	surface	**1,998**	XRF
LI-KQ2-SB010	Original LaPointe Keeper's Quarters	subsurface	**306**	XRF
LI-KQ2-SB011	Original LaPointe Keeper's Quarters	surface	**273**	XRF

Station	Group1	Group2	Long Island Lead (mg/kg)	Lab or XRF?
LI-KQ2-SB011	Original LaPointe Keeper's Quarters	subsurface	96.8	XRF
LI-KQ2-SB012	Original LaPointe Keeper's Quarters	surface	**427**	XRF
LI-KQ2-SB012	Original LaPointe Keeper's Quarters	subsurface	**813**	XRF
LI-KQ2-SB013	Original LaPointe Keeper's Quarters	surface	190	XRF
LI-KQ2-SB013	Original LaPointe Keeper's Quarters	subsurface	**1,049**	XRF
LI-KQ2-SB014	Original LaPointe Keeper's Quarters	surface	**1,222**	XRF
LI-KQ2-SB014	Original LaPointe Keeper's Quarters	subsurface	**629**	XRF
LI-KQ2-SB015	Original LaPointe Keeper's Quarters	surface	**4,432**	XRF
LI-KQ2-SB015	Original LaPointe Keeper's Quarters	subsurface	**987**	XRF
LI-KQ2-SB016	Original LaPointe Keeper's Quarters	surface	**1,141**	XRF
LI-KQ2-SB016	Original LaPointe Keeper's Quarters	subsurface	**630**	XRF
LI-KQ2-SB018	Original LaPointe Keeper's Quarters	surface	**587**	XRF
LI-KQ2-SB018	Original LaPointe Keeper's Quarters	subsurface	101.5	XRF
LI-KQ2-SB019	Original LaPointe Keeper's Quarters	surface	**1,049**	XRF
LI-KQ2-SB019	Original LaPointe Keeper's Quarters	subsurface	149	XRF
LI-KQ2-SB019	Original LaPointe Keeper's Quarters	subsurface	84.9	XRF
LI-KQ2-SB020	Original LaPointe Keeper's Quarters	surface	**263**	XRF
LI-KQ2-SB020	Original LaPointe Keeper's Quarters	subsurface	206	XRF
LI-KQ2-SB020	Original LaPointe Keeper's Quarters	subsurface	**532**	XRF
LI-KQ2-SB021	Original LaPointe Keeper's Quarters	surface	**1,080**	XRF
LI-KQ2-SB021	Original LaPointe Keeper's Quarters	subsurface	**291**	XRF
LI-KQ2-SB021	Original LaPointe Keeper's Quarters	subsurface	**556**	XRF
LI-KQ2-SB022	Original LaPointe Keeper's Quarters	surface	**347**	XRF
LI-KQ2-SB022	Original LaPointe Keeper's Quarters	subsurface	**624**	XRF
LI-KQ2-SB022	Original LaPointe Keeper's Quarters	subsurface	144	XRF
LI-KQ2-SB023	Original LaPointe Keeper's Quarters	surface	**479**	XRF
LI-KQ2-SB023	Original LaPointe Keeper's Quarters	subsurface	**286**	XRF
LI-KQ2-SB023	Original LaPointe Keeper's Quarters	subsurface	139.2	XRF
LI-KQ2-SB024	Original LaPointe Keeper's Quarters	surface	152	XRF
LI-KQ2-SB024	Original LaPointe Keeper's Quarters	subsurface	60.3	XRF
LI-KQ2-SB024	Original LaPointe Keeper's Quarters	subsurface	35.8	XRF
LI-KQ2-SB025	Original LaPointe Keeper's Quarters	surface	**2,057**	XRF
LI-KQ2-SB025	Original LaPointe Keeper's Quarters	subsurface	101.8	XRF
LI-KQ2-SB026	Original LaPointe Keeper's Quarters	surface	173	XRF
LI-KQ2-SB026	Original LaPointe Keeper's Quarters	subsurface	97.4	XRF
LI-KQ2-SB027	Original LaPointe Keeper's Quarters	surface	42.2	XRF
LI-KQ2-SB027	Original LaPointe Keeper's Quarters	subsurface	25.4	XRF
LI-KQ2-SB027	Original LaPointe Keeper's Quarters	subsurface	37	XRF
LI-KQ2-SB028	Original LaPointe Keeper's Quarters	surface	138.9	XRF
LI-KQ2-SB028	Original LaPointe Keeper's Quarters	subsurface	7.6	XRF
LI-KQ2-SB028	Original LaPointe Keeper's Quarters	subsurface	15.8	XRF
LI-KQ2-SB029	Original LaPointe Keeper's Quarters	surface	**526**	XRF
LI-KQ2-SB029	Original LaPointe Keeper's Quarters	subsurface	105	XRF
LI-KQ2-SB029	Original LaPointe Keeper's Quarters	subsurface	20.9	XRF
LI-KQ2-SB030	Original LaPointe Keeper's Quarters	surface	**514**	XRF
LI-KQ2-SB030	Original LaPointe Keeper's Quarters	subsurface	132.3	XRF
LI-KQ2-SB031	Original LaPointe Keeper's Quarters	surface	**464**	XRF
LI-KQ2-SB031	Original LaPointe Keeper's Quarters	subsurface	**380**	XRF
LI-KQ2-SB032	Original LaPointe Keeper's Quarters	surface	180	XRF
LI-KQ2-SB032	Original LaPointe Keeper's Quarters	subsurface	38.5	XRF

Station	Group1	Group2	Long Island Lead (mg/kg)	Lab or XRF?
LI-KQ2-SB033	Original LaPointe Keeper's Quarters	surface	**6,091**	XRF
LI-KQ2-SB033	Original LaPointe Keeper's Quarters	subsurface	**1,555**	XRF
LI-KQ2-SB034	Original LaPointe Keeper's Quarters	surface	**8,644**	XRF
LI-KQ2-SB034	Original LaPointe Keeper's Quarters	subsurface	**5,223**	XRF
LI-KQ2-SB035	Original LaPointe Keeper's Quarters	surface	**803**	XRF
LI-KQ2-SB035	Original LaPointe Keeper's Quarters	subsurface	63.9	XRF
LI-KQ2-SB036	Original LaPointe Keeper's Quarters	surface	233	XRF
LI-KQ2-SB036	Original LaPointe Keeper's Quarters	subsurface	101.5	XRF
LI-KQ2-SB037	Original LaPointe Keeper's Quarters	surface	77.8	XRF
LI-KQ2-SB037	Original LaPointe Keeper's Quarters	subsurface	39.4	XRF
LI-KQ2-SB038	Original LaPointe Keeper's Quarters	surface	71	XRF
LI-KQ2-SB038	Original LaPointe Keeper's Quarters	subsurface	16.8	XRF
LI-KQ2-SB039	Original LaPointe Keeper's Quarters	surface	167	XRF
LI-KQ2-SB039	Original LaPointe Keeper's Quarters	subsurface	10	XRF
LI-KQ2-SB040	Original LaPointe Keeper's Quarters	surface	**257**	XRF
LI-KQ2-SB040	Original LaPointe Keeper's Quarters	subsurface	17.4	XRF
LI-LH2-SB003	Old Chequamegon Lighthouse	subsurface	15	XRF
LI-LH2-SB004	Old Chequamegon Lighthouse	surface	15	XRF
LI-LH2-SB004	Old Chequamegon Lighthouse	subsurface	40	XRF
LI-LH2-SB006	Old Chequamegon Lighthouse	surface	16	XRF
LI-LH2-SB007	Old Chequamegon Lighthouse	surface	14	XRF
LI-LH2-SB007	Old Chequamegon Lighthouse	subsurface	19	XRF
LI-LH2-SB009	Old Chequamegon Lighthouse	subsurface	32	XRF
LI-LH2-SB010	Old Chequamegon Lighthouse	surface	0.92	Lab
LI-LH3-SB002	Chequamegon Lighthouse	surface	18	XRF
LI-FT2-SB001	LaPointe Radio Beacon	surface	20.6	XRF
LI-FT2-SB001	LaPointe Radio Beacon	subsurface	6.6	XRF
LI-FT2-SB002	LaPointe Radio Beacon	surface	47.2	XRF
LI-FT2-SB002	LaPointe Radio Beacon	subsurface	9.2	XRF
LI-FT2-SB003	LaPointe Radio Beacon	surface	87.3	XRF
LI-FT2-SB003	LaPointe Radio Beacon	subsurface	7.2	XRF
LI-FT2-SB004	LaPointe Radio Beacon	surface	31.4	XRF
LI-FT2-SB004	LaPointe Radio Beacon	subsurface	11.3	XRF
LI-FT2-SB005	LaPointe Radio Beacon	surface	25.4	XRF
LI-FT2-SB005	LaPointe Radio Beacon	subsurface	8.1	XRF
LI-FT2-SB006	LaPointe Radio Beacon	surface	13.6	XRF
LI-FT2-SB006	LaPointe Radio Beacon	subsurface	8.7	XRF
LI-FT2-SB007	LaPointe Radio Beacon	surface	11	XRF
LI-FT2-SB007	LaPointe Radio Beacon	subsurface	8.1	XRF
LI-FT2-SB008	LaPointe Radio Beacon	surface	12.5	XRF
LI-FT2-SB008	LaPointe Radio Beacon	subsurface	8	XRF
LI-FT2-SB009	LaPointe Radio Beacon	surface	11.9	XRF
LI-FT2-SB009	LaPointe Radio Beacon	subsurface	6	XRF

Station	Group1	Group2	Devils Island Lead (mg/kg)	Lab or XRF?
DI-FS1-SB001	Fog Signal Building	surface	**657**	XRF
DI-FS1-SB001	Fog Signal Building	subsurface	**638**	XRF
DI-FS1-SB002	Fog Signal Building	surface	**989**	XRF
DI-FS1-SB003	Fog Signal Building	surface	**1489**	XRF
DI-FS1-SB004	Fog Signal Building	surface	**296**	XRF
DI-FS1-SB004	Fog Signal Building	subsurface	39.3	XRF
DI-FS1-SB005	Fog Signal Building	surface	124.8	XRF
DI-FS1-SB006	Fog Signal Building	surface	**3,310**	XRF
DI-FS1-SB007	Fog Signal Building	surface	**1,903**	XRF
DI-FS1-SB007	Fog Signal Building	subsurface	**379**	XRF
DI-FS1-SB008	Fog Signal Building	surface	**3,095**	XRF
DI-FS1-SB009	Fog Signal Building	surface	**1,816**	XRF
DI-FS1-SB010	Fog Signal Building	surface	**587**	XRF
DI-FS1-SB011	Fog Signal Building	surface	**612**	XRF
DI-FS1-SB012	Fog Signal Building	surface	**369**	XRF
DI-FS1-SB013	Fog Signal Building	surface	**628**	XRF
DI-FS1-SB014	Fog Signal Building	surface	**618**	XRF
DI-FS1-SB015	Fog Signal Building	surface	**1,385**	XRF
DI-FS1-SB016	Fog Signal Building	surface	**401**	XRF
DI-FS1-SB016	Fog Signal Building	subsurface	177	XRF
DI-FS1-SB017	Fog Signal Building	surface	**263**	XRF
DI-FS1-SB018	Fog Signal Building	surface	**267**	XRF
DI-FS1-SB019	Fog Signal Building	surface	135.3	XRF
DI-FS1-SB020	Fog Signal Building	surface	**407**	XRF
DI-FS1-SB021	Fog Signal Building	surface	**307**	XRF
DI-FS1-SB022	Fog Signal Building	surface	**481**	XRF
DI-FS1-SB023	Fog Signal Building	surface	**1,025**	XRF
DI-FS1-SB024	Fog Signal Building	surface	**365**	XRF
DI-FS1-SB025	Fog Signal Building	surface	77.1	XRF
DI-FS1-SB026	Fog Signal Building	surface	**906**	XRF
DI-FS1-SB027	Fog Signal Building	surface	136.8	XRF
DI-FS1-SB028	Fog Signal Building	surface	**624**	XRF
DI-FS1-SB029	Fog Signal Building	surface	72.6	XRF
DI-FS1-SB030	Fog Signal Building	surface	**2,227**	XRF
DI-FS1-SB031	Fog Signal Building	surface	**624**	XRF
DI-FS1-SB032	Fog Signal Building	surface	32.3	XRF
DI-FS1-SB033	Fog Signal Building	surface	**546**	XRF
DI-KQ1-SB001	East Keeper's Quarters	surface	71.4	XRF
DI-KQ1-SB001	East Keeper's Quarters	subsurface	112	XRF
DI-KQ1-SB002	East Keeper's Quarters	surface	48.3	XRF
DI-KQ1-SB003	East Keeper's Quarters	surface	26.6	XRF
DI-KQ1-SB003	East Keeper's Quarters	subsurface	22.2	XRF
DI-KQ1-SB004	East Keeper's Quarters	surface	26.6	XRF

Station	Group1	Group2	Devils Island Lead (mg/kg)	Lab or XRF?
DI-KQ1-SB004	East Keeper's Quarters	subsurface	28.9	XRF
DI-KQ1-SB005	East Keeper's Quarters	surface	75.8	XRF
DI-KQ1-SB006	East Keeper's Quarters	surface	121.2	XRF
DI-KQ1-SB006	East Keeper's Quarters	subsurface	111.4	XRF
DI-KQ1-SB007	East Keeper's Quarters	surface	229	XRF
DI-KQ1-SB007	East Keeper's Quarters	subsurface	249	XRF
DI-KQ1-SB008	East Keeper's Quarters	surface	145	XRF
DI-KQ1-SB008	East Keeper's Quarters	subsurface	120.4	XRF
DI-KQ1-SB009	East Keeper's Quarters	surface	**678**	XRF
DI-KQ1-SB009	East Keeper's Quarters	subsurface	176	XRF
DI-KQ1-SB010	East Keeper's Quarters	surface	131.5	XRF
DI-KQ1-SB010	East Keeper's Quarters	subsurface	73.8	XRF
DI-KQ1-SB011	East Keeper's Quarters	surface	25.7	XRF
DI-KQ1-SB011	East Keeper's Quarters	subsurface	93.8	XRF
DI-KQ1-SB012	East Keeper's Quarters	surface	**913**	XRF
DI-KQ1-SB013	East Keeper's Quarters	surface	**677**	XRF
DI-KQ1-SB014	East Keeper's Quarters	surface	66.3	XRF
DI-KQ2-SB001	West Keeper's Quarters	surface	**770**	XRF
DI-KQ2-SB001	West Keeper's Quarters	subsurface	**2,282**	XRF
DI-KQ2-SB002	West Keeper's Quarters	surface	**402**	XRF
DI-KQ2-SB002	West Keeper's Quarters	subsurface	**420**	XRF
DI-KQ2-SB003	West Keeper's Quarters	surface	126.8	XRF
DI-KQ2-SB003	West Keeper's Quarters	subsurface	169	XRF
DI-KQ2-SB004	West Keeper's Quarters	surface	196	XRF
DI-KQ2-SB005	West Keeper's Quarters	surface	**546**	XRF
DI-KQ2-SB005	West Keeper's Quarters	subsurface	**1,264**	XRF
DI-KQ2-SB006	West Keeper's Quarters	surface	81.1	XRF
DI-KQ2-SB006	West Keeper's Quarters	subsurface	92.5	XRF
DI-KQ2-SB007	West Keeper's Quarters	surface	94.6	XRF
DI-KQ2-SB007	West Keeper's Quarters	subsurface	52.5	XRF
DI-KQ2-SB008	West Keeper's Quarters	surface	**265**	XRF
DI-KQ2-SB008	West Keeper's Quarters	subsurface	225	XRF
DI-KQ2-SB009	West Keeper's Quarters	surface	133.7	XRF
DI-KQ2-SB009	West Keeper's Quarters	subsurface	94.4	XRF
DI-KQ2-SB010	West Keeper's Quarters	surface	**278**	XRF
DI-KQ2-SB010	West Keeper's Quarters	subsurface	182	XRF
DI-KQ2-SB011	West Keeper's Quarters	surface	**299**	XRF
DI-KQ2-SB011	West Keeper's Quarters	subsurface	**337**	XRF
DI-KQ2-SB011	West Keeper's Quarters	subsurface	250	XRF
DI-KQ2-SB012	West Keeper's Quarters	surface	**261**	XRF
DI-KQ2-SB013	West Keeper's Quarters	surface	218	XRF
DI-KQ2-SB014	West Keeper's Quarters	surface	119.5	XRF
DI-KQ2-SB014	West Keeper's Quarters	subsurface	67.2	XRF

Station	Group1	Group2	Devils Island Lead (mg/kg)	Lab or XRF?
DI-KQ2-SB015	West Keeper's Quarters	surface	35.5	XRF
DI-KQ3-SB001	Assistant Keeper's Quarters	surface	47.9	XRF
DI-KQ3-SB001	Assistant Keeper's Quarters	subsurface	32	XRF
DI-KQ3-SB002	Assistant Keeper's Quarters	surface	**283**	XRF
DI-KQ3-SB002	Assistant Keeper's Quarters	subsurface	**509**	XRF
DI-KQ3-SB003	Assistant Keeper's Quarters	surface	83.5	XRF
DI-KQ3-SB003	Assistant Keeper's Quarters	subsurface	89.9	XRF
DI-KQ3-SB004	Assistant Keeper's Quarters	surface	29.7	XRF
DI-KQ3-SB005	Assistant Keeper's Quarters	surface	**575**	XRF
DI-KQ3-SB005	Assistant Keeper's Quarters	subsurface	**282**	XRF
DI-KQ3-SB006	Assistant Keeper's Quarters	surface	73.7	XRF
DI-KQ3-SB007	Assistant Keeper's Quarters	surface	126.6	XRF
DI-KQ3-SB008	Assistant Keeper's Quarters	surface	57.9	XRF
DI-KQ3-SB008	Assistant Keeper's Quarters	subsurface	25	XRF
DI-KQ3-SB009	Assistant Keeper's Quarters	surface	206	XRF
DI-KQ3-SB009	Assistant Keeper's Quarters	subsurface	69.7	XRF
DI-KQ3-SB010	Assistant Keeper's Quarters	surface	**394**	XRF
DI-KQ3-SB010	Assistant Keeper's Quarters	subsurface	**329**	XRF
DI-KQ3-SB011	Assistant Keeper's Quarters	surface	**1,055**	XRF
DI-KQ3-SB011	Assistant Keeper's Quarters	subsurface	**1,138**	XRF
DI-KQ3-SB012	Assistant Keeper's Quarters	surface	**442**	XRF
DI-KQ3-SB012	Assistant Keeper's Quarters	subsurface	**294**	XRF
DI-KQ3-SB013	Assistant Keeper's Quarters	surface	**1,237**	XRF
DI-KQ3-SB014	Assistant Keeper's Quarters	surface	**590**	XRF
DI-KQ3-SB015	Assistant Keeper's Quarters	surface	249	XRF
DI-KQ3-SB016	Assistant Keeper's Quarters	surface	110.9	XRF
DI-LH1-SB001	Lighthouse	surface	**3,506**	XRF
DI-LH1-SB001	Lighthouse	subsurface	**3,291**	XRF
DI-LH1-SB002	Lighthouse	surface	**3,323**	XRF
DI-LH1-SB003	Lighthouse	surface	**4,553**	XRF
DI-LH1-SB003	Lighthouse	subsurface	**4,050**	XRF
DI-LH1-SB004	Lighthouse	surface	**2,631**	XRF
DI-LH1-SB005	Lighthouse	surface	**3,753**	XRF
DI-LH1-SB006	Lighthouse	surface	**2,622**	XRF
DI-LH1-SB007	Lighthouse	surface	**3,611**	XRF
DI-LH1-SB008	Lighthouse	surface	**558**	XRF
DI-LH1-SB009	Lighthouse	surface	**2,063**	XRF
DI-LH1-SB010	Lighthouse	surface	**1,028**	XRF
DI-LH1-SB010	Lighthouse	subsurface	**415**	XRF
DI-LH1-SB011	Lighthouse	surface	**1,650**	XRF
DI-LH1-SB012	Lighthouse	surface	**3,719**	XRF
DI-LH1-SB013	Lighthouse	surface	**2,872**	XRF
DI-LH1-SB014	Lighthouse	surface	**1,921**	XRF

Station	Group1	Group2	Devils Island Lead (mg/kg)	Lab or XRF?
DI-LH1-SB015	Lighthouse	surface	**2,588**	XRF
DI-LH1-SB016	Lighthouse	surface	234	XRF
DI-LH1-SB017	Lighthouse	surface	**1,831**	XRF
DI-LH1-SB018	Lighthouse	surface	**1,144**	XRF
DI-LH1-SB019	Lighthouse	surface	**3,706**	XRF
DI-LH1-SB020	Lighthouse	surface	219	XRF
DI-LH1-SB021	Lighthouse	surface	**1,775**	XRF
DI-LH1-SB022	Lighthouse	surface	**516**	XRF
DI-LH1-SB023	Lighthouse	surface	**978**	XRF
DI-LH1-SB024	Lighthouse	surface	82	XRF
DI-LH1-SB025	Lighthouse	surface	**1,414**	XRF
DI-LH1-SB026	Lighthouse	surface	**947**	XRF
DI-LH1-SB027	Lighthouse	surface	**496**	XRF
DI-LH1-SB028	Lighthouse	surface	**484**	XRF
DI-LH1-SB029	Lighthouse	surface	**317**	XRF
DI-LH1-SB030	Lighthouse	surface	**613**	XRF
DI-LH1-SB031	Lighthouse	surface	**660**	XRF
DI-LH1-SB032	Lighthouse	surface	**445**	XRF
DI-LH1-SB033	Lighthouse	surface	**2,833**	XRF
DI-LH1-SB034	Lighthouse	surface	**409**	XRF
DI-LH1-SB035	Lighthouse	surface	**723**	XRF
DI-LH1-SB036	Lighthouse	surface	**394**	XRF
DI-LH1-SB037	Lighthouse	surface	141.8	XRF
DI-LH1-SB038	Lighthouse	surface	66.8	XRF
DI-LH1-SB039	Lighthouse	surface	87.5	XRF
DI-LH1-SB039	Lighthouse	subsurface	53	XRF
DI-LH1-SB040	Lighthouse	surface	**790**	XRF
DI-LH1-SB041	Lighthouse	surface	**288**	XRF
DI-LH1-SB042	Lighthouse	surface	45.3	XRF
DI-LH1-SB043	Lighthouse	surface	78.2	XRF
DI-LH2-SB001	Lighthouse	surface	51.9	XRF
DI-LH2-SB002	Lighthouse	surface	138	XRF
DI-LH2-SB003	Lighthouse	surface	216	XRF
DI-LH2-SB003	Lighthouse	subsurface	241	XRF
DI-LH2-SB004	Lighthouse	surface	58.8	XRF
DI-LH2-SB005	Lighthouse	surface	29	XRF
DI-OH1-SB001	East Outhouse	surface	151.5	XRF
DI-OH1-SB002	East Outhouse	surface	**402**	XRF
DI-OH1-SB003	East Outhouse	surface	176	XRF
DI-OH1-SB004	East Outhouse	surface	100.2	XRF
DI-OH1-SB005	East Outhouse	surface	**261**	XRF
DI-OH1-SB005	East Outhouse	subsurface	**304**	XRF
DI-OH1-SB006	East Outhouse	surface	**306**	XRF

Station	Group1	Group2	Devils Island Lead (mg/kg)	Lab or XRF?
DI-OH1-SB007	East Outhouse	surface	193	XRF
DI-OH2-SB001	West Outhouse	surface	**343**	XRF
DI-OH2-SB002	West Outhouse	surface	151.3	XRF
DI-OH2-SB003	West Outhouse	surface	**275**	XRF
DI-OH2-SB004	West Outhouse	surface	208	XRF
DI-OH2-SB005	West Outhouse	surface	67.7	XRF
DI-OH2-SB006	West Outhouse	surface	134.9	XRF
DI-OS1-SB001	East Oil Storage Building	surface	**5703**	XRF
DI-OS1-SB002	East Oil Storage Building	surface	**649**	XRF
DI-OS1-SB003	East Oil Storage Building	surface	**2,854**	XRF
DI-OS1-SB004	East Oil Storage Building	surface	**883**	XRF
DI-OS1-SB005	East Oil Storage Building	surface	**3,095**	XRF
DI-OS1-SB006	East Oil Storage Building	surface	**262**	XRF
DI-OS1-SB007	East Oil Storage Building	surface	199	XRF
DI-OS1-SB008	East Oil Storage Building	surface	60.1	XRF
DI-OS1-SB009	East Oil Storage Building	surface	**1,557**	XRF
DI-OS1-SB010	East Oil Storage Building	surface	**337**	XRF
DI-OS1-SB011	East Oil Storage Building	surface	**657**	XRF
DI-OS1-SB012	East Oil Storage Building	surface	**278**	XRF
DI-OS1-SB012	East Oil Storage Building	subsurface	26	XRF
DI-OS1-SB013	East Oil Storage Building	surface	236	XRF
DI-OS1-SB014	East Oil Storage Building	surface	139.3	XRF
DI-OS1-SB015	East Oil Storage Building	surface	57.9	XRF
DI-OS2-SB001	West Oil Storage Building	surface	**649**	XRF
DI-OS2-SB002	West Oil Storage Building	surface	**680**	XRF
DI-OS2-SB002	West Oil Storage Building	subsurface	**397**	XRF
DI-OS2-SB003	West Oil Storage Building	surface	**1,832**	XRF
DI-OS2-SB004	West Oil Storage Building	surface	**7,192**	XRF
DI-OS2-SB005	West Oil Storage Building	surface	**648**	XRF
DI-OS2-SB006	West Oil Storage Building	surface	146.2	XRF
DI-OS2-SB007	West Oil Storage Building	surface	185	XRF
DI-OS2-SB007	West Oil Storage Building	subsurface	36.6	XRF
DI-OS2-SB008	West Oil Storage Building	surface	249	XRF
DI-OS2-SB009	West Oil Storage Building	surface	146.5	XRF
DI-SH2-SB001	Storehouse	surface	**602**	XRF
DI-SH2-SB002	Storehouse	surface	113.6	XRF
DI-SH2-SB003	Storehouse	surface	171	XRF
DI-SH2-SB004	Storehouse	surface	**1,119**	XRF
DI-SH2-SB005	Storehouse	surface	**478**	XRF
DI-SH2-SB006	Storehouse	surface	231	XRF
DI-SH2-SB007	Storehouse	surface	**633**	XRF
DI-SH2-SB008	Storehouse	surface	205	XRF
DI-SH2-SB009	Storehouse	surface	**638**	XRF
DI-SH2-SB010	Storehouse	surface	157.2	XRF

Station	Group1	Group2	Devils Island Lead (mg/kg)	Lab or XRF?
DI-SH2-SB011	Storehouse	surface	219	XRF
DI-SH4-SB001	Tramway Engine Building	surface	**1,980**	XRF
DI-SH4-SB002	Tramway Engine Building	surface	**2,532**	XRF
DI-SH4-SB002	Tramway Engine Building	subsurface	148.4	XRF
DI-SH4-SB003	Tramway Engine Building	surface	**6,382**	XRF
DI-SH4-SB004	Tramway Engine Building	surface	**1,803**	XRF
DI-SH4-SB004	Tramway Engine Building	subsurface	48.4	XRF
DI-SH4-SB005	Tramway Engine Building	surface	**2,138**	XRF
DI-SH4-SB005	Tramway Engine Building	subsurface	**981**	XRF
DI-SH4-SB006	Tramway Engine Building	surface	198	XRF
DI-SH4-SB006	Tramway Engine Building	subsurface	29.8	XRF
DI-SH4-SB007	Tramway Engine Building	surface	161.7	XRF
DI-SH4-SB007	Tramway Engine Building	subsurface	32.3	XRF
DI-SH4-SB008	Tramway Engine Building	surface	**2,122**	XRF
DI-SH4-SB009	Tramway Engine Building	surface	**545**	XRF
DI-SH4-SB010	Tramway Engine Building	surface	103.3	XRF
DI-SH4-SB011	Tramway Engine Building	surface	134	XRF
DI-TW1-SB001	Metal Truss Tower	surface	23.8	XRF
DI-TW1-SB002	Metal Truss Tower	surface	42.2	XRF
DI-TW1-SB003	Metal Truss Tower	surface	24.1	XRF

Station	Group1	Group2	Raspberry Island Lead (mg/kg)	Lab or XRF?
RI-FS1-SB001	Fog Signal Building	surface	191	XRF
RI-FS1-SB002	Fog Signal Building	surface	**947**	XRF
RI-FS1-SB002	Fog Signal Building	subsurface	**927**	XRF
RI-FS1-SB003	Fog Signal Building	surface	**1,184**	XRF
RI-FS1-SB003	Fog Signal Building	subsurface	**390**	XRF
RI-FS1-SB004	Fog Signal Building	surface	**647**	XRF
RI-FS1-SB005	Fog Signal Building	surface	**934**	XRF
RI-FS1-SB005	Fog Signal Building	subsurface	**558**	XRF
RI-FS1-SB006	Fog Signal Building	surface	**853**	XRF
RI-FS1-SB006	Fog Signal Building	subsurface	**660**	XRF
RI-FS1-SB007	Fog Signal Building	surface	**1,744**	XRF
RI-FS1-SB007	Fog Signal Building	subsurface	193	XRF
RI-FS1-SB008	Fog Signal Building	surface	**684**	XRF
RI-FS1-SB008	Fog Signal Building	subsurface	**863**	XRF
RI-FS1-SB009	Fog Signal Building	surface	**1,114**	XRF
RI-FS1-SB009	Fog Signal Building	subsurface	**267**	XRF
RI-FS1-SB010	Fog Signal Building	surface	88	XRF
RI-FS1-SB010	Fog Signal Building	subsurface	**316**	XRF
RI-FS1-SB011	Fog Signal Building	surface	**417**	XRF
RI-FS1-SB012	Fog Signal Building	surface	120	XRF
RI-FS1-SB012	Fog Signal Building	subsurface	89	XRF
RI-FS1-SB013	Fog Signal Building	surface	95	XRF
RI-LH1-SB001	Lighthouse/Keeper's Quarters	surface	**312**	XRF
RI-LH1-SB001	Lighthouse/Keeper's Quarters	subsurface	139	XRF
RI-LH1-SB002	Lighthouse/Keeper's Quarters	surface	**544**	XRF
RI-LH1-SB002	Lighthouse/Keeper's Quarters	subsurface	**2,239**	XRF
RI-LH1-SB003	Lighthouse/Keeper's Quarters	surface	**4,877**	XRF
RI-LH1-SB003	Lighthouse/Keeper's Quarters	subsurface	**563**	XRF
RI-LH1-SB004	Lighthouse/Keeper's Quarters	surface	**361**	XRF
RI-LH1-SB004	Lighthouse/Keeper's Quarters	subsurface	**1,067**	XRF
RI-LH1-SB005	Lighthouse/Keeper's Quarters	surface	**321**	XRF
RI-LH1-SB005	Lighthouse/Keeper's Quarters	subsurface	174	XRF
RI-LH1-SB006	Lighthouse/Keeper's Quarters	surface	232	XRF
RI-LH1-SB006	Lighthouse/Keeper's Quarters	subsurface	**466**	XRF
RI-LH1-SB007	Lighthouse/Keeper's Quarters	surface	**290**	XRF
RI-LH1-SB008	Lighthouse/Keeper's Quarters	surface	103	XRF
RI-LH1-SB008	Lighthouse/Keeper's Quarters	subsurface	85	XRF
RI-LH1-SB009	Lighthouse/Keeper's Quarters	surface	**297**	XRF
RI-LH1-SB009	Lighthouse/Keeper's Quarters	subsurface	243	XRF
RI-LH1-SB010	Lighthouse/Keeper's Quarters	surface	**286**	XRF
RI-LH1-SB010	Lighthouse/Keeper's Quarters	subsurface	241	XRF
RI-LH1-SB011	Lighthouse/Keeper's Quarters	surface	**409**	XRF
RI-LH1-SB012	Lighthouse/Keeper's Quarters	surface	**347**	XRF
RI-LH1-SB013	Lighthouse/Keeper's Quarters	surface	51	XRF
RI-LH1-SB014	Lighthouse/Keeper's Quarters	surface	168	XRF
RI-LH1-SB015	Lighthouse/Keeper's Quarters	surface	225	XRF
RI-LH1-SB015	Lighthouse/Keeper's Quarters	subsurface	133	XRF
RI-LH1-SB016	Lighthouse/Keeper's Quarters	surface	242	XRF
RI-LH1-SB017	Lighthouse/Keeper's Quarters	surface	225	XRF
RI-LH1-SB018	Lighthouse/Keeper's Quarters	surface	**483**	XRF

Station	Group1	Group2	Raspberry Island Lead (mg/kg)	Lab or XRF?
RI-LH1-SB019	Lighthouse/Keeper's Quarters	surface	**432**	XRF
RI-LH1-SB019	Lighthouse/Keeper's Quarters	subsurface	42	XRF
RI-LH1-SB020	Lighthouse/Keeper's Quarters	surface	**3,907**	XRF
RI-LH1-SB020	Lighthouse/Keeper's Quarters	subsurface	**454**	XRF
RI-LH1-SB021	Lighthouse/Keeper's Quarters	surface	**352**	XRF
RI-LH1-SB022	Lighthouse/Keeper's Quarters	surface	240	XRF
RI-LH1-SB023	Lighthouse/Keeper's Quarters	surface	**275**	XRF
RI-LH1-SB024	Lighthouse/Keeper's Quarters	surface	**1,057**	XRF
RI-LH1-SB025	Lighthouse/Keeper's Quarters	surface	69	XRF
RI-LH1-SB025	Lighthouse/Keeper's Quarters	subsurface	249	XRF
RI-LH1-SB026	Lighthouse/Keeper's Quarters	surface	**390**	XRF
RI-LH1-SB027	Lighthouse/Keeper's Quarters	surface	**284**	XRF
RI-LH1-SB028	Lighthouse/Keeper's Quarters	surface	66	XRF
RI-LH1-SB029	Lighthouse/Keeper's Quarters	surface	180	XRF
RI-OH1-SB001	Outhouse	surface	**471**	XRF
RI-OH1-SB001	Outhouse	subsurface	247	XRF
RI-OH1-SB002	Outhouse	surface	**1,088**	XRF
RI-OH1-SB002	Outhouse	subsurface	**733**	XRF
RI-OH1-SB002	Outhouse	subsurface	55	XRF
RI-OH1-SB003	Outhouse	surface	155	XRF
RI-OH1-SB004	Outhouse	surface	**309**	XRF
RI-OH1-SB004	Outhouse	subsurface	149	XRF
RI-OH1-SB005	Outhouse	surface	187	XRF
RI-OH2-SB001	Outhouse	surface	**338**	XRF
RI-OH2-SB001	Outhouse	subsurface	234	XRF
RI-OH2-SB002	Outhouse	surface	**801**	XRF
RI-OH2-SB002	Outhouse	subsurface	**970**	XRF
RI-OH2-SB003	Outhouse	surface	**783**	XRF
RI-OH2-SB003	Outhouse	subsurface	**337**	XRF
RI-OH2-SB003	Outhouse	subsurface	179	XRF
RI-OH2-SB004	Outhouse	surface	**435**	XRF
RI-OH2-SB005	Outhouse	surface	148	XRF
RI-OH2-SB005	Outhouse	subsurface	161	XRF
RI-OH2-SB006	Outhouse	surface	154	XRF
RI-OS1-SB001	Oil Storage Building	surface	**540**	XRF
RI-OS1-SB001	Oil Storage Building	subsurface	**283**	XRF
RI-OS1-SB002	Oil Storage Building	surface	**322**	XRF
RI-OS1-SB002	Oil Storage Building	subsurface	37	XRF
RI-OS1-SB003	Oil Storage Building	surface	**512**	XRF
RI-OS1-SB003	Oil Storage Building	subsurface	187	XRF
RI-OS1-SB004	Oil Storage Building	surface	**256**	XRF
RI-OS1-SB004	Oil Storage Building	subsurface	93	XRF
RI-OS1-SB005	Oil Storage Building	surface	**276**	XRF
RI-OS1-SB006	Oil Storage Building	surface	**734**	XRF
RI-OS1-SB006	Oil Storage Building	subsurface	61	XRF
RI-OS1-SB007	Oil Storage Building	surface	238	XRF
RI-OS1-SB007	Oil Storage Building	subsurface	29	XRF
RI-OS1-SB008	Oil Storage Building	surface	**455**	XRF
RI-OS1-SB008	Oil Storage Building	subsurface	84	XRF
RI-OS1-SB009	Oil Storage Building	surface	229	XRF

Station	Group1	Group2	Raspberry Island Lead (mg/kg)	Lab or XRF?
RI-OS1-SB010	Oil Storage Building	surface	**409**	XRF
RI-OS1-SB011	Oil Storage Building	surface	**562**	XRF
RI-OS1-SB011	Oil Storage Building	subsurface	**454**	XRF
RI-OS1-SB012	Oil Storage Building	surface	113	XRF
RI-OS1-SB013	Oil Storage Building	surface	132	XRF
RI-OS1-SB014	Oil Storage Building	surface	**484**	XRF
RI-OS1-SB015	Oil Storage Building	surface	**484**	XRF
RI-OS1-SB016	Oil Storage Building	surface	192	XRF
RI-SH1-SB001	Shed	surface	**526**	XRF
RI-SH1-SB001	Shed	subsurface	**291**	XRF
RI-SH1-SB002	Shed	surface	**1,213**	XRF
RI-SH1-SB002	Shed	subsurface	**398**	XRF
RI-SH1-SB003	Shed	surface	**1,053**	XRF
RI-SH1-SB003	Shed	subsurface	**271**	XRF
RI-SH1-SB004	Shed	surface	**339**	XRF
RI-SH1-SB005	Shed	surface	186	XRF
RI-SH1-SB005	Shed	subsurface	29	XRF
RI-SH1-SB006	Shed	surface	**346**	XRF
RI-SH1-SB006	Shed	subsurface	225	XRF
RI-SH1-SB007	Shed	surface	**263**	XRF
RI-SH1-SB007	Shed	subsurface	16	XRF
RI-SH1-SB008	Shed	surface	**366**	XRF
RI-SH1-SB008	Shed	subsurface	161	XRF
RI-SH1-SB009	Shed	surface	111	XRF
RI-SH1-SB010	Shed	surface	79	XRF
RI-SH1-SB010	Shed	surface	244	Lab *
RI-SH2-SB001	Shed	surface	**780**	XRF
RI-SH2-SB001	Shed	subsurface	86	XRF
RI-SH2-SB002	Shed	surface	**2,226**	XRF
RI-SH2-SB002	Shed	subsurface	**586**	XRF
RI-SH2-SB003	Shed	surface	**3,157**	XRF
RI-SH2-SB003	Shed	subsurface	**2,212**	XRF
RI-SH2-SB003	Shed	subsurface	181	XRF
RI-SH2-SB004	Shed	surface	**1,133**	XRF
RI-SH2-SB004	Shed	subsurface	166	XRF
RI-SH2-SB005	Shed	surface	**289**	XRF
RI-SH2-SB006	Shed	surface	**488**	XRF
RI-SH2-SB006	Shed	subsurface	100	XRF
RI-SH2-SB007	Shed	surface	**853**	XRF
RI-SH2-SB007	Shed	subsurface	203	XRF
RI-SH2-SB008	Shed	surface	**910**	XRF
RI-SH2-SB009	Shed	surface	**278**	XRF
RI-SH2-SB010	Shed	surface	187	XRF
RI-SH2-SB011	Shed	surface	173	XRF
RI-SH2-SB012	Shed	surface	118	XRF
RI-SH2-SB013	Shed	surface	**350**	XRF
RI-SH2-SB014	Shed	surface	169	XRF
RI-SH3-SB001	Shed	surface	**415**	XRF
RI-SH3-SB001	Shed	subsurface	183	XRF
RI-SH3-SB002	Shed	surface	**1,404**	XRF

Station	Group1	Group2	Raspberry Island Lead (mg/kg)	Lab or XRF?
RI-SH3-SB002	Shed	subsurface	**713**	XRF
RI-SH3-SB003	Shed	surface	**654**	XRF
RI-SH3-SB003	Shed	subsurface	**1,196**	XRF
RI-SH3-SB004	Shed	surface	**446**	XRF
RI-SH3-SB004	Shed	subsurface	**437**	XRF
RI-SH3-SB005	Shed	surface	**822**	XRF
RI-SH3-SB006	Shed	surface	**398**	XRF
RI-SH3-SB006	Shed	subsurface	76	XRF
RI-SH3-SB007	Shed	surface	244	XRF
RI-SH3-SB008	Shed	surface	**280**	XRF
RI-SH3-SB009	Shed	surface	87	XRF
RI-SH3-SB010	Shed	surface	**656**	XRF
RI-SH3-SB010	Shed	subsurface	142	XRF
RI-SH3-SB011	Shed	surface	**547**	XRF
RI-SH3-SB011	Shed	subsurface	54	XRF
RI-SH3-SB012	Shed	surface	**424**	XRF
RI-SH3-SB013	Shed	surface	**575**	XRF
RI-SH3-SB014	Shed	surface	**466**	XRF
RI-SH3-SB015	Shed	surface	173	XRF
RI-SH3-SB016	Shed	surface	172	XRF
RI-SW1-SB001	Drainage Swale	surface	180	XRF
RI-SW1-SB002	Drainage Swale	surface	34	XRF
RI-SW1-SB003	Drainage Swale	surface	107	XRF
RI-SW1-SB004	Drainage Swale	surface	**270**	XRF
RI-GARDEN-N	Garden	surface	36	XRF
RI-GARDEN-S	Garden	surface	65.9	XRF

Station	Group1	Group2	Outer Island Lead (mg/kg)	Lab or XRF?
OI-AS1-SB001	Above Ground Storage Tank	surface	**920**	XRF
OI-AS1-SB001	Above Ground Storage Tank	subsurface	**300**	XRF
OI-AS1-SB002	Above Ground Storage Tank	surface	**574**	XRF
OI-AS1-SB002	Above Ground Storage Tank	subsurface	70	XRF
OI-AS1-SB003	Above Ground Storage Tank	surface	54	XRF
OI-AS1-SB004	Above Ground Storage Tank	surface	163	XRF
OI-AS1-SB004	Above Ground Storage Tank	subsurface	50	XRF
OI-AS1-SB005	Above Ground Storage Tank	surface	**297**	XRF
OI-AS1-SB006	Above Ground Storage Tank	surface	112	XRF
OI-FS1-SB001	Fog Signal Building	surface	**4,491**	XRF
OI-FS1-SB001	Fog Signal Building	subsurface	**1,276**	XRF
OI-FS1-SB002	Fog Signal Building	surface	**676**	XRF
OI-FS1-SB002	Fog Signal Building	subsurface	**328**	XRF
OI-FS1-SB003	Fog Signal Building	surface	**524**	XRF
OI-FS1-SB003	Fog Signal Building	subsurface	**387**	XRF
OI-FS1-SB004	Fog Signal Building	surface	**791**	XRF
OI-FS1-SB004	Fog Signal Building	subsurface	118	XRF
OI-FS1-SB005	Fog Signal Building	surface	123	XRF
OI-FS1-SB005	Fog Signal Building	subsurface	**1,148**	XRF
OI-FS1-SB006	Fog Signal Building	surface	**704**	XRF
OI-FS1-SB006	Fog Signal Building	subsurface	**1,314**	XRF
OI-FS1-SB007	Fog Signal Building	surface	**433**	XRF
OI-FS1-SB007	Fog Signal Building	subsurface	77	XRF
OI-FS1-SB008	Fog Signal Building	surface	**715**	XRF
OI-FS1-SB008	Fog Signal Building	subsurface	20	XRF
OI-FS1-SB009	Fog Signal Building	surface	**323**	XRF
OI-FS1-SB010	Fog Signal Building	surface	**528**	XRF
OI-FS1-SB011	Fog Signal Building	surface	**7,610**	Lab
OI-FS1-SB012	Fog Signal Building	surface	**642**	XRF
OI-FS1-SB013	Fog Signal Building	surface	**512**	XRF
OI-FS1-SB013	Fog Signal Building	subsurface	**263**	XRF
OI-FS1-SB014	Fog Signal Building	surface	**297**	XRF
OI-FS1-SB015	Fog Signal Building	surface	155	XRF
OI-FS1-SB016	Fog Signal Building	surface	**478**	XRF
OI-FS1-SB016	Fog Signal Building	subsurface	71	XRF
OI-FS1-SB017	Fog Signal Building	surface	**270**	XRF
OI-FS1-SB018	Fog Signal Building	surface	**1,561**	XRF
OI-FS1-SB019	Fog Signal Building	surface	**474**	XRF
OI-FS1-SB020	Fog Signal Building	surface	112	XRF
OI-FS1-SB021	Fog Signal Building	surface	**510**	XRF
OI-FS1-SB022	Fog Signal Building	surface	14	XRF
OI-FS1-SB023	Fog Signal Building	surface	17	XRF
OI-FS1-SB024	Fog Signal Building	surface	**255**	XRF
OI-FS1-SB025	Fog Signal Building	surface	135	XRF
OI-LH1-SB001	Lighthouse/Keeper's Quarters	surface	**761**	XRF
OI-LH1-SB001	Lighthouse/Keeper's Quarters	subsurface	**447**	XRF
OI-LH1-SB001	Lighthouse/Keeper's Quarters	subsurface	191	XRF
OI-LH1-SB002	Lighthouse/Keeper's Quarters	surface	**1,019**	XRF
OI-LH1-SB002	Lighthouse/Keeper's Quarters	subsurface	**472**	XRF
OI-LH1-SB002	Lighthouse/Keeper's Quarters	subsurface	**661**	XRF

Station	Group1	Group2	Outer Island Lead (mg/kg)	Lab or XRF?
OI-LH1-SB003	Lighthouse/Keeper's Quarters	surface	**332**	XRF
OI-LH1-SB004	Lighthouse/Keeper's Quarters	surface	**562**	XRF
OI-LH1-SB004	Lighthouse/Keeper's Quarters	subsurface	197	XRF
OI-LH1-SB005	Lighthouse/Keeper's Quarters	surface	161	XRF
OI-LH1-SB005	Lighthouse/Keeper's Quarters	subsurface	82	XRF
OI-LH1-SB006	Lighthouse/Keeper's Quarters	surface	**261**	XRF
OI-LH1-SB006	Lighthouse/Keeper's Quarters	subsurface	105	XRF
OI-LH1-SB007	Lighthouse/Keeper's Quarters	surface	198	XRF
OI-LH1-SB008	Lighthouse/Keeper's Quarters	surface	**422**	XRF
OI-LH1-SB008	Lighthouse/Keeper's Quarters	subsurface	**290**	XRF
OI-LH1-SB009	Lighthouse/Keeper's Quarters	surface	**476**	XRF
OI-LH1-SB009	Lighthouse/Keeper's Quarters	subsurface	143	XRF
OI-LH1-SB010	Lighthouse/Keeper's Quarters	surface	**382**	XRF
OI-LH1-SB010	Lighthouse/Keeper's Quarters	subsurface	177	XRF
OI-LH1-SB011	Lighthouse/Keeper's Quarters	surface	**703**	XRF
OI-LH1-SB011	Lighthouse/Keeper's Quarters	subsurface	249	XRF
OI-LH1-SB012	Lighthouse/Keeper's Quarters	surface	**335**	XRF
OI-LH1-SB012	Lighthouse/Keeper's Quarters	subsurface	198	XRF
OI-LH1-SB013	Lighthouse/Keeper's Quarters	surface	177	XRF
OI-LH1-SB014	Lighthouse/Keeper's Quarters	surface	180	XRF
OI-LH1-SB015	Lighthouse/Keeper's Quarters	surface	**699**	XRF
OI-LH1-SB015	Lighthouse/Keeper's Quarters	subsurface	185	XRF
OI-LH1-SB016	Lighthouse/Keeper's Quarters	surface	**319**	XRF
OI-LH1-SB017	Lighthouse/Keeper's Quarters	surface	204	XRF
OI-LH1-SB018	Lighthouse/Keeper's Quarters	surface	134	XRF
OI-LH1-SB019	Lighthouse/Keeper's Quarters	surface	**479**	XRF
OI-LH1-SB020	Lighthouse/Keeper's Quarters	surface	**326**	XRF
OI-LH1-SB021	Lighthouse/Keeper's Quarters	surface	224	XRF
OI-LH1-SB022	Lighthouse/Keeper's Quarters	surface	223	XRF
OI-LH1-SB023	Lighthouse/Keeper's Quarters	surface	122	XRF
OI-OH1-SB001	Outhouse	surface	**742**	XRF
OI-OH1-SB001	Outhouse	subsurface	**467**	XRF
OI-OH1-SB002	Outhouse	surface	**325**	XRF
OI-OH1-SB002	Outhouse	subsurface	173	XRF
OI-OH1-SB003	Outhouse	surface	**338**	XRF
OI-OH1-SB003	Outhouse	subsurface	51	XRF
OI-OH1-SB004	Outhouse	surface	215	XRF
OI-OH1-SB005	Outhouse	surface	240	XRF
OI-OS1-SB001	Oil Storage Building	surface	**1,850**	lab
OI-OS1-SB001	Oil Storage Building	subsurface	80	XRF
OI-OS1-SB002	Oil Storage Building	surface	**1,116**	XRF
OI-OS1-SB002	Oil Storage Building	subsurface	**263**	XRF
OI-OS1-SB003	Oil Storage Building	surface	**335**	XRF
OI-OS1-SB004	Oil Storage Building	surface	**434**	XRF
OI-OS1-SB004	Oil Storage Building	subsurface	96	XRF
OI-OS1-SB005	Oil Storage Building	surface	**521**	XRF
OI-OS1-SB006	Oil Storage Building	surface	**291**	XRF
OI-OS1-SB007	Oil Storage Building	surface	**622**	XRF
OI-OS1-SB008	Oil Storage Building	surface	**502**	XRF
OI-OS1-SB009	Oil Storage Building	surface	**1,881**	XRF

Station	Group1	Group2	Outer Island Lead (mg/kg)	Lab or XRF?
OI-OS1-SB010	Oil Storage Building	surface	62	XRF
OI-OS1-SB011	Oil Storage Building	surface	247	XRF
OI-OS1-SB012	Oil Storage Building	surface	**350**	XRF
OI-OS1-SB013	Oil Storage Building	surface	**763**	XRF

Michigan Island Station	Group1	Group2	Lab or XRF?	Michigan Island Station
MI-FS1-SB001	Fog Signal Building	surface	XRF	**382**
MI-FS1-SB001	Fog Signal Building	subsurface	XRF	182
MI-FS1-SB002	Fog Signal Building	surface	XRF	**396**
MI-FS1-SB002	Fog Signal Building	subsurface	XRF	**278**
MI-FS1-SB003	Fog Signal Building	surface	XRF	**261**
MI-FS1-SB003	Fog Signal Building	subsurface	XRF	41
MI-FS1-SB004	Fog Signal Building	surface	XRF	120
MI-FS1-SB004	Fog Signal Building	subsurface	XRF	237
MI-FS1-SB005	Fog Signal Building	surface	XRF	250
MI-FS1-SB006	Fog Signal Building	surface	XRF	167
MI-FS1-SB006	Fog Signal Building	subsurface	XRF	64
MI-FS1-SB007	Fog Signal Building	surface	XRF	85
MI-KQ1-SB001	Keeper's Quarters	surface	XRF	**372**
MI-KQ1-SB001	Keeper's Quarters	subsurface	XRF	96
MI-KQ1-SB002	Keeper's Quarters	surface	XRF	71
MI-KQ1-SB002	Keeper's Quarters	subsurface	XRF	45
MI-KQ1-SB003	Keeper's Quarters	surface	XRF	89
MI-KQ1-SB003	Keeper's Quarters	subsurface	XRF	71
MI-KQ1-SB004	Keeper's Quarters	surface	lab	106
MI-KQ1-SB005	Keeper's Quarters	surface	XRF	177
MI-KQ2-SB001	Assistant Keeper's Quarters	surface	XRF	**827**
MI-KQ2-SB002	Assistant Keeper's Quarters	surface	XRF	**423**
MI-KQ2-SB002	Assistant Keeper's Quarters	subsurface	XRF	155
MI-KQ2-SB003	Assistant Keeper's Quarters	surface	XRF	**454**
MI-KQ2-SB003	Assistant Keeper's Quarters	subsurface	XRF	37
MI-KQ2-SB004	Assistant Keeper's Quarters	surface	XRF	**888**
MI-KQ2-SB004	Assistant Keeper's Quarters	subsurface	XRF	137
MI-KQ2-SB005	Assistant Keeper's Quarters	surface	XRF	**287**
MI-KQ2-SB006	Assistant Keeper's Quarters	surface	XRF	88
MI-KQ2-SB007	Assistant Keeper's Quarters	surface	XRF	**359**
MI-KQ2-SB008	Assistant Keeper's Quarters	surface	XRF	**482**
MI-KQ2-SB009	Assistant Keeper's Quarters	surface	XRF	79
MI-KQ2-SB010	Assistant Keeper's Quarters	surface	XRF	194
MI-KQ2-SB011	Assistant Keeper's Quarters	surface	XRF	**678**
MI-KQ2-SB012	Assistant Keeper's Quarters	surface	XRF	**401**
MI-KQ2-SB013	Assistant Keeper's Quarters	surface	XRF	72
MI-KQ2-SB014	Assistant Keeper's Quarters	surface	XRF	115
MI-KQ2-SB015	Assistant Keeper's Quarters	surface	XRF	212
MI-KQ2-SB016	Assistant Keeper's Quarters	surface	XRF	87
MI-LH1-SB001	Lighthouse/Keeper's Quarters	surface	XRF	146
MI-LH1-SB002	Lighthouse/Keeper's Quarters	surface	XRF	168
MI-LH1-SB003	Lighthouse/Keeper's Quarters	surface	XRF	**303**
MI-LH1-SB004	Lighthouse/Keeper's Quarters	surface	XRF	189
MI-LH1-SB004	Lighthouse/Keeper's Quarters	subsurface	XRF	145
MI-LH1-SB005	Lighthouse/Keeper's Quarters	surface	XRF	54
MI-LH1-SB005	Lighthouse/Keeper's Quarters	subsurface	XRF	81
MI-LH1-SB006	Lighthouse/Keeper's Quarters	surface	XRF	177
MI-LH1-SB006	Lighthouse/Keeper's Quarters	subsurface	XRF	174
MI-LH1-SB007	Lighthouse/Keeper's Quarters	surface	XRF	89
MI-LH1-SB008	Lighthouse/Keeper's Quarters	surface	XRF	147

Michigan Island Station	Group1	Group2	Lab or XRF?	Michigan Island Station
MI-LH2-SB001	Lighthouse	surface	XRF	**8,703**
MI-LH2-SB001	Lighthouse	subsurface	XRF	**2,009**
MI-LH2-SB002	Lighthouse	surface	XRF	**5,847**
MI-LH2-SB003	Lighthouse	surface	XRF	**14,012**
MI-LH2-SB004	Lighthouse	surface	XRF	**1,732**
MI-LH2-SB004	Lighthouse	subsurface	lab	**1,610**
MI-LH2-SB005	Lighthouse	surface	XRF	**897**
MI-LH2-SB006	Lighthouse	surface	XRF	**561**
MI-LH2-SB007	Lighthouse	surface	XRF	**10,130**
MI-LH2-SB008	Lighthouse	surface	XRF	**293**
MI-LH2-SB009	Lighthouse	surface	XRF	**543**
MI-LH2-SB010	Lighthouse	surface	XRF	172
MI-LH2-SB011	Lighthouse	surface	XRF	193
MI-LH2-SB012	Lighthouse	surface	XRF	162
MI-LH2-SB013	Lighthouse	surface	XRF	**15,078**
MI-LH2-SB013	Lighthouse	subsurface	XRF	**699**
MI-LH2-SB013	Lighthouse	subsurface	XRF	28
MI-LH2-SB013	Lighthouse	subsurface	XRF	60
MI-OH1-SB001	Outhouse	surface	XRF	**1,582**
MI-OH1-SB002	Outhouse	surface	XRF	**1,038**
MI-OH1-SB002	Outhouse	subsurface	XRF	190
MI-OH1-SB003	Outhouse	surface	XRF	**629**
MI-OH1-SB003	Outhouse	subsurface	XRF	**489**
MI-OH1-SB004	Outhouse	surface	XRF	**554**
MI-OH1-SB004	Outhouse	subsurface	XRF	47
MI-OH1-SB005	Outhouse	surface	XRF	**371**
MI-OH1-SB006	Outhouse	surface	XRF	151
MI-OH1-SB007	Outhouse	surface	XRF	36
MI-OH1-SB008	Outhouse	surface	XRF	171
MI-OH1-SB009	Outhouse	surface	XRF	65
MI-OS1-SB001	Oil Storage Building	surface	XRF	143
MI-OS1-SB001	Oil Storage Building	subsurface	XRF	39.4
MI-OS1-SB002	Oil Storage Building	surface	XRF	63.3
MI-OS1-SB002	Oil Storage Building	subsurface	XRF	49.3
MI-OS1-SB003	Oil Storage Building	surface	XRF	128.3
MI-OS1-SB004	Oil Storage Building	surface	XRF	147
MI-OS1-SB004	Oil Storage Building	subsurface	XRF	103.3
MI-SH1-SB001	Shed	surface	XRF	**292**
MI-SH1-SB001	Shed	subsurface	XRF	**314**
MI-SH1-SB002	Shed	surface	XRF	246
MI-SH1-SB002	Shed	subsurface	XRF	233
MI-SH1-SB003	Shed	surface	XRF	**1,457**
MI-SH1-SB003	Shed	subsurface	XRF	**351**
MI-SH1-SB004	Shed	surface	XRF	**523**
MI-SH1-SB004	Shed	subsurface	XRF	133
MI-SH1-SB005	Shed	surface	XRF	**442**
MI-SH1-SB006	Shed	surface	XRF	**800**
MI-SH1-SB007	Shed	surface	XRF	94
MI-SH1-SB008	Shed	surface	XRF	135
MI-SH1-SB008	Shed	subsurface	XRF	107

Michigan Island Station	Group1	Group2	Lab or XRF?	Michigan Island Station
MI-SH1-SB009	Shed	surface	XRF	**539**
MI-SH1-SB010	Shed	surface	XRF	**291**
MI-SH1-SB011	Shed	surface	XRF	**910**

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:38:19 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (subsurface)

General Statistics

Total Number of Observations	48	Number of Distinct Observations	48
		Number of Missing Observations	0
Minimum	22.2	Mean	426.6
Maximum	4050	Median	172.5
SD	796.8	Std. Error of Mean	115
Coefficient of Variation	1.868	Skewness	3.396

Normal GOF Test

Shapiro Wilk Test Statistic	0.521	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.337	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.128	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	619.6	95% Adjusted-CLT UCL (Chen-1995)	676
		95% Modified-t UCL (Johnson-1978)	629

Gamma GOF Test

A-D Test Statistic	2.149	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.801	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.176	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.134	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.65	k star (bias corrected MLE)	0.624
Theta hat (MLE)	656	Theta star (bias corrected MLE)	684.1
nu hat (MLE)	62.43	nu star (bias corrected)	59.87
MLE Mean (bias corrected)	426.6	MLE Sd (bias corrected)	540.3
		Approximate Chi Square Value (0.05)	43.07
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	42.63

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	593	95% Adjusted Gamma UCL (use when n<50)	599.1

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.953	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0739	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.128	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.1	Mean of logged Data	5.117
Maximum of Logged Data	8.306	SD of logged Data	1.31

Assuming Lognormal Distribution

95% H-UCL	658.4	90% Chebyshev (MVUE) UCL	655.5
95% Chebyshev (MVUE) UCL	779.7	97.5% Chebyshev (MVUE) UCL	952.1
99% Chebyshev (MVUE) UCL	1291		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	615.8	95% Jackknife UCL	619.6
95% Standard Bootstrap UCL	613.5	95% Bootstrap-t UCL	788.2
95% Hall's Bootstrap UCL	747.9	95% Percentile Bootstrap UCL	634.2
95% BCA Bootstrap UCL	686.3		
90% Chebyshev(Mean, Sd) UCL	771.7	95% Chebyshev(Mean, Sd) UCL	927.9
97.5% Chebyshev(Mean, Sd) UCL	1145	99% Chebyshev(Mean, Sd) UCL	1571

Suggested UCL to Use

95% H-UCL	658.4

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.

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

C3 (surface)

General Statistics

Total Number of Observations	185	Number of Distinct Observations	172
		Number of Missing Observations	0
Minimum	25.7	Mean	844
Maximum	7192	Median	365
SD	1190	Std. Error of Mean	87.49
Coefficient of Variation	1.41	Skewness	2.57

Normal GOF Test

Shapiro Wilk Test Statistic	0.673	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.274	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.0651	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	988.6	95% Adjusted-CLT UCL (Chen-1995)	1006
		95% Modified-t UCL (Johnson-1978)	991.4

Gamma GOF Test

A-D Test Statistic	4.143	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.796	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.134	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.0702	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.748	k star (bias corrected MLE)	0.74
Theta hat (MLE)	1128	Theta star (bias corrected MLE)	1141
nu hat (MLE)	276.9	nu star (bias corrected)	273.7
MLE Mean (bias corrected)	844	MLE Sd (bias corrected)	981.3
		Approximate Chi Square Value (0.05)	236.4
Adjusted Level of Significance	0.0487	Adjusted Chi Square Value	236.1

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	977.2	95% Adjusted Gamma UCL (use when n<50)	978.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.965	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.00466	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.055	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.0651	Data appear Lognormal at 5% Significance Level	

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.246	Mean of logged Data	5.938
Maximum of Logged Data	8.881	SD of logged Data	1.302

Assuming Lognormal Distribution

95% H-UCL	1120	90% Chebyshev (MVUE) UCL	1214
95% Chebyshev (MVUE) UCL	1366	97.5% Chebyshev (MVUE) UCL	1577
99% Chebyshev (MVUE) UCL	1992		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	987.9	95% Jackknife UCL	988.6
95% Standard Bootstrap UCL	990.3	95% Bootstrap-t UCL	1018

95% Hall's Bootstrap UCL	1003	95% Percentile Bootstrap UCL	992.4
95% BCA Bootstrap UCL	998.7		
90% Chebyshev(Mean, Sd) UCL	1106	95% Chebyshev(Mean, Sd) UCL	1225
97.5% Chebyshev(Mean, Sd) UCL	1390	99% Chebyshev(Mean, Sd) UCL	1714

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	1225

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:39:44 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (assistant keeper's quarters)

General Statistics

Total Number of Observations	25	Number of Distinct Observations	25
		Number of Missing Observations	0
Minimum	25	Mean	333.2
Maximum	1237	Median	249
SD	351.9	Std. Error of Mean	70.38
Coefficient of Variation	1.056	Skewness	1.514

Normal GOF Test

Shapiro Wilk Test Statistic	0.794	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.191	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.177	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	453.6	95% Adjusted-CLT UCL (Chen-1995)	471.7
		95% Modified-t UCL (Johnson-1978)	457.2

Gamma GOF Test

A-D Test Statistic	0.417	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.773	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.124	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.18	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1	k star (bias corrected MLE)	0.907
Theta hat (MLE)	333.2	Theta star (bias corrected MLE)	367.5
nu hat (MLE)	50	nu star (bias corrected)	45.33
MLE Mean (bias corrected)	333.2	MLE Sd (bias corrected)	349.9
		Approximate Chi Square Value (0.05)	30.89
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	30.07

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	489	95% Adjusted Gamma UCL (use when n<50)	502.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.955	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.117	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.177	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.219	Mean of logged Data	5.231
Maximum of Logged Data	7.12	SD of logged Data	1.171

Assuming Lognormal Distribution

95% H-UCL	711	90% Chebyshev (MVUE) UCL	648.2
95% Chebyshev (MVUE) UCL	780.7	97.5% Chebyshev (MVUE) UCL	964.7
99% Chebyshev (MVUE) UCL	1326		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	449	95% Jackknife UCL	453.6
95% Standard Bootstrap UCL	447.5	95% Bootstrap-t UCL	477.8
95% Hall's Bootstrap UCL	464.3	95% Percentile Bootstrap UCL	454.2
95% BCA Bootstrap UCL	463.4		
90% Chebyshev(Mean, Sd) UCL	544.3	95% Chebyshev(Mean, Sd) UCL	640
97.5% Chebyshev(Mean, Sd) UCL	772.7	99% Chebyshev(Mean, Sd) UCL	1033

Suggested UCL to Use

95% Adjusted Gamma UCL	502.3

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.

C3 (east keeper's quarters)

General Statistics

Total Number of Observations	23	Number of Distinct Observations	22
		Number of Missing Observations	0
Minimum	22.2	Mean	183.6
Maximum	913	Median	111.4
SD	238.3	Std. Error of Mean	49.69
Coefficient of Variation	1.298	Skewness	2.206

Normal GOF Test

Shapiro Wilk Test Statistic	0.646	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.914	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.303	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.185	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	268.9	95% Adjusted-CLT UCL (Chen-1995)	289.8
		95% Modified-t UCL (Johnson-1978)	272.7

Gamma GOF Test

A-D Test Statistic	1.113	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.769	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.193	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.187	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.001	k star (bias corrected MLE)	0.899
Theta hat (MLE)	183.4	Theta star (bias corrected MLE)	204.1
nu hat (MLE)	46.05	nu star (bias corrected)	41.38
MLE Mean (bias corrected)	183.6	MLE Sd (bias corrected)	193.6
		Approximate Chi Square Value (0.05)	27.63
Adjusted Level of Significance	0.0389	Adjusted Chi Square Value	26.82

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	274.9	95% Adjusted Gamma UCL (use when n<50)	283.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.938	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.914	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.113	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.185	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.1	Mean of logged Data	4.636
Maximum of Logged Data	6.817	SD of logged Data	1.055

Assuming Lognormal Distribution

95% H-UCL	322.8	90% Chebyshev (MVUE) UCL	304.5
95% Chebyshev (MVUE) UCL	363.7	97.5% Chebyshev (MVUE) UCL	445.9
99% Chebyshev (MVUE) UCL	607.4		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	265.3	95% Jackknife UCL	268.9
95% Standard Bootstrap UCL	263.3	95% Bootstrap-t UCL	304.3
95% Hall's Bootstrap UCL	267.2	95% Percentile Bootstrap UCL	268.8
95% BCA Bootstrap UCL	294.6		
90% Chebyshev(Mean, Sd) UCL	332.7	95% Chebyshev(Mean, Sd) UCL	400.2
97.5% Chebyshev(Mean, Sd) UCL	493.9	99% Chebyshev(Mean, Sd) UCL	678

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	400.2

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.

C3 (east oil storage building)

General Statistics

Total Number of Observations	16	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	26	Mean	1062
Maximum	5703	Median	307.5
SD	1563	Std. Error of Mean	390.7
Coefficient of Variation	1.472	Skewness	2.147

Normal GOF Test

Shapiro Wilk Test Statistic	0.686	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.296	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.222	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	1747	95% Adjusted-CLT UCL (Chen-1995)	1929
		95% Modified-t UCL (Johnson-1978)	1782

Gamma GOF Test

A-D Test Statistic	0.51	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.785	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.187	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.225	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.628	k star (bias corrected MLE)	0.552
Theta hat (MLE)	1690	Theta star (bias corrected MLE)	1923
nu hat (MLE)	20.11	nu star (bias corrected)	17.67
MLE Mean (bias corrected)	1062	MLE Sd (bias corrected)	1429
		Approximate Chi Square Value (0.05)	9.154
Adjusted Level of Significance	0.0335	Adjusted Chi Square Value	8.463

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	2050	95% Adjusted Gamma UCL (use when n<50)	2218

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.976	**Shapiro Wilk Lognormal GOF Test**

5% Shapiro Wilk Critical Value	0.887	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.107	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.222	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.258	Mean of logged Data	5.991
Maximum of Logged Data	8.649	SD of logged Data	1.529

Assuming Lognormal Distribution

95% H-UCL	5329	90% Chebyshev (MVUE) UCL	2618
95% Chebyshev (MVUE) UCL	3294	97.5% Chebyshev (MVUE) UCL	4232
99% Chebyshev (MVUE) UCL	6075		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1705	95% Jackknife UCL	1747
95% Standard Bootstrap UCL	1690	95% Bootstrap-t UCL	2351
95% Hall's Bootstrap UCL	1960	95% Percentile Bootstrap UCL	1732
95% BCA Bootstrap UCL	1910		
90% Chebyshev(Mean, Sd) UCL	2234	95% Chebyshev(Mean, Sd) UCL	2765
97.5% Chebyshev(Mean, Sd) UCL	3502	99% Chebyshev(Mean, Sd) UCL	4950

Suggested UCL to Use

95% Adjusted Gamma UCL 2218

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.

C3 (east outhouse)

General Statistics

Total Number of Observations	8	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	100.2	Mean	236.7
Maximum	402	Median	227
SD	99.09	Std. Error of Mean	35.03
Coefficient of Variation	0.419	Skewness	0.332

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.966	**Shapiro Wilk GOF Test**

5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.17	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.313	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	303.1	95% Adjusted-CLT UCL (Chen-1995)	298.7
		95% Modified-t UCL (Johnson-1978)	303.8

Gamma GOF Test

A-D Test Statistic	0.209	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.718	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.157	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.295	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	6.112	k star (bias corrected MLE)	3.903
Theta hat (MLE)	38.73	Theta star (bias corrected MLE)	60.64
nu hat (MLE)	97.79	nu star (bias corrected)	62.45
MLE Mean (bias corrected)	236.7	MLE Sd (bias corrected)	119.8
		Approximate Chi Square Value (0.05)	45.27
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	41.6

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	326.5	95% Adjusted Gamma UCL (use when n<50)	355.4

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.966	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.156	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.313	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.607	Mean of logged Data	5.383
Maximum of Logged Data	5.996	SD of logged Data	0.452

Assuming Lognormal Distribution

95% H-UCL	355.5	90% Chebyshev (MVUE) UCL	352.7
95% Chebyshev (MVUE) UCL	404.8	97.5% Chebyshev (MVUE) UCL	477
99% Chebyshev (MVUE) UCL	619		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	294.3	95% Jackknife UCL	303.1
95% Standard Bootstrap UCL	290.4	95% Bootstrap-t UCL	307.3
95% Hall's Bootstrap UCL	297.5	95% Percentile Bootstrap UCL	291.6

95% BCA Bootstrap UCL	290.8		
90% Chebyshev(Mean, Sd) UCL	341.8	95% Chebyshev(Mean, Sd) UCL	389.4
97.5% Chebyshev(Mean, Sd) UCL	455.5	99% Chebyshev(Mean, Sd) UCL	585.3

Suggested UCL to Use

95% Student's-t UCL	303.1

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.

C3 (fog signal building)

General Statistics

Total Number of Observations	37	Number of Distinct Observations	36
		Number of Missing Observations	0
Minimum	32.3	Mean	757
Maximum	3310	Median	546
SD	799.3	Std. Error of Mean	131.4
Coefficient of Variation	1.056	Skewness	1.893

Normal GOF Test

Shapiro Wilk Test Statistic	0.767	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.936	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.28	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.146	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	978.8	95% Adjusted-CLT UCL (Chen-1995)	1017
		95% Modified-t UCL (Johnson-1978)	985.7

Gamma GOF Test

A-D Test Statistic	0.441	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.775	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.158	**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)	1.095	k star (bias corrected MLE)	1.024
Theta hat (MLE)	691.6	Theta star (bias corrected MLE)	739.4
nu hat (MLE)	80.99	nu star (bias corrected)	75.76
MLE Mean (bias corrected)	757	MLE Sd (bias corrected)	748.2
		Approximate Chi Square Value (0.05)	56.71
Adjusted Level of Significance	0.0431	Adjusted Chi Square Value	56

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	1011	95% Adjusted Gamma UCL (use when n<50)	1024

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.965	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.936	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.102	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.146	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.475	Mean of logged Data	6.107
Maximum of Logged Data	8.105	SD of logged Data	1.123

Assuming Lognormal Distribution

95% H-UCL	1355	90% Chebyshev (MVUE) UCL	1365
95% Chebyshev (MVUE) UCL	1611	97.5% Chebyshev (MVUE) UCL	1952
99% Chebyshev (MVUE) UCL	2623		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	973.1	95% Jackknife UCL	978.8
95% Standard Bootstrap UCL	967.1	95% Bootstrap-t UCL	1055
95% Hall's Bootstrap UCL	1011	95% Percentile Bootstrap UCL	977.2
95% BCA Bootstrap UCL	1026		
90% Chebyshev(Mean, Sd) UCL	1151	95% Chebyshev(Mean, Sd) UCL	1330
97.5% Chebyshev(Mean, Sd) UCL	1578	99% Chebyshev(Mean, Sd) UCL	2064

Suggested UCL to Use

95% Adjusted Gamma UCL	1024

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.

C3 (lighthouse)

General Statistics

Total Number of Observations	53	Number of Distinct Observations	53
		Number of Missing Observations	0
Minimum	29	Mean	1333
Maximum	4553	Median	660
SD	1360	Std. Error of Mean	186.8
Coefficient of Variation	1.02	Skewness	0.876

Normal GOF Test

Shapiro Wilk Test Statistic	0.825	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	3.6330E-8	Data Not Normal at 5% Significance Level	

Lilliefors Test Statistic	0.202	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.122	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	1646	95% Adjusted-CLT UCL (Chen-1995)	1664
		95% Modified-t UCL (Johnson-1978)	1650

Gamma GOF Test

A-D Test Statistic	0.855	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.791	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.11	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.127	Detected data appear Gamma Distributed at 5% Significance Level	

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

Gamma Statistics

k hat (MLE)	0.78	k star (bias corrected MLE)	0.749
Theta hat (MLE)	1709	Theta star (bias corrected MLE)	1781
nu hat (MLE)	82.71	nu star (bias corrected)	79.36
MLE Mean (bias corrected)	1333	MLE Sd (bias corrected)	1541
		Approximate Chi Square Value (0.05)	59.84
Adjusted Level of Significance	0.0455	Adjusted Chi Square Value	59.36

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	1768	95% Adjusted Gamma UCL (use when n<50)	1782

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.922	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.00206	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.109	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.122	Data appear Lognormal at 5% Significance Level	

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.367	Mean of logged Data	6.432
Maximum of Logged Data	8.424	SD of logged Data	1.447

Assuming Lognormal Distribution

95% H-UCL	3162	90% Chebyshev (MVUE) UCL	3044
95% Chebyshev (MVUE) UCL	3651	97.5% Chebyshev (MVUE) UCL	4493
99% Chebyshev (MVUE) UCL	6148		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1640	95% Jackknife UCL	1646
95% Standard Bootstrap UCL	1643	95% Bootstrap-t UCL	1672
95% Hall's Bootstrap UCL	1661	95% Percentile Bootstrap UCL	1665
95% BCA Bootstrap UCL	1652		

90% Chebyshev(Mean, Sd) UCL	1893	95% Chebyshev(Mean, Sd) UCL	2147
97.5% Chebyshev(Mean, Sd) UCL	2499	99% Chebyshev(Mean, Sd) UCL	3191

Suggested UCL to Use

95% Approximate Gamma UCL	1768

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.

C3 (storehouse)

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	113.6	Mean	415.2
Maximum	1119	Median	231
SD	310.6	Std. Error of Mean	93.66
Coefficient of Variation	0.748	Skewness	1.201

Normal GOF Test

Shapiro Wilk Test Statistic	0.842	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.269	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.267	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	584.9	95% Adjusted-CLT UCL (Chen-1995)	605.5
		95% Modified-t UCL (Johnson-1978)	590.6

Gamma GOF Test

A-D Test Statistic	0.556	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.738	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.254	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.258	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.166	k star (bias corrected MLE)	1.636
Theta hat (MLE)	191.6	Theta star (bias corrected MLE)	253.7
nu hat (MLE)	47.66	nu star (bias corrected)	36
MLE Mean (bias corrected)	415.2	MLE Sd (bias corrected)	324.6
		Approximate Chi Square Value (0.05)	23.27
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	21.61

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	642.3	95% Adjusted Gamma UCL (use when n<50)	691.6

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.922	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.221	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.267	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.733	Mean of logged Data	5.78
Maximum of Logged Data	7.02	SD of logged Data	0.741

Assuming Lognormal Distribution

95% H-UCL	771.1	90% Chebyshev (MVUE) UCL	701.8
95% Chebyshev (MVUE) UCL	832.4	97.5% Chebyshev (MVUE) UCL	1014
99% Chebyshev (MVUE) UCL	1370		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	569.2	95% Jackknife UCL	584.9
95% Standard Bootstrap UCL	567.4	95% Bootstrap-t UCL	630
95% Hall's Bootstrap UCL	614.7	95% Percentile Bootstrap UCL	564.9
95% BCA Bootstrap UCL	589.9		
90% Chebyshev(Mean, Sd) UCL	696.2	95% Chebyshev(Mean, Sd) UCL	823.4
97.5% Chebyshev(Mean, Sd) UCL	1000	99% Chebyshev(Mean, Sd) UCL	1347

Suggested UCL to Use

95% Adjusted Gamma UCL	691.6

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.

C3 (tramway engine building)

General Statistics

Total Number of Observations	16	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	29.8	Mean	1209
Maximum	6382	Median	371.5
SD	1661	Std. Error of Mean	415.3
Coefficient of Variation	1.374	Skewness	2.193

Normal GOF Test

Shapiro Wilk Test Statistic	0.715	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.887	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.239	**Lilliefors GOF Test**	

5% Lilliefors Critical Value	0.222	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	1937	95% Adjusted-CLT UCL (Chen-1995)	2135
		95% Modified-t UCL (Johnson-1978)	1975

Gamma GOF Test

A-D Test Statistic	0.629	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.791	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.216	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.226	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.564	k star (bias corrected MLE)	0.5
Theta hat (MLE)	2143	Theta star (bias corrected MLE)	2418
nu hat (MLE)	18.04	nu star (bias corrected)	15.99
MLE Mean (bias corrected)	1209	MLE Sd (bias corrected)	1710
		Approximate Chi Square Value (0.05)	7.958
Adjusted Level of Significance	0.0335	Adjusted Chi Square Value	7.32

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	2429	95% Adjusted Gamma UCL (use when n<50)	2641

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.921	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.887	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.182	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.222	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.395	Mean of logged Data	5.991
Maximum of Logged Data	8.761	SD of logged Data	1.737

Assuming Lognormal Distribution

95% H-UCL	10756	90% Chebyshev (MVUE) UCL	3755
95% Chebyshev (MVUE) UCL	4781	97.5% Chebyshev (MVUE) UCL	6205
99% Chebyshev (MVUE) UCL	9002		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1892	95% Jackknife UCL	1937
95% Standard Bootstrap UCL	1863	95% Bootstrap-t UCL	2482
95% Hall's Bootstrap UCL	4519	95% Percentile Bootstrap UCL	1927
95% BCA Bootstrap UCL	2140		
90% Chebyshev(Mean, Sd) UCL	2455	95% Chebyshev(Mean, Sd) UCL	3019

97.5% Chebyshev(Mean, Sd) UCL	3802	99% Chebyshev(Mean, Sd) UCL	5341

Suggested UCL to Use

95% Adjusted Gamma UCL	2641

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.

C3 (west keeper's quarters)

General Statistics

Total Number of Observations	27	Number of Distinct Observations	27
		Number of Missing Observations	0
Minimum	35.5	Mean	343
Maximum	2282	Median	218
SD	465.2	Std. Error of Mean	89.52
Coefficient of Variation	1.356	Skewness	3.289

Normal GOF Test

Shapiro Wilk Test Statistic	0.587	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.923	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.286	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.171	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	495.7	95% Adjusted-CLT UCL (Chen-1995)	550.8
		95% Modified-t UCL (Johnson-1978)	505.2

Gamma GOF Test

A-D Test Statistic	1.006	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.77	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.172	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.172	Detected data appear Gamma Distributed at 5% Significance Level

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

Gamma Statistics

k hat (MLE)	1.157	k star (bias corrected MLE)	1.053
Theta hat (MLE)	296.5	Theta star (bias corrected MLE)	325.8
nu hat (MLE)	62.46	nu star (bias corrected)	56.86
MLE Mean (bias corrected)	343	MLE Sd (bias corrected)	334.3
		Approximate Chi Square Value (0.05)	40.52
Adjusted Level of Significance	0.0401	Adjusted Chi Square Value	39.64

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	481.3	95% Adjusted Gamma UCL (use when n<50)	492

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.977	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.923	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0944	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.171	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.57	Mean of logged Data	5.347
Maximum of Logged Data	7.733	SD of logged Data	0.942

Assuming Lognormal Distribution

95% H-UCL	514	90% Chebyshev (MVUE) UCL	516.2
95% Chebyshev (MVUE) UCL	605.1	97.5% Chebyshev (MVUE) UCL	728.5
99% Chebyshev (MVUE) UCL	971		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	490.3	95% Jackknife UCL	495.7
95% Standard Bootstrap UCL	484.6	95% Bootstrap-t UCL	720
95% Hall's Bootstrap UCL	1123	95% Percentile Bootstrap UCL	498.6
95% BCA Bootstrap UCL	578.6		
90% Chebyshev(Mean, Sd) UCL	611.6	95% Chebyshev(Mean, Sd) UCL	733.3
97.5% Chebyshev(Mean, Sd) UCL	902.1	99% Chebyshev(Mean, Sd) UCL	1234

Suggested UCL to Use

95% Adjusted Gamma UCL	492

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.

C3 (west oil storage building)

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	36.6	Mean	1106
Maximum	7192	Median	397
SD	2079	Std. Error of Mean	627
Coefficient of Variation	1.881	Skewness	3.002

Normal GOF Test

Shapiro Wilk Test Statistic	0.529	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.399	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.267	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	2242	95% Adjusted-CLT UCL (Chen-1995)	2743
		95% Modified-t UCL (Johnson-1978)	2336

Gamma GOF Test

A-D Test Statistic	0.752	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.772	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.284	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.267	Data Not Gamma Distributed at 5% Significance Level	

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

Gamma Statistics

k hat (MLE)	0.619	k star (bias corrected MLE)	0.511
Theta hat (MLE)	1786	Theta star (bias corrected MLE)	2164
nu hat (MLE)	13.62	nu star (bias corrected)	11.24
MLE Mean (bias corrected)	1106	MLE Sd (bias corrected)	1547
		Approximate Chi Square Value (0.05)	4.729
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	4.063

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	2627	95% Adjusted Gamma UCL (use when n<50)	3058

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.965	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.178	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.267	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.6	Mean of logged Data	6.014
Maximum of Logged Data	8.881	SD of logged Data	1.413

Assuming Lognormal Distribution

95% H-UCL	6188	90% Chebyshev (MVUE) UCL	2272
95% Chebyshev (MVUE) UCL	2868	97.5% Chebyshev (MVUE) UCL	3695
99% Chebyshev (MVUE) UCL	5320		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	2137	95% Jackknife UCL	2242
95% Standard Bootstrap UCL	2066	95% Bootstrap-t UCL	7435
95% Hall's Bootstrap UCL	6990	95% Percentile Bootstrap UCL	2252
95% BCA Bootstrap UCL	2852		
90% Chebyshev(Mean, Sd) UCL	2986	95% Chebyshev(Mean, Sd) UCL	3838
97.5% Chebyshev(Mean, Sd) UCL	5021	99% Chebyshev(Mean, Sd) UCL	7344

Suggested UCL to Use

95% Adjusted Gamma UCL	3058

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.

C3 (west outhouse)

General Statistics

Total Number of Observations	6	Number of Distinct Observations	6
		Number of Missing Observations	0
Minimum	67.7	Mean	196.7
Maximum	343	Median	179.7
SD	100.2	Std. Error of Mean	40.9
Coefficient of Variation	0.509	Skewness	0.341

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.976	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.788	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.175	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.362	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	279.1	95% Adjusted-CLT UCL (Chen-1995)	270
		95% Modified-t UCL (Johnson-1978)	280

Gamma GOF Test

A-D Test Statistic	0.181	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.7	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.144	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.333	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	4.119	k star (bias corrected MLE)	2.171
Theta hat (MLE)	47.74	Theta star (bias corrected MLE)	90.6
nu hat (MLE)	49.43	nu star (bias corrected)	26.05
MLE Mean (bias corrected)	196.7	MLE Sd (bias corrected)	133.5
		Approximate Chi Square Value (0.05)	15.42
Adjusted Level of Significance	0.0122	Adjusted Chi Square Value	12.56

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	332.3	95% Adjusted Gamma UCL (use when n<50)	407.8

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.963	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.788	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.166	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.362	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.215	Mean of logged Data	5.155
Maximum of Logged Data	5.838	SD of logged Data	0.579

Assuming Lognormal Distribution

95% H-UCL	427.4	90% Chebyshev (MVUE) UCL	339.5
95% Chebyshev (MVUE) UCL	403.2	97.5% Chebyshev (MVUE) UCL	491.6
99% Chebyshev (MVUE) UCL	665.4		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	263.9	95% Jackknife UCL	279.1
95% Standard Bootstrap UCL	259.1	95% Bootstrap-t UCL	289.9
95% Hall's Bootstrap UCL	305.6	95% Percentile Bootstrap UCL	262.4
95% BCA Bootstrap UCL	256.4		
90% Chebyshev(Mean, Sd) UCL	319.3	95% Chebyshev(Mean, Sd) UCL	374.9
97.5% Chebyshev(Mean, Sd) UCL	452.1	99% Chebyshev(Mean, Sd) UCL	603.6

Suggested UCL to Use

95% Student's-t UCL	279.1

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:49:14 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (assistant keeper's quarters)

General Statistics

Total Number of Observations	9	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	25	Mean	307.6
Maximum	1138	Median	282
SD	352	Std. Error of Mean	117.3
Coefficient of Variation	1.144	Skewness	1.892

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.782	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.254	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	525.8	95% Adjusted-CLT UCL (Chen-1995)	579.7
		95% Modified-t UCL (Johnson-1978)	538.1

Gamma GOF Test

A-D Test Statistic	0.296	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.746	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.171	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.288	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.915	k star (bias corrected MLE)	0.684
Theta hat (MLE)	336.3	Theta star (bias corrected MLE)	449.9
nu hat (MLE)	16.46	nu star (bias corrected)	12.31
MLE Mean (bias corrected)	307.6	MLE Sd (bias corrected)	372
		Approximate Chi Square Value (0.05)	5.431
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	4.506

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	697.2	95% Adjusted Gamma UCL (use when n<50)	840.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.944	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.22	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.219	Mean of logged Data	5.091
Maximum of Logged Data	7.037	SD of logged Data	1.297

Assuming Lognormal Distribution

95% H-UCL	2289	90% Chebyshev (MVUE) UCL	767.5
95% Chebyshev (MVUE) UCL	967	97.5% Chebyshev (MVUE) UCL	1244
99% Chebyshev (MVUE) UCL	1788		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	500.6	95% Jackknife UCL	525.8
95% Standard Bootstrap UCL	491.5	95% Bootstrap-t UCL	701.3
95% Hall's Bootstrap UCL	1390	95% Percentile Bootstrap UCL	498.6
95% BCA Bootstrap UCL	574		
90% Chebyshev(Mean, Sd) UCL	659.6	95% Chebyshev(Mean, Sd) UCL	819.1
97.5% Chebyshev(Mean, Sd) UCL	1040	99% Chebyshev(Mean, Sd) UCL	1475

Suggested UCL to Use

95% Student's-t UCL	525.8

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.

C3 (east keeper's quarters)

General Statistics

Total Number of Observations	9	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	22.2	Mean	109.7
Maximum	249	Median	111.4
SD	70.4	Std. Error of Mean	23.47
Coefficient of Variation	0.642	Skewness	0.804

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use

guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.932	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.829	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.218	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.295	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	153.4	95% Adjusted-CLT UCL (Chen-1995)	155
		95% Modified-t UCL (Johnson-1978)	154.4

Gamma GOF Test

A-D Test Statistic	0.325	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.729	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.162	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.282	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.333	k star (bias corrected MLE)	1.629
Theta hat (MLE)	47.04	Theta star (bias corrected MLE)	67.35
nu hat (MLE)	41.99	nu star (bias corrected)	29.32
MLE Mean (bias corrected)	109.7	MLE Sd (bias corrected)	85.96
		Approximate Chi Square Value (0.05)	17.96
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	16.11

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	179.1	95% Adjusted Gamma UCL (use when n<50)	199.7

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.911	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.203	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.295	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.1	Mean of logged Data	4.469
Maximum of Logged Data	5.517	SD of logged Data	0.786

Assuming Lognormal Distribution

95% H-UCL	257.7	90% Chebyshev (MVUE) UCL	206.1
95% Chebyshev (MVUE) UCL	247.9	97.5% Chebyshev (MVUE) UCL	305.8
99% Chebyshev (MVUE) UCL	419.6		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	148.3	95% Jackknife UCL	153.4
95% Standard Bootstrap UCL	145.6	95% Bootstrap-t UCL	167.4
95% Hall's Bootstrap UCL	206	95% Percentile Bootstrap UCL	146.5
95% BCA Bootstrap UCL	154.2		
90% Chebyshev(Mean, Sd) UCL	180.1	95% Chebyshev(Mean, Sd) UCL	212
97.5% Chebyshev(Mean, Sd) UCL	256.3	99% Chebyshev(Mean, Sd) UCL	343.2

Suggested UCL to Use

95% Student's-t UCL	153.4

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.

C3 (east oil storage building)

General Statistics

Total Number of Observations	1	Number of Distinct Observations	1
		Number of Missing Observations	0
Minimum	26	Mean	26
Maximum	26	Median	26

Warning: This data set only has 1 observations!
Data set is too small to compute reliable and meaningful statistics and estimates!
The data set for variable C3 (east oil storage building) was not processed!

It is suggested to collect at least 8 to 10 observations before using these statistical methods!
If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

C3 (east outhouse)

General Statistics

Total Number of Observations	1	Number of Distinct Observations	1
		Number of Missing Observations	0
Minimum	304	Mean	304
Maximum	304	Median	304

Warning: This data set only has 1 observations!
Data set is too small to compute reliable and meaningful statistics and estimates!
The data set for variable C3 (east outhouse) was not processed!

It is suggested to collect at least 8 to 10 observations before using these statistical methods!
If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

C3 (fog signal building)

General Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	39.3	Mean	308.3
Maximum	638	Median	278
SD	260.3	Std. Error of Mean	130.2
Coefficient of Variation	0.844	Skewness	0.546

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.975	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.193	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	614.6	95% Adjusted-CLT UCL (Chen-1995)	560.4
		95% Modified-t UCL (Johnson-1978)	620.6

Gamma GOF Test

A-D Test Statistic	0.22	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.664	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.203	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.4	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.332	k star (bias corrected MLE)	0.5
Theta hat (MLE)	231.6	Theta star (bias corrected MLE)	617.2
nu hat (MLE)	10.65	nu star (bias corrected)	3.996
MLE Mean (bias corrected)	308.3	MLE Sd (bias corrected)	436.2
		Approximate Chi Square Value (0.05)	0.72
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1711	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.945	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.206	**Lilliefors Lognormal GOF Test**

5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.671	Mean of logged Data	5.311
Maximum of Logged Data	6.458	SD of logged Data	1.213

Assuming Lognormal Distribution

95% H-UCL	117098	90% Chebyshev (MVUE) UCL	880.8
95% Chebyshev (MVUE) UCL	1128	97.5% Chebyshev (MVUE) UCL	1472
99% Chebyshev (MVUE) UCL	2147		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	522.4	95% Jackknife UCL	614.6
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	698.8	95% Chebyshev(Mean, Sd) UCL	875.7
97.5% Chebyshev(Mean, Sd) UCL	1121	99% Chebyshev(Mean, Sd) UCL	1603

Suggested UCL to Use

95% Student's-t UCL	614.6

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.

C3 (lighthouse)

General Statistics

Total Number of Observations	5	Number of Distinct Observations	5
		Number of Missing Observations	0
Minimum	53	Mean	1610
Maximum	4050	Median	415
SD	1904	Std. Error of Mean	851.6
Coefficient of Variation	1.183	Skewness	0.678

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.793	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.762	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.335	**Lilliefors GOF Test**	

5% Lilliefors Critical Value	0.396	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	3426	95% Adjusted-CLT UCL (Chen-1995)	3287
		95% Modified-t UCL (Johnson-1978)	3469

Gamma GOF Test

A-D Test Statistic	0.398	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.705	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.26	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.369	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.612	k star (bias corrected MLE)	0.378
Theta hat (MLE)	2630	Theta star (bias corrected MLE)	4257
nu hat (MLE)	6.122	nu star (bias corrected)	3.782
MLE Mean (bias corrected)	1610	MLE Sd (bias corrected)	2618
		Approximate Chi Square Value (0.05)	0.638
Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	0.256

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	9551	95% Adjusted Gamma UCL (use when n<50)	23829

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.921	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.227	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.97	Mean of logged Data	6.378
Maximum of Logged Data	8.306	SD of logged Data	1.83

Assuming Lognormal Distribution

95% H-UCL	8324779	90% Chebyshev (MVUE) UCL	5626
95% Chebyshev (MVUE) UCL	7349	97.5% Chebyshev (MVUE) UCL	9742
99% Chebyshev (MVUE) UCL	14442		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	3011	95% Jackknife UCL	3426
95% Standard Bootstrap UCL	2883	95% Bootstrap-t UCL	18511
95% Hall's Bootstrap UCL	26895	95% Percentile Bootstrap UCL	2985
95% BCA Bootstrap UCL	2947		
90% Chebyshev(Mean, Sd) UCL	4165	95% Chebyshev(Mean, Sd) UCL	5322

97.5% Chebyshev(Mean, Sd) UCL	6928	99% Chebyshev(Mean, Sd) UCL	10084

Suggested UCL to Use

95% Student's-t UCL	3426

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.

C3 (tramway engine building)

General Statistics

Total Number of Observations	5	Number of Distinct Observations	5
		Number of Missing Observations	0
Minimum	29.8	Mean	248
Maximum	981	Median	48.4
SD	412.7	Std. Error of Mean	184.6
Coefficient of Variation	1.664	Skewness	2.161

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.64	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.395	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	641.4	95% Adjusted-CLT UCL (Chen-1995)	742.1
		95% Modified-t UCL (Johnson-1978)	671.1

Gamma GOF Test

A-D Test Statistic	0.654	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.705	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.313	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.369	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.623	k star (bias corrected MLE)	0.383
Theta hat (MLE)	397.9	Theta star (bias corrected MLE)	648.1
nu hat (MLE)	6.233	nu star (bias corrected)	3.826
MLE Mean (bias corrected)	248	MLE Sd (bias corrected)	400.9
		Approximate Chi Square Value (0.05)	0.654

Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	0.264

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1450	95% Adjusted Gamma UCL (use when n<50)	3598

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.841	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.271	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.395	Mean of logged Data	4.528
Maximum of Logged Data	6.889	SD of logged Data	1.467

Assuming Lognormal Distribution

95% H-UCL	45127	90% Chebyshev (MVUE) UCL	552.4
95% Chebyshev (MVUE) UCL	712.7	97.5% Chebyshev (MVUE) UCL	935.1
99% Chebyshev (MVUE) UCL	1372		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	551.5	95% Jackknife UCL	641.4
95% Standard Bootstrap UCL	517.6	95% Bootstrap-t UCL	9524
95% Hall's Bootstrap UCL	3678	95% Percentile Bootstrap UCL	600.5
95% BCA Bootstrap UCL	624.7		
90% Chebyshev(Mean, Sd) UCL	801.6	95% Chebyshev(Mean, Sd) UCL	1052
97.5% Chebyshev(Mean, Sd) UCL	1401	99% Chebyshev(Mean, Sd) UCL	2084

Suggested UCL to Use

95% Student's-t UCL	641.4

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.

C3 (west keeper's quarters)

General Statistics

Total Number of Observations	12	Number of Distinct Observations	12
		Number of Missing Observations	0
Minimum	52.5	Mean	453
Maximum	2282	Median	203.5
SD	662.8	Std. Error of Mean	191.3
Coefficient of Variation	1.463	Skewness	2.388

Normal GOF Test

Shapiro Wilk Test Statistic	0.628	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.859	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.353	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.256	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	796.6	95% Adjusted-CLT UCL (Chen-1995)	908.6
		95% Modified-t UCL (Johnson-1978)	818.6

Gamma GOF Test

A-D Test Statistic	0.8	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.761	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.218	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.254	Detected data appear Gamma Distributed at 5% Significance Level

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

Gamma Statistics

k hat (MLE)	0.866	k star (bias corrected MLE)	0.705
Theta hat (MLE)	523	Theta star (bias corrected MLE)	642.4
nu hat (MLE)	20.78	nu star (bias corrected)	16.92
MLE Mean (bias corrected)	453	MLE Sd (bias corrected)	539.5
		Approximate Chi Square Value (0.05)	8.616
Adjusted Level of Significance	0.029	Adjusted Chi Square Value	7.727

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	889.6	95% Adjusted Gamma UCL (use when n<50)	991.9

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.936	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.859	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.137	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.256	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.961	Mean of logged Data	5.437
Maximum of Logged Data	7.733	SD of logged Data	1.134

Assuming Lognormal Distribution

95% H-UCL	1291	90% Chebyshev (MVUE) UCL	833.7
95% Chebyshev (MVUE) UCL	1028	97.5% Chebyshev (MVUE) UCL	1298
99% Chebyshev (MVUE) UCL	1828		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	767.7	95% Jackknife UCL	796.6

95% Standard Bootstrap UCL	756.4	95% Bootstrap-t UCL	2028
95% Hall's Bootstrap UCL	2392	95% Percentile Bootstrap UCL	767.5
95% BCA Bootstrap UCL	893.4		
90% Chebyshev(Mean, Sd) UCL	1027	95% Chebyshev(Mean, Sd) UCL	1287
97.5% Chebyshev(Mean, Sd) UCL	1648	99% Chebyshev(Mean, Sd) UCL	2357

Suggested UCL to Use

95% Adjusted Gamma UCL	991.9

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.

C3 (west oil storage building)

General Statistics

Total Number of Observations	2	Number of Distinct Observations	2
		Number of Missing Observations	0
Minimum	36.6	Mean	216.8
Maximum	397	Median	216.8

Warning: This data set only has 2 observations!
Data set is too small to compute reliable and meaningful statistics and estimates!
The data set for variable C3 (west oil storage building) was not processed!

It is suggested to collect at least 8 to 10 observations before using these statistical methods!
If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:44:45 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (assistant keeper's quarters)

General Statistics

Total Number of Observations	16	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	29.7	Mean	347.6
Maximum	1237	Median	227.5
SD	362.5	Std. Error of Mean	90.63
Coefficient of Variation	1.043	Skewness	1.494

Normal GOF Test

Shapiro Wilk Test Statistic	0.81	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.196	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.222	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	506.5	95% Adjusted-CLT UCL (Chen-1995)	532.8
		95% Modified-t UCL (Johnson-1978)	512.1

Gamma GOF Test

A-D Test Statistic	0.302	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.762	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.145	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.221	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.061	k star (bias corrected MLE)	0.904
Theta hat (MLE)	327.7	Theta star (bias corrected MLE)	384.7
nu hat (MLE)	33.94	nu star (bias corrected)	28.91
MLE Mean (bias corrected)	347.6	MLE Sd (bias corrected)	365.7
		Approximate Chi Square Value (0.05)	17.64
Adjusted Level of Significance	0.0335	Adjusted Chi Square Value	16.64

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	569.7	95% Adjusted Gamma UCL (use when n<50)	603.8

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.968	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.887	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0986	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.222	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.391	Mean of logged Data	5.311
Maximum of Logged Data	7.12	SD of logged Data	1.13

Assuming Lognormal Distribution

95% H-UCL	896.2	90% Chebyshev (MVUE) UCL	703.1
95% Chebyshev (MVUE) UCL	857.9	97.5% Chebyshev (MVUE) UCL	1073
99% Chebyshev (MVUE) UCL	1495		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	496.7	95% Jackknife UCL	506.5
95% Standard Bootstrap UCL	492	95% Bootstrap-t UCL	606.7
95% Hall's Bootstrap UCL	636.4	95% Percentile Bootstrap UCL	504.8
95% BCA Bootstrap UCL	540.8		
90% Chebyshev(Mean, Sd) UCL	619.5	95% Chebyshev(Mean, Sd) UCL	742.6
97.5% Chebyshev(Mean, Sd) UCL	913.6	99% Chebyshev(Mean, Sd) UCL	1249

Suggested UCL to Use

95% Student's-t UCL	506.5

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.

C3 (east keeper's quarters)

General Statistics

Total Number of Observations	14	Number of Distinct Observations	13
		Number of Missing Observations	0
Minimum	25.7	Mean	231.1
Maximum	913	Median	98.5
SD	294.7	Std. Error of Mean	78.76
Coefficient of Variation	1.275	Skewness	1.57

Normal GOF Test

Shapiro Wilk Test Statistic	0.701	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.874	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.329	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.237	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	370.6	95% Adjusted-CLT UCL (Chen-1995)	396
		95% Modified-t UCL (Johnson-1978)	376.1

Gamma GOF Test

A-D Test Statistic	0.847	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.767	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.222	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.237	Detected data appear Gamma Distributed at 5% Significance Level

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

Gamma Statistics

k hat (MLE)	0.843	k star (bias corrected MLE)	0.71
Theta hat (MLE)	274	Theta star (bias corrected MLE)	325.3
nu hat (MLE)	23.62	nu star (bias corrected)	19.89
MLE Mean (bias corrected)	231.1	MLE Sd (bias corrected)	274.2
		Approximate Chi Square Value (0.05)	10.77
Adjusted Level of Significance	0.0312	Adjusted Chi Square Value	9.889

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	426.8	95% Adjusted Gamma UCL (use when n<50)	464.8

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.913	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.142	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.237	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.246	Mean of logged Data	4.744
Maximum of Logged Data	6.817	SD of logged Data	1.213

Assuming Lognormal Distribution

95% H-UCL	693.6	90% Chebyshev (MVUE) UCL	459.3
95% Chebyshev (MVUE) UCL	567.1	97.5% Chebyshev (MVUE) UCL	716.8
99% Chebyshev (MVUE) UCL	1011		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	360.6	95% Jackknife UCL	370.6
95% Standard Bootstrap UCL	355	95% Bootstrap-t UCL	447.6
95% Hall's Bootstrap UCL	339.9	95% Percentile Bootstrap UCL	362.4
95% BCA Bootstrap UCL	388.9		
90% Chebyshev(Mean, Sd) UCL	467.4	95% Chebyshev(Mean, Sd) UCL	574.4
97.5% Chebyshev(Mean, Sd) UCL	723	99% Chebyshev(Mean, Sd) UCL	1015

Suggested UCL to Use

95% Adjusted Gamma UCL	464.8

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.

C3 (east oil storage building)

General Statistics

Total Number of Observations	15	Number of Distinct Observations	15
		Number of Missing Observations	0
Minimum	57.9	Mean	1131
Maximum	5703	Median	337
SD	1592	Std. Error of Mean	411.1
Coefficient of Variation	1.408	Skewness	2.069

Normal GOF Test

Shapiro Wilk Test Statistic	0.699	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.881	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.295	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.229	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	1855	95% Adjusted-CLT UCL (Chen-1995)	2042
		95% Modified-t UCL (Johnson-1978)	1892

Gamma GOF Test

A-D Test Statistic	0.581	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.778	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.197	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.231	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.704	k star (bias corrected MLE)	0.608
Theta hat (MLE)	1606	Theta star (bias corrected MLE)	1861
nu hat (MLE)	21.13	nu star (bias corrected)	18.24
MLE Mean (bias corrected)	1131	MLE Sd (bias corrected)	1451
		Approximate Chi Square Value (0.05)	9.562
Adjusted Level of Significance	0.0324	Adjusted Chi Square Value	8.796

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	2157	95% Adjusted Gamma UCL (use when n<50)	2345

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.96	**Shapiro Wilk Lognormal GOF Test**

5% Shapiro Wilk Critical Value	0.881	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.134	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.229	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.059	Mean of logged Data	6.174
Maximum of Logged Data	8.649	SD of logged Data	1.392

Assuming Lognormal Distribution

95% H-UCL	4499	90% Chebyshev (MVUE) UCL	2516
95% Chebyshev (MVUE) UCL	3143	97.5% Chebyshev (MVUE) UCL	4013
99% Chebyshev (MVUE) UCL	5722		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1807	95% Jackknife UCL	1855
95% Standard Bootstrap UCL	1774	95% Bootstrap-t UCL	2575
95% Hall's Bootstrap UCL	2108	95% Percentile Bootstrap UCL	1830
95% BCA Bootstrap UCL	2015		
90% Chebyshev(Mean, Sd) UCL	2365	95% Chebyshev(Mean, Sd) UCL	2923
97.5% Chebyshev(Mean, Sd) UCL	3699	99% Chebyshev(Mean, Sd) UCL	5222

Suggested UCL to Use

95% Adjusted Gamma UCL 2345

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.

C3 (east outhouse)

General Statistics

Total Number of Observations	7	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	100.2	Mean	227.1
Maximum	402	Median	193
SD	102.9	Std. Error of Mean	38.9
Coefficient of Variation	0.453	Skewness	0.692

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.959	**Shapiro Wilk GOF Test**	

5% Shapiro Wilk Critical Value	0.803	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.201	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.335	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	302.7	95% Adjusted-CLT UCL (Chen-1995)	302
		95% Modified-t UCL (Johnson-1978)	304.4

Gamma GOF Test

A-D Test Statistic	0.163	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.71	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.165	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.313	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	5.697	k star (bias corrected MLE)	3.351
Theta hat (MLE)	39.86	Theta star (bias corrected MLE)	67.77
nu hat (MLE)	79.76	nu star (bias corrected)	46.91
MLE Mean (bias corrected)	227.1	MLE Sd (bias corrected)	124.1
		Approximate Chi Square Value (0.05)	32.19
Adjusted Level of Significance	0.0158	Adjusted Chi Square Value	28.56

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	330.9	95% Adjusted Gamma UCL (use when n<50)	373

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.988	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.803	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.133	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.335	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.607	Mean of logged Data	5.335
Maximum of Logged Data	5.996	SD of logged Data	0.466

Assuming Lognormal Distribution

95% H-UCL	364.3	90% Chebyshev (MVUE) UCL	348.2
95% Chebyshev (MVUE) UCL	402.8	97.5% Chebyshev (MVUE) UCL	478.7
99% Chebyshev (MVUE) UCL	627.7		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	291.1	95% Jackknife UCL	302.7
95% Standard Bootstrap UCL	286.9	95% Bootstrap-t UCL	319.9
95% Hall's Bootstrap UCL	319.6	95% Percentile Bootstrap UCL	288.3

95% BCA Bootstrap UCL	293.9		
90% Chebyshev(Mean, Sd) UCL	343.8	95% Chebyshev(Mean, Sd) UCL	396.7
97.5% Chebyshev(Mean, Sd) UCL	470	99% Chebyshev(Mean, Sd) UCL	614.2

Suggested UCL to Use

95% Student's-t UCL	302.7

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.

C3 (fog signal building)

General Statistics

Total Number of Observations	33	Number of Distinct Observations	32
		Number of Missing Observations	0
Minimum	32.3	Mean	811.4
Maximum	3310	Median	587
SD	827.1	Std. Error of Mean	144
Coefficient of Variation	1.019	Skewness	1.761

Normal GOF Test

Shapiro Wilk Test Statistic	0.783	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.931	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.271	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.154	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	1055	95% Adjusted-CLT UCL (Chen-1995)	1095
		95% Modified-t UCL (Johnson-1978)	1063

Gamma GOF Test

A-D Test Statistic	0.405	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.773	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.157	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.157	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.149	k star (bias corrected MLE)	1.064
Theta hat (MLE)	706.5	Theta star (bias corrected MLE)	762.3
nu hat (MLE)	75.8	nu star (bias corrected)	70.25
MLE Mean (bias corrected)	811.4	MLE Sd (bias corrected)	786.5
		Approximate Chi Square Value (0.05)	51.95
Adjusted Level of Significance	0.0419	Adjusted Chi Square Value	51.14

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	1097	95% Adjusted Gamma UCL (use when n<50)	1115

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.97	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.931	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0995	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.154	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.475	Mean of logged Data	6.204
Maximum of Logged Data	8.105	SD of logged Data	1.091

Assuming Lognormal Distribution

95% H-UCL	1468	90% Chebyshev (MVUE) UCL	1459
95% Chebyshev (MVUE) UCL	1725	97.5% Chebyshev (MVUE) UCL	2093
99% Chebyshev (MVUE) UCL	2817		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1048	95% Jackknife UCL	1055
95% Standard Bootstrap UCL	1041	95% Bootstrap-t UCL	1120
95% Hall's Bootstrap UCL	1128	95% Percentile Bootstrap UCL	1061
95% BCA Bootstrap UCL	1087		
90% Chebyshev(Mean, Sd) UCL	1243	95% Chebyshev(Mean, Sd) UCL	1439
97.5% Chebyshev(Mean, Sd) UCL	1711	99% Chebyshev(Mean, Sd) UCL	2244

Suggested UCL to Use

95% Adjusted Gamma UCL	1115

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.

C3 (lighthouse)

General Statistics

Total Number of Observations	48	Number of Distinct Observations	48
		Number of Missing Observations	0
Minimum	29	Mean	1304
Maximum	4553	Median	691.5
SD	1314	Std. Error of Mean	189.7
Coefficient of Variation	1.008	Skewness	0.917

Normal GOF Test

Shapiro Wilk Test Statistic	0.835	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level	

Lilliefors Test Statistic	0.194	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.128	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	1623	95% Adjusted-CLT UCL (Chen-1995)	1643
		95% Modified-t UCL (Johnson-1978)	1627

Gamma GOF Test

A-D Test Statistic	0.647	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.789	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.103	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.133	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.806	k star (bias corrected MLE)	0.77
Theta hat (MLE)	1618	Theta star (bias corrected MLE)	1695
nu hat (MLE)	77.38	nu star (bias corrected)	73.88
MLE Mean (bias corrected)	1304	MLE Sd (bias corrected)	1487
		Approximate Chi Square Value (0.05)	55.08
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	54.58

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	1749	95% Adjusted Gamma UCL (use when n<50)	1766

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.927	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.947	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.106	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.128	Data appear Lognormal at 5% Significance Level	

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.367	Mean of logged Data	6.438
Maximum of Logged Data	8.424	SD of logged Data	1.426

Assuming Lognormal Distribution

95% H-UCL	3113	90% Chebyshev (MVUE) UCL	2991
95% Chebyshev (MVUE) UCL	3594	97.5% Chebyshev (MVUE) UCL	4432
99% Chebyshev (MVUE) UCL	6077		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1616	95% Jackknife UCL	1623
95% Standard Bootstrap UCL	1612	95% Bootstrap-t UCL	1648
95% Hall's Bootstrap UCL	1630	95% Percentile Bootstrap UCL	1625
95% BCA Bootstrap UCL	1631		

90% Chebyshev(Mean, Sd) UCL	1873	95% Chebyshev(Mean, Sd) UCL	2131
97.5% Chebyshev(Mean, Sd) UCL	2489	99% Chebyshev(Mean, Sd) UCL	3192

Suggested UCL to Use

95% Adjusted Gamma UCL	1766

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.

C3 (storehouse)

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	113.6	Mean	415.2
Maximum	1119	Median	231
SD	310.6	Std. Error of Mean	93.66
Coefficient of Variation	0.748	Skewness	1.201

Normal GOF Test

Shapiro Wilk Test Statistic	0.842	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.269	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.267	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	584.9	95% Adjusted-CLT UCL (Chen-1995)	605.5
		95% Modified-t UCL (Johnson-1978)	590.6

Gamma GOF Test

A-D Test Statistic	0.556	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.738	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.254	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.258	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.166	k star (bias corrected MLE)	1.636
Theta hat (MLE)	191.6	Theta star (bias corrected MLE)	253.7
nu hat (MLE)	47.66	nu star (bias corrected)	36
MLE Mean (bias corrected)	415.2	MLE Sd (bias corrected)	324.6
		Approximate Chi Square Value (0.05)	23.27
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	21.61

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	642.3	95% Adjusted Gamma UCL (use when n<50)	691.6

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.922	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.221	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.267	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.733	Mean of logged Data	5.78
Maximum of Logged Data	7.02	SD of logged Data	0.741

Assuming Lognormal Distribution

95% H-UCL	771.1	90% Chebyshev (MVUE) UCL	701.8
95% Chebyshev (MVUE) UCL	832.4	97.5% Chebyshev (MVUE) UCL	1014
99% Chebyshev (MVUE) UCL	1370		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	569.2	95% Jackknife UCL	584.9
95% Standard Bootstrap UCL	561.7	95% Bootstrap-t UCL	637.5
95% Hall's Bootstrap UCL	617.2	95% Percentile Bootstrap UCL	578.3
95% BCA Bootstrap UCL	598.1		
90% Chebyshev(Mean, Sd) UCL	696.2	95% Chebyshev(Mean, Sd) UCL	823.4
97.5% Chebyshev(Mean, Sd) UCL	1000	99% Chebyshev(Mean, Sd) UCL	1347

Suggested UCL to Use

95% Adjusted Gamma UCL	691.6

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.

C3 (tramway engine building)

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	103.3	Mean	1645
Maximum	6382	Median	1803
SD	1844	Std. Error of Mean	555.9
Coefficient of Variation	1.121	Skewness	1.803

Normal GOF Test

Shapiro Wilk Test Statistic	0.775	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.224	**Lilliefors GOF Test**	

5% Lilliefors Critical Value	0.267	Data appear Normal at 5% Significance Level	

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	2653	95% Adjusted-CLT UCL (Chen-1995)	2883
		95% Modified-t UCL (Johnson-1978)	2703

Gamma GOF Test

A-D Test Statistic	0.614	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.761	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.222	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.264	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.793	k star (bias corrected MLE)	0.638
Theta hat (MLE)	2074	Theta star (bias corrected MLE)	2581
nu hat (MLE)	17.45	nu star (bias corrected)	14.03
MLE Mean (bias corrected)	1645	MLE Sd (bias corrected)	2061
		Approximate Chi Square Value (0.05)	6.589
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	5.778

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	3502	95% Adjusted Gamma UCL (use when n<50)	3994

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.876	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.264	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.267	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.638	Mean of logged Data	6.657
Maximum of Logged Data	8.761	SD of logged Data	1.451

Assuming Lognormal Distribution

95% H-UCL	13528	90% Chebyshev (MVUE) UCL	4584
95% Chebyshev (MVUE) UCL	5800	97.5% Chebyshev (MVUE) UCL	7488
99% Chebyshev (MVUE) UCL	10804		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	2560	95% Jackknife UCL	2653
95% Standard Bootstrap UCL	2516	95% Bootstrap-t UCL	3213
95% Hall's Bootstrap UCL	6449	95% Percentile Bootstrap UCL	2567
95% BCA Bootstrap UCL	2951		
90% Chebyshev(Mean, Sd) UCL	3313	95% Chebyshev(Mean, Sd) UCL	4069

97.5% Chebyshev(Mean, Sd) UCL	5117	99% Chebyshev(Mean, Sd) UCL	7177

Suggested UCL to Use

95% Student's-t UCL	2653

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.

C3 (west keeper's quarters)

General Statistics

Total Number of Observations	15	Number of Distinct Observations	15
		Number of Missing Observations	0
Minimum	35.5	Mean	255.1
Maximum	770	Median	218
SD	195.1	Std. Error of Mean	50.36
Coefficient of Variation	0.765	Skewness	1.53

Normal GOF Test

Shapiro Wilk Test Statistic	0.861	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.881	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.211	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.229	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	343.8	95% Adjusted-CLT UCL (Chen-1995)	359.2
		95% Modified-t UCL (Johnson-1978)	347.1

Gamma GOF Test

A-D Test Statistic	0.197	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.747	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.121	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.224	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.023	k star (bias corrected MLE)	1.663
Theta hat (MLE)	126.1	Theta star (bias corrected MLE)	153.4
nu hat (MLE)	60.68	nu star (bias corrected)	49.88
MLE Mean (bias corrected)	255.1	MLE Sd (bias corrected)	197.8
		Approximate Chi Square Value (0.05)	34.66
Adjusted Level of Significance	0.0324	Adjusted Chi Square Value	33.1

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	367.1	95% Adjusted Gamma UCL (use when n<50)	384.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.981	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.881	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.11	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.229	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.57	Mean of logged Data	5.274
Maximum of Logged Data	6.646	SD of logged Data	0.79

Assuming Lognormal Distribution

95% H-UCL	445.4	90% Chebyshev (MVUE) UCL	429.4
95% Chebyshev (MVUE) UCL	506.1	97.5% Chebyshev (MVUE) UCL	612.6
99% Chebyshev (MVUE) UCL	821.9		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	337.9	95% Jackknife UCL	343.8
95% Standard Bootstrap UCL	334	95% Bootstrap-t UCL	389.8
95% Hall's Bootstrap UCL	425.3	95% Percentile Bootstrap UCL	344.6
95% BCA Bootstrap UCL	360		
90% Chebyshev(Mean, Sd) UCL	406.2	95% Chebyshev(Mean, Sd) UCL	474.6
97.5% Chebyshev(Mean, Sd) UCL	569.6	99% Chebyshev(Mean, Sd) UCL	756.2

Suggested UCL to Use

95% Student's-t UCL	343.8

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.

C3 (west oil storage building)

General Statistics

Total Number of Observations	9	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	146.2	Mean	1303
Maximum	7192	Median	648
SD	2271	Std. Error of Mean	756.8
Coefficient of Variation	1.742	Skewness	2.717

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.566	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.386	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.295	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	2710	95% Adjusted-CLT UCL (Chen-1995)	3280
		95% Modified-t UCL (Johnson-1978)	2825

Gamma GOF Test

A-D Test Statistic	0.807	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.757	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.303	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.291	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.684	k star (bias corrected MLE)	0.53
Theta hat (MLE)	1905	Theta star (bias corrected MLE)	2458
nu hat (MLE)	12.31	nu star (bias corrected)	9.542
MLE Mean (bias corrected)	1303	MLE Sd (bias corrected)	1790
		Approximate Chi Square Value (0.05)	3.657
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	2.931

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	3400	95% Adjusted Gamma UCL (use when n<50)	4243

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.889	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.206	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.985	Mean of logged Data	6.286
Maximum of Logged Data	8.881	SD of logged Data	1.298

Assuming Lognormal Distribution

95% H-UCL	7584	90% Chebyshev (MVUE) UCL	2539
95% Chebyshev (MVUE) UCL	3199	97.5% Chebyshev (MVUE) UCL	4115
99% Chebyshev (MVUE) UCL	5915		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	2548	95% Jackknife UCL	2710

95% Standard Bootstrap UCL	2469	95% Bootstrap-t UCL	9743
95% Hall's Bootstrap UCL	8455	95% Percentile Bootstrap UCL	2733
95% BCA Bootstrap UCL	3537		
90% Chebyshev(Mean, Sd) UCL	3574	95% Chebyshev(Mean, Sd) UCL	4602
97.5% Chebyshev(Mean, Sd) UCL	6030	99% Chebyshev(Mean, Sd) UCL	8833

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL 4602

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.

C3 (west outhouse)

General Statistics

Total Number of Observations	6	Number of Distinct Observations	6
		Number of Missing Observations	0
Minimum	67.7	Mean	196.7
Maximum	343	Median	179.7
SD	100.2	Std. Error of Mean	40.9
Coefficient of Variation	0.509	Skewness	0.341

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.976	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.788	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.175	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.362	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	279.1	95% Adjusted-CLT UCL (Chen-1995)	270
		95% Modified-t UCL (Johnson-1978)	280

Gamma GOF Test

A-D Test Statistic	0.181	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.7	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.144	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.333	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	4.119	k star (bias corrected MLE)	2.171

Theta hat (MLE)	47.74	Theta star (bias corrected MLE)	90.6
nu hat (MLE)	49.43	nu star (bias corrected)	26.05
MLE Mean (bias corrected)	196.7	MLE Sd (bias corrected)	133.5
		Approximate Chi Square Value (0.05)	15.42
Adjusted Level of Significance	0.0122	Adjusted Chi Square Value	12.56

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	332.3	95% Adjusted Gamma UCL (use when n<50)	407.8

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.963	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.788	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.166	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.362	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.215	Mean of logged Data	5.155
Maximum of Logged Data	5.838	SD of logged Data	0.579

Assuming Lognormal Distribution

95% H-UCL	427.4	90% Chebyshev (MVUE) UCL	339.5
95% Chebyshev (MVUE) UCL	403.2	97.5% Chebyshev (MVUE) UCL	491.6
99% Chebyshev (MVUE) UCL	665.4		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	263.9	95% Jackknife UCL	279.1
95% Standard Bootstrap UCL	258.6	95% Bootstrap-t UCL	294.8
95% Hall's Bootstrap UCL	305.6	95% Percentile Bootstrap UCL	263.3
95% BCA Bootstrap UCL	263.1		
90% Chebyshev(Mean, Sd) UCL	319.3	95% Chebyshev(Mean, Sd) UCL	374.9
97.5% Chebyshev(Mean, Sd) UCL	452.1	99% Chebyshev(Mean, Sd) UCL	603.6

Suggested UCL to Use

95% Student's-t UCL	279.1

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:37:13 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3

General Statistics

Total Number of Observations	233	Number of Distinct Observations	215
		Number of Missing Observations	0
Minimum	22.2	Mean	758
Maximum	7192	Median	288
SD	1131	Std. Error of Mean	74.13
Coefficient of Variation	1.493	Skewness	2.706

Normal GOF Test

Shapiro Wilk Test Statistic	0.649	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.279	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.058	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	880.4	95% Adjusted-CLT UCL (Chen-1995)	894
		95% Modified-t UCL (Johnson-1978)	882.6

Gamma GOF Test

A-D Test Statistic	5.775	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.801	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.127	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.0624	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.701	k star (bias corrected MLE)	0.695
Theta hat (MLE)	1081	Theta star (bias corrected MLE)	1091
nu hat (MLE)	326.7	nu star (bias corrected)	323.8
MLE Mean (bias corrected)	758	MLE Sd (bias corrected)	909.3
		Approximate Chi Square Value (0.05)	283.1
Adjusted Level of Significance	0.049	Adjusted Chi Square Value	282.9

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	867	95% Adjusted Gamma UCL (use when n<50)	867.7

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.963	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	2.7476E-4	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0491	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.058	Data appear Lognormal at 5% Significance Level	

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.1	Mean of logged Data	5.769
Maximum of Logged Data	8.881	SD of logged Data	1.343

Assuming Lognormal Distribution

95% H-UCL	980.5	90% Chebyshev (MVUE) UCL	1063
95% Chebyshev (MVUE) UCL	1190	97.5% Chebyshev (MVUE) UCL	1366
99% Chebyshev (MVUE) UCL	1712		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	879.9	95% Jackknife UCL	880.4
95% Standard Bootstrap UCL	882	95% Bootstrap-t UCL	888.2
95% Hall's Bootstrap UCL	890.7	95% Percentile Bootstrap UCL	884.3
95% BCA Bootstrap UCL	884		
90% Chebyshev(Mean, Sd) UCL	980.4	95% Chebyshev(Mean, Sd) UCL	1081
97.5% Chebyshev(Mean, Sd) UCL	1221	99% Chebyshev(Mean, Sd) UCL	1496

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	1081

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:22:50 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (subsurface)

General Statistics

Total Number of Observations	50	Number of Distinct Observations	48
		Number of Missing Observations	0
Minimum	6.9	Mean	287.5
Maximum	3359	Median	94.5
SD	627.9	Std. Error of Mean	88.8
Coefficient of Variation	2.184	Skewness	3.698

Normal GOF Test

Shapiro Wilk Test Statistic	0.477	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.334	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.125	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	436.4	95% Adjusted-CLT UCL (Chen-1995)	483.2
		95% Modified-t UCL (Johnson-1978)	444.1

Gamma GOF Test

A-D Test Statistic	3.123	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.813	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.249	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.132	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.519	k star (bias corrected MLE)	0.501
Theta hat (MLE)	554.2	Theta star (bias corrected MLE)	573.8
nu hat (MLE)	51.88	nu star (bias corrected)	50.1
MLE Mean (bias corrected)	287.5	MLE Sd (bias corrected)	406.2
		Approximate Chi Square Value (0.05)	34.85
Adjusted Level of Significance	0.0452	Adjusted Chi Square Value	34.47

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	413.3	95% Adjusted Gamma UCL (use when n<50)	417.9

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.948	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.132	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.125	Data Not Lognormal at 5% Significance Level	

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.932	Mean of logged Data	4.444
Maximum of Logged Data	8.119	SD of logged Data	1.469

Assuming Lognormal Distribution

95% H-UCL	460.3	90% Chebyshev (MVUE) UCL	437.1
95% Chebyshev (MVUE) UCL	526.4	97.5% Chebyshev (MVUE) UCL	650.3
99% Chebyshev (MVUE) UCL	893.8		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	433.6	95% Jackknife UCL	436.4
95% Standard Bootstrap UCL	435.5	95% Bootstrap-t UCL	554.9
95% Hall's Bootstrap UCL	660.6	95% Percentile Bootstrap UCL	441.7
95% BCA Bootstrap UCL	497.9		
90% Chebyshev(Mean, Sd) UCL	553.9	95% Chebyshev(Mean, Sd) UCL	674.6
97.5% Chebyshev(Mean, Sd) UCL	842.1	99% Chebyshev(Mean, Sd) UCL	1171

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	674.6

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.

C3 (surface)

General Statistics

Total Number of Observations	80	Number of Distinct Observations	76
		Number of Missing Observations	0
Minimum	17.5	Mean	589.6
Maximum	8662	Median	261.5
SD	1154	Std. Error of Mean	129
Coefficient of Variation	1.957	Skewness	5.047

Normal GOF Test

Shapiro Wilk Test Statistic	0.468	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.31	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.0991	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	804.2	95% Adjusted-CLT UCL (Chen-1995)	879.5
		95% Modified-t UCL (Johnson-1978)	816.4

Gamma GOF Test

A-D Test Statistic	3.316	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.793	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.167	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.104	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.761	k star (bias corrected MLE)	0.741
Theta hat (MLE)	774.5	Theta star (bias corrected MLE)	795.6
nu hat (MLE)	121.8	nu star (bias corrected)	118.6
MLE Mean (bias corrected)	589.6	MLE Sd (bias corrected)	684.9
		Approximate Chi Square Value (0.05)	94.42
Adjusted Level of Significance	0.047	Adjusted Chi Square Value	94.03

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	740.3	95% Adjusted Gamma UCL (use when n<50)	743.4

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.982	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.677	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0648	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.0991	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.862	Mean of logged Data	5.595
Maximum of Logged Data	9.067	SD of logged Data	1.175

Assuming Lognormal Distribution

95% H-UCL	741.6	90% Chebyshev (MVUE) UCL	790.3
95% Chebyshev (MVUE) UCL	908.7	97.5% Chebyshev (MVUE) UCL	1073
99% Chebyshev (MVUE) UCL	1396		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	801.7	95% Jackknife UCL	804.2
95% Standard Bootstrap UCL	795.5	95% Bootstrap-t UCL	965.1
95% Hall's Bootstrap UCL	1594	95% Percentile Bootstrap UCL	822.2
95% BCA Bootstrap UCL	912.5		
90% Chebyshev(Mean, Sd) UCL	976.5	95% Chebyshev(Mean, Sd) UCL	1152
97.5% Chebyshev(Mean, Sd) UCL	1395	99% Chebyshev(Mean, Sd) UCL	1873

Suggested UCL to Use

95% H-UCL	741.6

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.

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

UCL Statistics for Uncensored Full Data Sets

User Selected Options

Date/Time of Computation	3/6/2014 14:50
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (above ground storage tank)

General Statistics

Total Number of Observations	12	Number of Distinct Observations	12
		Number of Missing Observations	0
Minimum	20	Mean	211.2
Maximum	936	Median	124
SD	251	Std. Error of Mean	72.45
Coefficient of Variation	1.188	Skewness	2.563

Normal GOF Test

Shapiro Wilk Test Statistic	0.666	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.859	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.331	Lilliefors GOF Test
5% Lilliefors Critical Value	0.256	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	341.3	95% Adjusted-CLT UCL (Chen-1995)	387.6
		95% Modified-t UCL (Johnson-1978)	350.2

Gamma GOF Test

A-D Test Statistic	0.565	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.752	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.243	Kolmogrov-Smirnoff Gamma GOF Test
5% K-S Critical Value	0.251	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.225	k star (bias corrected MLE)	0.974
Theta hat (MLE)	172.4	Theta star (bias corrected MLE)	216.8
nu hat (MLE)	29.4	nu star (bias corrected)	23.38
MLE Mean (bias corrected)	211.2	MLE Sd (bias corrected)	213.9
		Approximate Chi Square Value (0.05)	13.38
Adjusted Level of Significance	0.029	Adjusted Chi Square Value	12.24

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	369	95% Adjusted Gamma UCL (use when n<50)	403.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.96	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk Critical Value	0.859	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.196	Lilliefors Lognormal GOF Test
5% Lilliefors Critical Value	0.256	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.996	Mean of logged Data	4.892
Maximum of Logged Data	6.842	SD of logged Data	0.993

Assuming Lognormal Distribution

95% H-UCL	519.5	90% Chebyshev (MVUE) UCL	395.6
95% Chebyshev (MVUE) UCL	481.5	97.5% Chebyshev (MVUE) UCL	600.6
99% Chebyshev (MVUE) UCL	834.5		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	330.3	95% Jackknife UCL	341.3
95% Standard Bootstrap UCL	324.1	95% Bootstrap-t UCL	599.5

95% Hall's Bootstrap UCL	843.2	95% Percentile Bootstrap UCL	332.3
95% BCA Bootstrap UCL	394		
90% Chebyshev(Mean, Sd) UCL	428.5	95% Chebyshev(Mean, Sd) UCL	526.9
97.5% Chebyshev(Mean, Sd) UCL	663.6	99% Chebyshev(Mean, Sd) UCL	932

Suggested UCL to Use
95% Adjusted Gamma UCL 403.5

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.

C3 (fog signal building)

General Statistics

Total Number of Observations	24	Number of Distinct Observations	23
		Number of Missing Observations	0
Minimum	14	Mean	835
Maximum	8662	Median	349
SD	1744	Std. Error of Mean	356.1
Coefficient of Variation	2.089	Skewness	4.277

Normal GOF Test

Shapiro Wilk Test Statistic	0.431	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.916	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.374	Lilliefors GOF Test
5% Lilliefors Critical Value	0.181	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	1445	95% Adjusted-CLT UCL (Chen-1995)	1753
		95% Modified-t UCL (Johnson-1978)	1497

Gamma GOF Test

A-D Test Statistic	0.934	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.792	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.211	Kolmogrov-Smirnoff Gamma GOF Test
5% K-S Critical Value	0.186	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.649	k star (bias corrected MLE)	0.596
Theta hat (MLE)	1287	Theta star (bias corrected MLE)	1402
nu hat (MLE)	31.15	nu star (bias corrected)	28.59
MLE Mean (bias corrected)	835	MLE Sd (bias corrected)	1082
		Approximate Chi Square Value (0.05)	17.39
Adjusted Level of Significance	0.0392	Adjusted Chi Square Value	16.77

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1373	95% Adjusted Gamma UCL (use when n<50)	1423

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.98	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk Critical Value	0.916	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.122	Lilliefors Lognormal GOF Test
5% Lilliefors Critical Value	0.181	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.639	Mean of logged Data	5.786
Maximum of Logged Data	9.067	SD of logged Data	1.385

Assuming Lognormal Distribution

95% H-UCL	2079	90% Chebyshev (MVUE) UCL	1603
95% Chebyshev (MVUE) UCL	1971	97.5% Chebyshev (MVUE) UCL	2481
99% Chebyshev (MVUE) UCL	3482		

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1421	95% Jackknife UCL	1445
95% Standard Bootstrap UCL	1421	95% Bootstrap-t UCL	3316
95% Hall's Bootstrap UCL	3632	95% Percentile Bootstrap UCL	1490
95% BCA Bootstrap UCL	1879		
90% Chebyshev(Mean, Sd) UCL	1903	95% Chebyshev(Mean, Sd) UCL	2387
97.5% Chebyshev(Mean, Sd) UCL	3059	99% Chebyshev(Mean, Sd) UCL	4378

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	2387

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.

C3 (former radio tower footers)

General Statistics

Total Number of Observations	8	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	15	Mean	64
Maximum	171	Median	45.5
SD	55.47	Std. Error of Mean	19.61
Coefficient of Variation	0.867	Skewness	1.186

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.848	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.253	Lilliefors GOF Test
5% Lilliefors Critical Value	0.313	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	101.2	95% Adjusted-CLT UCL (Chen-1995)	105
		95% Modified-t UCL (Johnson-1978)	102.5

Gamma GOF Test

A-D Test Statistic	0.408	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.727	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.266	Kolmogrov-Smirnoff Gamma GOF Test
5% K-S Critical Value	0.299	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.636	k star (bias corrected MLE)	1.106
Theta hat (MLE)	39.13	Theta star (bias corrected MLE)	57.89
nu hat (MLE)	26.17	nu star (bias corrected)	17.69
MLE Mean (bias corrected)	64	MLE Sd (bias corrected)	60.87
		Approximate Chi Square Value (0.05)	9.167
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	7.666

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	123.5	95% Adjusted Gamma UCL (use when n<50)	147.7

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.925	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.238	Lilliefors Lognormal GOF Test
5% Lilliefors Critical Value	0.313	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.708	Mean of logged Data	3.823

Maximum of Logged Data	5.142	SD of logged Data	0.885

Assuming Lognormal Distribution

95% H-UCL	194	90% Chebyshev (MVUE) UCL	124.6
95% Chebyshev (MVUE) UCL	152.3	97.5% Chebyshev (MVUE) UCL	190.6
99% Chebyshev (MVUE) UCL	265.9		

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

Nonparametric Distribution Free UCLs

95% CLT UCL	96.26	95% Jackknife UCL	101.2
95% Standard Bootstrap UCL	93.87	95% Bootstrap-t UCL	128
95% Hall's Bootstrap UCL	132.4	95% Percentile Bootstrap UCL	95.63
95% BCA Bootstrap UCL	101.4		
90% Chebyshev(Mean, Sd) UCL	122.8	95% Chebyshev(Mean, Sd) UCL	149.5
97.5% Chebyshev(Mean, Sd) UCL	186.5	99% Chebyshev(Mean, Sd) UCL	259.1

Suggested UCL to Use

95% Student's-t UCL	101.2

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.

C3 (group1)

General Statistics

Total Number of Observations	0	Number of Distinct Observations	0
		Number of Missing Observations	1
Minimum	N/A	Mean	N/A
Maximum	N/A	Median	N/A

Warning: This data set only has 0 observations!
Data set is too small to compute reliable and meaningful statistics and estimates!
The data set for variable C3 (group1) was not processed!

It is suggested to collect at least 8 to 10 observations before using these statistical methods!
If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

C3 (keeper's quarters)

General Statistics

Total Number of Observations	18	Number of Distinct Observations	18
		Number of Missing Observations	0
Minimum	13	Mean	265
Maximum	1021	Median	220.5
SD	262.2	Std. Error of Mean	61.81
Coefficient of Variation	0.99	Skewness	1.625

Normal GOF Test

Shapiro Wilk Test Statistic	0.845	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.897	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.177	Lilliefors GOF Test
5% Lilliefors Critical Value	0.209	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	372.5	95% Adjusted-CLT UCL (Chen-1995)	392
		95% Modified-t UCL (Johnson-1978)	376.5

Gamma GOF Test

A-D Test Statistic	0.199	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.767	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0989	Kolmogrov-Smirnoff Gamma GOF Test
5% K-S Critical Value	0.209	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.998	k star (bias corrected MLE)	0.869
Theta hat (MLE)	265.4	Theta star (bias corrected MLE)	305
nu hat (MLE)	35.94	nu star (bias corrected)	31.28
MLE Mean (bias corrected)	265	MLE Sd (bias corrected)	284.3
		Approximate Chi Square Value (0.05)	19.5
Adjusted Level of Significance	0.0357	Adjusted Chi Square Value	18.61

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	425	95% Adjusted Gamma UCL (use when n<50)	445.4

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.943	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk Critical Value	0.897	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.15	Lilliefors Lognormal GOF Test
5% Lilliefors Critical Value	0.209	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.565	Mean of logged Data	5.001
Maximum of Logged Data	6.929	SD of logged Data	1.267

Assuming Lognormal Distribution

95% H-UCL	847.2	90% Chebyshev (MVUE) UCL	626.6
95% Chebyshev (MVUE) UCL	770.6	97.5% Chebyshev (MVUE) UCL	970.4
99% Chebyshev (MVUE) UCL	1363		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	366.7	95% Jackknife UCL	372.5
95% Standard Bootstrap UCL	363.6	95% Bootstrap-t UCL	413.9
95% Hall's Bootstrap UCL	475.6	95% Percentile Bootstrap UCL	362.8
95% BCA Bootstrap UCL	386.7		
90% Chebyshev(Mean, Sd) UCL	450.4	95% Chebyshev(Mean, Sd) UCL	534.4
97.5% Chebyshev(Mean, Sd) UCL	651	99% Chebyshev(Mean, Sd) UCL	880

Suggested UCL to Use

95% Student's-t UCL	372.5

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.

C3 (lapointe cistern)

General Statistics

Total Number of Observations	7	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	32.2	Mean	116.3
Maximum	282	Median	115.2
SD	91.03	Std. Error of Mean	34.41
Coefficient of Variation	0.783	Skewness	0.985

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.886	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.803	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.208	Lilliefors GOF Test
5% Lilliefors Critical Value	0.335	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL	95% UCLs (Adjusted for Skewness)

95% Student's-t UCL	183.2	95% Adjusted-CLT UCL (Chen-1995)	186.6
		95% Modified-t UCL (Johnson-1978)	185.3

Gamma GOF Test

A-D Test Statistic	0.365	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.717	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.224	Kolmogrov-Smirnoff Gamma GOF Test
5% K-S Critical Value	0.316	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.843	k star (bias corrected MLE)	1.148
Theta hat (MLE)	63.13	Theta star (bias corrected MLE)	101.3
nu hat (MLE)	25.8	nu star (bias corrected)	16.07
MLE Mean (bias corrected)	116.3	MLE Sd (bias corrected)	108.6
		Approximate Chi Square Value (0.05)	8.014
Adjusted Level of Significance	0.0158	Adjusted Chi Square Value	6.374

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	233.3	95% Adjusted Gamma UCL (use when n<50)	293.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.9	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk Critical Value	0.803	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.201	Lilliefors Lognormal GOF Test
5% Lilliefors Critical Value	0.335	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.472	Mean of logged Data	4.461
Maximum of Logged Data	5.642	SD of logged Data	0.862

Assuming Lognormal Distribution

95% H-UCL	403.5	90% Chebyshev (MVUE) UCL	233.4
95% Chebyshev (MVUE) UCL	285.8	97.5% Chebyshev (MVUE) UCL	358.6
99% Chebyshev (MVUE) UCL	501.5		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	172.9	95% Jackknife UCL	183.2
95% Standard Bootstrap UCL	168.2	95% Bootstrap-t UCL	215.9
95% Hall's Bootstrap UCL	203.2	95% Percentile Bootstrap UCL	172.7
95% BCA Bootstrap UCL	182.7		
90% Chebyshev(Mean, Sd) UCL	219.5	95% Chebyshev(Mean, Sd) UCL	266.3
97.5% Chebyshev(Mean, Sd) UCL	331.2	99% Chebyshev(Mean, Sd) UCL	458.7

Suggested UCL to Use

95% Student's-t UCL	183.2

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.

C3 (lapointe east shed)

General Statistics

Total Number of Observations	25	Number of Distinct Observations	25
		Number of Missing Observations	0
Minimum	6.9	Mean	147.8
Maximum	596	Median	98.5
SD	157.6	Std. Error of Mean	31.52
Coefficient of Variation	1.066	Skewness	1.817

Normal GOF Test

Shapiro Wilk Test Statistic	0.774	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.244	Lilliefors GOF Test
5% Lilliefors Critical Value	0.177	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	201.7	95% Adjusted-CLT UCL (Chen-1995)	211.9
		95% Modified-t UCL (Johnson-1978)	203.6

Gamma GOF Test

A-D Test Statistic	0.301	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.773	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.129	Kolmogrov-Smirnoff Gamma GOF Test
5% K-S Critical Value	0.179	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.019	k star (bias corrected MLE)	0.924
Theta hat (MLE)	145	Theta star (bias corrected MLE)	160
nu hat (MLE)	50.96	nu star (bias corrected)	46.18
MLE Mean (bias corrected)	147.8	MLE Sd (bias corrected)	153.8
		Approximate Chi Square Value (0.05)	31.59
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	30.76

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	216.1	95% Adjusted Gamma UCL (use when n<50)	221.9

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.964	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk Critical Value	0.918	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.109	Lilliefors Lognormal GOF Test
5% Lilliefors Critical Value	0.177	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.932	Mean of logged Data	4.431
Maximum of Logged Data	6.39	SD of logged Data	1.186

Assuming Lognormal Distribution

95% H-UCL	329.6	90% Chebyshev (MVUE) UCL	298.1
95% Chebyshev (MVUE) UCL	359.6	97.5% Chebyshev (MVUE) UCL	444.9
99% Chebyshev (MVUE) UCL	612.6		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	199.7	95% Jackknife UCL	201.7
95% Standard Bootstrap UCL	198.7	95% Bootstrap-t UCL	225
95% Hall's Bootstrap UCL	241.2	95% Percentile Bootstrap UCL	201.9
95% BCA Bootstrap UCL	222.3		
90% Chebyshev(Mean, Sd) UCL	242.4	95% Chebyshev(Mean, Sd) UCL	285.2
97.5% Chebyshev(Mean, Sd) UCL	344.7	99% Chebyshev(Mean, Sd) UCL	461.5

Suggested UCL to Use

95% Adjusted Gamma UCL	221.9

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.

C3 (lapointe lighthouse)

General Statistics

Total Number of Observations	21	Number of Distinct Observations	21
		Number of Missing Observations	0
Minimum	16	Mean	1134
Maximum	3733	Median	499
SD	1288	Std. Error of Mean	281.1
Coefficient of Variation	1.136	Skewness	1.031

Normal GOF Test

Shapiro Wilk Test Statistic	0.78	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.908	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.27	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	1619	95% Adjusted-CLT UCL (Chen-1995)	1664
		95% Modified-t UCL (Johnson-1978)	1629
Gamma GOF Test			
A-D Test Statistic	0.514	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.788	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.128	Kolmogrov-Smirnoff Gamma GOF Test	
5% K-S Critical Value	0.198	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	0.691	k star (bias corrected MLE)	0.624
Theta hat (MLE)	1642	Theta star (bias corrected MLE)	1818
nu hat (MLE)	29	nu star (bias corrected)	26.19
MLE Mean (bias corrected)	1134	MLE Sd (bias corrected)	1436
		Approximate Chi Square Value (0.05)	15.53
Adjusted Level of Significance	0.0383	Adjusted Chi Square Value	14.9
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50)	1913	95% Adjusted Gamma UCL (use when n<50)	1994
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.928	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.908	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.118	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.193	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.773	Mean of logged Data	6.157
Maximum of Logged Data	8.225	SD of logged Data	1.599
Assuming Lognormal Distribution			
95% H-UCL	5863	90% Chebyshev (MVUE) UCL	3416
95% Chebyshev (MVUE) UCL	4283	97.5% Chebyshev (MVUE) UCL	5486
99% Chebyshev (MVUE) UCL	7849		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	1596	95% Jackknife UCL	1619
95% Standard Bootstrap UCL	1586	95% Bootstrap-t UCL	1711
95% Hall's Bootstrap UCL	1587	95% Percentile Bootstrap UCL	1614
95% BCA Bootstrap UCL	1641		
90% Chebyshev(Mean, Sd) UCL	1977	95% Chebyshev(Mean, Sd) UCL	2360
97.5% Chebyshev(Mean, Sd) UCL	2890	99% Chebyshev(Mean, Sd) UCL	3931
Suggested UCL to Use			
95% Adjusted Gamma UCL	1994		

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.

C3 (oil storage shed)

General Statistics			
Total Number of Observations	15	Number of Distinct Observations	15
		Number of Missing Observations	0
Minimum	48	Mean	357.3
Maximum	1686	Median	166

SD	428.4	Std. Error of Mean	110.6
Coefficient of Variation	1.199	Skewness	2.395
Normal GOF Test			
Shapiro Wilk Test Statistic	0.71	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.881	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.235	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.229	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	552.1	95% Adjusted-CLT UCL (Chen-1995)	612.4
		95% Modified-t UCL (Johnson-1978)	563.5
Gamma GOF Test			
A-D Test Statistic	0.453	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.761	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.178	Kolmogrov-Smirnoff Gamma GOF Test	
5% K-S Critical Value	0.227	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.088	k star (bias corrected MLE)	0.914
Theta hat (MLE)	328.6	Theta star (bias corrected MLE)	390.8
nu hat (MLE)	32.63	nu star (bias corrected)	27.43
MLE Mean (bias corrected)	357.3	MLE Sd (bias corrected)	373.7
		Approximate Chi Square Value (0.05)	16.49
Adjusted Level of Significance	0.0324	Adjusted Chi Square Value	15.45
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50)	594.6	95% Adjusted Gamma UCL (use when n<50)	634.5
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.964	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.881	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.125	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.229	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	3.871	Mean of logged Data	5.353
Maximum of Logged Data	7.43	SD of logged Data	1.045
Assuming Lognormal Distribution			
95% H-UCL	801.2	90% Chebyshev (MVUE) UCL	654.5
95% Chebyshev (MVUE) UCL	794	97.5% Chebyshev (MVUE) UCL	987.7
99% Chebyshev (MVUE) UCL	1368		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	539.3	95% Jackknife UCL	552.1
95% Standard Bootstrap UCL	534.4	95% Bootstrap-t UCL	723.8
95% Hall's Bootstrap UCL	1228	95% Percentile Bootstrap UCL	543.5
95% BCA Bootstrap UCL	615.6		
90% Chebyshev(Mean, Sd) UCL	689.1	95% Chebyshev(Mean, Sd) UCL	839.4
97.5% Chebyshev(Mean, Sd) UCL	1048	99% Chebyshev(Mean, Sd) UCL	1458
Suggested UCL to Use			
95% Adjusted Gamma UCL	634.5		

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:19:28 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (above ground storage tank)

General Statistics

Total Number of Observations	5	Number of Distinct Observations	5
		Number of Missing Observations	0
Minimum	20	Mean	135.2
Maximum	413	Median	94
SD	159.4	Std. Error of Mean	71.28
Coefficient of Variation	1.179	Skewness	1.956

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.754	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.37	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	287.2	95% Adjusted-CLT UCL (Chen-1995)	319.1
		95% Modified-t UCL (Johnson-1978)	297.6

Gamma GOF Test

A-D Test Statistic	0.326	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.69	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.265	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.364	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.113	k star (bias corrected MLE)	0.579
Theta hat (MLE)	121.4	Theta star (bias corrected MLE)	233.6
nu hat (MLE)	11.13	nu star (bias corrected)	5.787
MLE Mean (bias corrected)	135.2	MLE Sd (bias corrected)	177.7
		Approximate Chi Square Value (0.05)	1.532
Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	0.767

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	510.7	95% Adjusted Gamma UCL (use when n<50)	1020

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.974	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.203	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.996	Mean of logged Data	4.395
Maximum of Logged Data	6.023	SD of logged Data	1.134

Assuming Lognormal Distribution

95% H-UCL	3453	90% Chebyshev (MVUE) UCL	318
95% Chebyshev (MVUE) UCL	403	97.5% Chebyshev (MVUE) UCL	520.9
99% Chebyshev (MVUE) UCL	752.6		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	252.4	95% Jackknife UCL	287.2
95% Standard Bootstrap UCL	240.2	95% Bootstrap-t UCL	532.3
95% Hall's Bootstrap UCL	813.4	95% Percentile Bootstrap UCL	260.2
95% BCA Bootstrap UCL	277.6		
90% Chebyshev(Mean, Sd) UCL	349	95% Chebyshev(Mean, Sd) UCL	445.9
97.5% Chebyshev(Mean, Sd) UCL	580.4	99% Chebyshev(Mean, Sd) UCL	844.4

Suggested UCL to Use

95% Student's-t UCL	287.2

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.

C3 (fog signal building)

General Statistics

Total Number of Observations	8	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	14	Mean	296.9
Maximum	1492	Median	106.5
SD	502.7	Std. Error of Mean	177.7
Coefficient of Variation	1.693	Skewness	2.452

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use

guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.611	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.389	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.313	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	633.6	95% Adjusted-CLT UCL (Chen-1995)	753.9
		95% Modified-t UCL (Johnson-1978)	659.3

Gamma GOF Test

A-D Test Statistic	0.621	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.754	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.322	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.307	Data Not Gamma Distributed at 5% Significance Level

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

Gamma Statistics

k hat (MLE)	0.619	k star (bias corrected MLE)	0.47
Theta hat (MLE)	479.4	Theta star (bias corrected MLE)	631.1
nu hat (MLE)	9.909	nu star (bias corrected)	7.526
MLE Mean (bias corrected)	296.9	MLE Sd (bias corrected)	432.9
		Approximate Chi Square Value (0.05)	2.464
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	1.796

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	906.9	95% Adjusted Gamma UCL (use when n<50)	1244

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.949	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.231	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.639	Mean of logged Data	4.7
Maximum of Logged Data	7.308	SD of logged Data	1.465

Assuming Lognormal Distribution

95% H-UCL	4215	90% Chebyshev (MVUE) UCL	666.4
95% Chebyshev (MVUE) UCL	850.6	97.5% Chebyshev (MVUE) UCL	1106
99% Chebyshev (MVUE) UCL	1609		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	589.2	95% Jackknife UCL	633.6
95% Standard Bootstrap UCL	568.4	95% Bootstrap-t UCL	3031
95% Hall's Bootstrap UCL	2459	95% Percentile Bootstrap UCL	608.6
95% BCA Bootstrap UCL	787.1		
90% Chebyshev(Mean, Sd) UCL	830.1	95% Chebyshev(Mean, Sd) UCL	1072
97.5% Chebyshev(Mean, Sd) UCL	1407	99% Chebyshev(Mean, Sd) UCL	2065

Suggested UCL to Use

95% Adjusted Gamma UCL	1244

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.

C3 (former radio tower footers)

General Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	15	Mean	21.75
Maximum	26	Median	23
SD	4.992	Std. Error of Mean	2.496
Coefficient of Variation	0.23	Skewness	-1.055

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.906	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.243	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	27.62	95% Adjusted-CLT UCL (Chen-1995)	24.45
		95% Modified-t UCL (Johnson-1978)	27.4

Gamma GOF Test

A-D Test Statistic	0.381	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.657	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.273	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.394	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	22.66	k star (bias corrected MLE)	5.832
Theta hat (MLE)	0.96	Theta star (bias corrected MLE)	3.73
nu hat (MLE)	181.3	nu star (bias corrected)	46.65
MLE Mean (bias corrected)	21.75	MLE Sd (bias corrected)	9.007
		Approximate Chi Square Value (0.05)	31.98
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	31.73	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.879	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.24	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.708	Mean of logged Data	3.057
Maximum of Logged Data	3.258	SD of logged Data	0.251

Assuming Lognormal Distribution

95% H-UCL	32.04	90% Chebyshev (MVUE) UCL	29.93
95% Chebyshev (MVUE) UCL	33.62	97.5% Chebyshev (MVUE) UCL	38.74
99% Chebyshev (MVUE) UCL	48.81		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	25.86	95% Jackknife UCL	27.62
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	29.24	95% Chebyshev(Mean, Sd) UCL	32.63
97.5% Chebyshev(Mean, Sd) UCL	37.34	99% Chebyshev(Mean, Sd) UCL	46.58

Suggested UCL to Use

95% Student's-t UCL	27.62

Recommended UCL exceeds the maximum observation

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be

reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

C3 (keeper's quarters)

General Statistics

Total Number of Observations	5	Number of Distinct Observations	5
		Number of Missing Observations	0
Minimum	13	Mean	76.4
Maximum	245	Median	22
SD	98.42	Std. Error of Mean	44.01
Coefficient of Variation	1.288	Skewness	1.831

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.743	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.31	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	170.2	95% Adjusted-CLT UCL (Chen-1995)	187.3
		95% Modified-t UCL (Johnson-1978)	176.2

Gamma GOF Test

A-D Test Statistic	0.495	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.693	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.332	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.365	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.922	k star (bias corrected MLE)	0.502
Theta hat (MLE)	82.83	Theta star (bias corrected MLE)	152.1
nu hat (MLE)	9.224	nu star (bias corrected)	5.023
MLE Mean (bias corrected)	76.4	MLE Sd (bias corrected)	107.8
		Approximate Chi Square Value (0.05)	1.163
Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	0.541

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	330	95% Adjusted Gamma UCL (use when n<50)	709.4

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.889	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Lognormal at 5% Significance Level

Lilliefors Test Statistic	0.292	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.396	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.565	Mean of logged Data	3.704
Maximum of Logged Data	5.501	SD of logged Data	1.224

Assuming Lognormal Distribution

95% H-UCL	3146	90% Chebyshev (MVUE) UCL	178.3
95% Chebyshev (MVUE) UCL	227.3	97.5% Chebyshev (MVUE) UCL	295.2
99% Chebyshev (MVUE) UCL	428.6		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	148.8	95% Jackknife UCL	170.2
95% Standard Bootstrap UCL	141.2	95% Bootstrap-t UCL	1524
95% Hall's Bootstrap UCL	899.3	95% Percentile Bootstrap UCL	153.4
95% BCA Bootstrap UCL	167.4		
90% Chebyshev(Mean, Sd) UCL	208.4	95% Chebyshev(Mean, Sd) UCL	268.2
97.5% Chebyshev(Mean, Sd) UCL	351.3	99% Chebyshev(Mean, Sd) UCL	514.3

Suggested UCL to Use

95% Student's-t UCL	170.2

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.

C3 (lapointe cistern)

General Statistics

Total Number of Observations	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	46.1	Mean	110.4
Maximum	170	Median	115.2
SD	62.09	Std. Error of Mean	35.85
Coefficient of Variation	0.562	Skewness	-0.343

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.996	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level	

Lilliefors Test Statistic	0.197	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.512	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	215.1	95% Adjusted-CLT UCL (Chen-1995)	161.8
		95% Modified-t UCL (Johnson-1978)	213.9

Gamma GOF Test

Not Enough Data to Perform GOF Test

Gamma Statistics

k hat (MLE)	3.909	k star (bias corrected MLE)	N/A
Theta hat (MLE)	28.25	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	23.46	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.948	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.27	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.512	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.831	Mean of logged Data	4.571
Maximum of Logged Data	5.136	SD of logged Data	0.67

Assuming Lognormal Distribution

95% H-UCL	7550	90% Chebyshev (MVUE) UCL	234.5
95% Chebyshev (MVUE) UCL	290.1	97.5% Chebyshev (MVUE) UCL	367.3
99% Chebyshev (MVUE) UCL	519		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	169.4	95% Jackknife UCL	215.1
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	218	95% Chebyshev(Mean, Sd) UCL	266.7
97.5% Chebyshev(Mean, Sd) UCL	334.3	99% Chebyshev(Mean, Sd) UCL	467.1

Suggested UCL to Use

95% Student's-t UCL	215.1

Recommended UCL exceeds the maximum observation

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

C3 (lapointe east shed)

General Statistics

Total Number of Observations	13	Number of Distinct Observations	13
		Number of Missing Observations	0
Minimum	6.9	Mean	130.3
Maximum	572	Median	97.2
SD	155.5	Std. Error of Mean	43.14
Coefficient of Variation	1.193	Skewness	2.153

Normal GOF Test

Shapiro Wilk Test Statistic	0.756	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.866	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.266	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.246	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	207.2	95% Adjusted-CLT UCL (Chen-1995)	228.8
		95% Modified-t UCL (Johnson-1978)	211.5

Gamma GOF Test

A-D Test Statistic	0.221	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.764	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.136	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.244	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.874	k star (bias corrected MLE)	0.723
Theta hat (MLE)	149.1	Theta star (bias corrected MLE)	180.1
nu hat (MLE)	22.72	nu star (bias corrected)	18.81
MLE Mean (bias corrected)	130.3	MLE Sd (bias corrected)	153.2
		Approximate Chi Square Value (0.05)	9.979
Adjusted Level of Significance	0.0301	Adjusted Chi Square Value	9.075

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	245.7	95% Adjusted Gamma UCL (use when n<50)	270.1

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.965	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.866	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.151	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.246	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.932	Mean of logged Data	4.199
Maximum of Logged Data	6.349	SD of logged Data	1.319

Assuming Lognormal Distribution

95% H-UCL	587.5	90% Chebyshev (MVUE) UCL	315.8
95% Chebyshev (MVUE) UCL	394.1	97.5% Chebyshev (MVUE) UCL	502.9
99% Chebyshev (MVUE) UCL	716.5		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	201.3	95% Jackknife UCL	207.2
95% Standard Bootstrap UCL	198	95% Bootstrap-t UCL	278.5
95% Hall's Bootstrap UCL	496.3	95% Percentile Bootstrap UCL	201.9
95% BCA Bootstrap UCL	220.9		
90% Chebyshev(Mean, Sd) UCL	259.7	95% Chebyshev(Mean, Sd) UCL	318.4
97.5% Chebyshev(Mean, Sd) UCL	399.7	99% Chebyshev(Mean, Sd) UCL	559.5

Suggested UCL to Use

95% Adjusted Gamma UCL	270.1

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.

C3 (lapointe lighthouse)

General Statistics

Total Number of Observations	8	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	16	Mean	1064
Maximum	3359	Median	610.5
SD	1258	Std. Error of Mean	444.8
Coefficient of Variation	1.183	Skewness	1.165

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.827	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.258	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	1907	95% Adjusted-CLT UCL (Chen-1995)	1991
		95% Modified-t UCL (Johnson-1978)	1937

Gamma GOF Test

A-D Test Statistic	0.299	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.76	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.16	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.308	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.528	k star (bias corrected MLE)	0.413
Theta hat (MLE)	2014	Theta star (bias corrected MLE)	2573
nu hat (MLE)	8.45	nu star (bias corrected)	6.614
MLE Mean (bias corrected)	1064	MLE Sd (bias corrected)	1654
		Approximate Chi Square Value (0.05)	1.961
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	1.387

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	3587	95% Adjusted Gamma UCL (use when n<50)	5074

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.882	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.236	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.773	Mean of logged Data	5.777
Maximum of Logged Data	8.119	SD of logged Data	2.111

Assuming Lognormal Distribution

95% H-UCL	514476	90% Chebyshev (MVUE) UCL	5271
95% Chebyshev (MVUE) UCL	6893	97.5% Chebyshev (MVUE) UCL	9145
99% Chebyshev (MVUE) UCL	13568		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1795	95% Jackknife UCL	1907
95% Standard Bootstrap UCL	1736	95% Bootstrap-t UCL	2957
95% Hall's Bootstrap UCL	5706	95% Percentile Bootstrap UCL	1796
95% BCA Bootstrap UCL	1945		
90% Chebyshev(Mean, Sd) UCL	2398	95% Chebyshev(Mean, Sd) UCL	3003
97.5% Chebyshev(Mean, Sd) UCL	3842	99% Chebyshev(Mean, Sd) UCL	5490

Suggested UCL to Use

95% Student's-t UCL	1907

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.

C3 (oil storage shed)

General Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	48	Mean	80
Maximum	103	Median	84.5
SD	24.59	Std. Error of Mean	12.29
Coefficient of Variation	0.307	Skewness	-0.782

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.941	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.229	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	108.9	95% Adjusted-CLT UCL (Chen-1995)	95.09
		95% Modified-t UCL (Johnson-1978)	108.1

Gamma GOF Test

A-D Test Statistic	0.326	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.657	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.263	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.395	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	12.34	k star (bias corrected MLE)	3.252
Theta hat (MLE)	6.482	Theta star (bias corrected MLE)	24.6
nu hat (MLE)	98.74	nu star (bias corrected)	26.02
MLE Mean (bias corrected)	80	MLE Sd (bias corrected)	44.36
		Approximate Chi Square Value (0.05)	15.39
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	135.2	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.908	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.232	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.871	Mean of logged Data	4.341
Maximum of Logged Data	4.635	SD of logged Data	0.343

Assuming Lognormal Distribution

95% H-UCL	145.8	90% Chebyshev (MVUE) UCL	121.2
95% Chebyshev (MVUE) UCL	139.7	97.5% Chebyshev (MVUE) UCL	165.5
99% Chebyshev (MVUE) UCL	216		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	100.2	95% Jackknife UCL	108.9
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	116.9	95% Chebyshev(Mean, Sd) UCL	133.6
97.5% Chebyshev(Mean, Sd) UCL	156.8	99% Chebyshev(Mean, Sd) UCL	202.3

Suggested UCL to Use

95% Student's-t UCL	108.9

Recommended UCL exceeds the maximum observation

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:16:31 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (above ground storage tank)

General Statistics

Total Number of Observations	7	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	99	Mean	265.4
Maximum	936	Median	156
SD	300.5	Std. Error of Mean	113.6
Coefficient of Variation	1.132	Skewness	2.481

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.603	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.803	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.363	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.335	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	486.1	95% Adjusted-CLT UCL (Chen-1995)	566
		95% Modified-t UCL (Johnson-1978)	503.9

Gamma GOF Test

A-D Test Statistic	0.939	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.719	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.342	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.316	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.642	k star (bias corrected MLE)	1.034
Theta hat (MLE)	161.6	Theta star (bias corrected MLE)	256.8
nu hat (MLE)	22.99	nu star (bias corrected)	14.47
MLE Mean (bias corrected)	265.4	MLE Sd (bias corrected)	261.1
		Approximate Chi Square Value (0.05)	6.896
Adjusted Level of Significance	0.0158	Adjusted Chi Square Value	5.397

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	557	95% Adjusted Gamma UCL (use when n<50)	711.7

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.802	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.803	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.302	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.335	Data appear Lognormal at 5% Significance Level

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.595	Mean of logged Data	5.247
Maximum of Logged Data	6.842	SD of logged Data	0.772

Assuming Lognormal Distribution

95% H-UCL	676.6	90% Chebyshev (MVUE) UCL	458
95% Chebyshev (MVUE) UCL	555.2	97.5% Chebyshev (MVUE) UCL	690.2
99% Chebyshev (MVUE) UCL	955.2		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	452.2	95% Jackknife UCL	486.1
95% Standard Bootstrap UCL	433.9	95% Bootstrap-t UCL	1829
95% Hall's Bootstrap UCL	1532	95% Percentile Bootstrap UCL	481.4
95% BCA Bootstrap UCL	592		
90% Chebyshev(Mean, Sd) UCL	606.1	95% Chebyshev(Mean, Sd) UCL	760.5
97.5% Chebyshev(Mean, Sd) UCL	974.7	99% Chebyshev(Mean, Sd) UCL	1395

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	760.5

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.

C3 (fog signal building)

General Statistics

Total Number of Observations	16	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	146	Mean	1104
Maximum	8662	Median	517.5
SD	2078	Std. Error of Mean	519.4
Coefficient of Variation	1.882	Skewness	3.641

Normal GOF Test

Shapiro Wilk Test Statistic	0.446	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.887	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.426	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.222	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	2015	95% Adjusted-CLT UCL (Chen-1995)	2463
		95% Modified-t UCL (Johnson-1978)	2093

Gamma GOF Test

A-D Test Statistic	1.61	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.769	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.325	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.222	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.867	k star (bias corrected MLE)	0.746
Theta hat (MLE)	1274	Theta star (bias corrected MLE)	1480
nu hat (MLE)	27.74	nu star (bias corrected)	23.87
MLE Mean (bias corrected)	1104	MLE Sd (bias corrected)	1278
		Approximate Chi Square Value (0.05)	13.75
Adjusted Level of Significance	0.0335	Adjusted Chi Square Value	12.88

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1917	95% Adjusted Gamma UCL (use when n<50)	2046

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.888	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.887	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.218	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.222	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.984	Mean of logged Data	6.329
Maximum of Logged Data	9.067	SD of logged Data	0.998

Assuming Lognormal Distribution

95% H-UCL	1851	90% Chebyshev (MVUE) UCL	1611
95% Chebyshev (MVUE) UCL	1940	97.5% Chebyshev (MVUE) UCL	2397
99% Chebyshev (MVUE) UCL	3295		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1958	95% Jackknife UCL	2015
95% Standard Bootstrap UCL	1927	95% Bootstrap-t UCL	6750

95% Hall's Bootstrap UCL	6085	95% Percentile Bootstrap UCL	2057
95% BCA Bootstrap UCL	2630		
90% Chebyshev(Mean, Sd) UCL	2662	95% Chebyshev(Mean, Sd) UCL	3368
97.5% Chebyshev(Mean, Sd) UCL	4348	99% Chebyshev(Mean, Sd) UCL	6272

Suggested UCL to Use

95% H-UCL	1851

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.

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

C3 (former radio tower footers)

General Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	65	Mean	106.3
Maximum	171	Median	94.5
SD	48.93	Std. Error of Mean	24.47
Coefficient of Variation	0.461	Skewness	0.924

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.9	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.258	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	163.8	95% Adjusted-CLT UCL (Chen-1995)	158.6
		95% Modified-t UCL (Johnson-1978)	165.7

Gamma GOF Test

A-D Test Statistic	0.338	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.658	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.291	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.396	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	6.65	k star (bias corrected MLE)	1.829
Theta hat (MLE)	15.98	Theta star (bias corrected MLE)	58.09
nu hat (MLE)	53.2	nu star (bias corrected)	14.63
MLE Mean (bias corrected)	106.3	MLE Sd (bias corrected)	78.56
		Approximate Chi Square Value (0.05)	7.007
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	221.9	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.92	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.256	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.174	Mean of logged Data	4.589
Maximum of Logged Data	5.142	SD of logged Data	0.449

Assuming Lognormal Distribution

95% H-UCL	262.8	90% Chebyshev (MVUE) UCL	176.3
95% Chebyshev (MVUE) UCL	208.1	97.5% Chebyshev (MVUE) UCL	252.3
99% Chebyshev (MVUE) UCL	339.2		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	146.5	95% Jackknife UCL	163.8
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	179.6	95% Chebyshev(Mean, Sd) UCL	212.9
97.5% Chebyshev(Mean, Sd) UCL	259	99% Chebyshev(Mean, Sd) UCL	349.7

Suggested UCL to Use

95% Student's-t UCL	163.8

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.

C3 (keeper's quarters)

General Statistics

Total Number of Observations	13	Number of Distinct Observations	13
		Number of Missing Observations	0
Minimum	46	Mean	337.5
Maximum	1021	Median	291
SD	271.4	Std. Error of Mean	75.27
Coefficient of Variation	0.804	Skewness	1.462

Normal GOF Test

Shapiro Wilk Test Statistic	0.876	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.866	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.178	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.246	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	471.7	95% Adjusted-CLT UCL (Chen-1995)	494
		95% Modified-t UCL (Johnson-1978)	476.8

Gamma GOF Test

A-D Test Statistic	0.154	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.747	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0909	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.24	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.704	k star (bias corrected MLE)	1.362
Theta hat (MLE)	198.1	Theta star (bias corrected MLE)	247.8
nu hat (MLE)	44.3	nu star (bias corrected)	35.41
MLE Mean (bias corrected)	337.5	MLE Sd (bias corrected)	289.2
		Approximate Chi Square Value (0.05)	22.8
Adjusted Level of Significance	0.0301	Adjusted Chi Square Value	21.36

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	524.3	95% Adjusted Gamma UCL (use when n<50)	559.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.961	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.866	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.116	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.246	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.829	Mean of logged Data	5.5
Maximum of Logged Data	6.929	SD of logged Data	0.898

Assuming Lognormal Distribution

95% H-UCL	732.3	90% Chebyshev (MVUE) UCL	632.2

95% Chebyshev (MVUE) UCL	759.2	97.5% Chebyshev (MVUE) UCL	935.5
99% Chebyshev (MVUE) UCL	1282		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	461.4	95% Jackknife UCL	471.7
95% Standard Bootstrap UCL	457	95% Bootstrap-t UCL	530.9
95% Hall's Bootstrap UCL	1119	95% Percentile Bootstrap UCL	464.6
95% BCA Bootstrap UCL	487.3		
90% Chebyshev(Mean, Sd) UCL	563.4	95% Chebyshev(Mean, Sd) UCL	665.6
97.5% Chebyshev(Mean, Sd) UCL	807.6	99% Chebyshev(Mean, Sd) UCL	1086

Suggested UCL to Use

95% Student's-t UCL	471.7

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.

C3 (lapointe cistern)

General Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	32.2	Mean	120.7
Maximum	282	Median	84.35
SD	118.1	Std. Error of Mean	59.04
Coefficient of Variation	0.978	Skewness	1.143

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.854	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.272	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	259.7	95% Adjusted-CLT UCL (Chen-1995)	253.9
		95% Modified-t UCL (Johnson-1978)	265.3

Gamma GOF Test

A-D Test Statistic	0.429	**Anderson-Darling Gamma GOF Test**		
5% A-D Critical Value	0.664	Detected data appear Gamma Distributed at 5% Significance Level		
K-S Test Statistic	0.325	**Kolmogrov-Smirnoff Gamma GOF Test**		
5% K-S Critical Value	0.4	Detected data appear Gamma Distributed at 5% Significance Level		

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.347	k star (bias corrected MLE)	0.503
Theta hat (MLE)	89.62	Theta star (bias corrected MLE)	239.8
nu hat (MLE)	10.78	nu star (bias corrected)	4.027
MLE Mean (bias corrected)	120.7	MLE Sd (bias corrected)	170.1
		Approximate Chi Square Value (0.05)	0.733
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	663.7	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.856	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.295	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.472	Mean of logged Data	4.378
Maximum of Logged Data	5.642	SD of logged Data	1.08

Assuming Lognormal Distribution

95% H-UCL	12509	90% Chebyshev (MVUE) UCL	296.9
95% Chebyshev (MVUE) UCL	377.3	97.5% Chebyshev (MVUE) UCL	488.9
99% Chebyshev (MVUE) UCL	708.2		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	217.8	95% Jackknife UCL	259.7
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	297.8	95% Chebyshev(Mean, Sd) UCL	378.1
97.5% Chebyshev(Mean, Sd) UCL	489.4	99% Chebyshev(Mean, Sd) UCL	708.2

Suggested UCL to Use

95% Student's-t UCL	259.7

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.

C3 (lapointe east shed)

General Statistics

Total Number of Observations	12	Number of Distinct Observations	12
		Number of Missing Observations	0
Minimum	17.5	Mean	166.7
Maximum	596	Median	105.1
SD	164.5	Std. Error of Mean	47.49
Coefficient of Variation	0.987	Skewness	1.793

Normal GOF Test

Shapiro Wilk Test Statistic	0.802	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.859	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.243	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.256	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	252	95% Adjusted-CLT UCL (Chen-1995)	271.1
		95% Modified-t UCL (Johnson-1978)	256.1

Gamma GOF Test

A-D Test Statistic	0.262	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.75	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.151	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.251	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.293	k star (bias corrected MLE)	1.025
Theta hat (MLE)	128.9	Theta star (bias corrected MLE)	162.6
nu hat (MLE)	31.03	nu star (bias corrected)	24.61
MLE Mean (bias corrected)	166.7	MLE Sd (bias corrected)	164.7
		Approximate Chi Square Value (0.05)	14.31
Adjusted Level of Significance	0.029	Adjusted Chi Square Value	13.13

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	286.7	95% Adjusted Gamma UCL (use when n<50)	312.6

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.976	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.859	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.132	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.256	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.862	Mean of logged Data	4.682

Maximum of Logged Data	6.39	SD of logged Data	1.019

Assuming Lognormal Distribution

95% H-UCL	449.2	90% Chebyshev (MVUE) UCL	332.7
95% Chebyshev (MVUE) UCL	405.9	97.5% Chebyshev (MVUE) UCL	507.6
99% Chebyshev (MVUE) UCL	707.2		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	244.8	95% Jackknife UCL	252
95% Standard Bootstrap UCL	240.2	95% Bootstrap-t UCL	299.8
95% Hall's Bootstrap UCL	355.4	95% Percentile Bootstrap UCL	248.4
95% BCA Bootstrap UCL	272.7		
90% Chebyshev(Mean, Sd) UCL	309.2	95% Chebyshev(Mean, Sd) UCL	373.7
97.5% Chebyshev(Mean, Sd) UCL	463.3	99% Chebyshev(Mean, Sd) UCL	639.2

Suggested UCL to Use

95% Student's-t UCL 252

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.

C3 (lapointe lighthouse)

General Statistics

Total Number of Observations	13	Number of Distinct Observations	13
		Number of Missing Observations	0
Minimum	126	Mean	1177
Maximum	3733	Median	417
SD	1356	Std. Error of Mean	376
Coefficient of Variation	1.151	Skewness	1.075

Normal GOF Test

Shapiro Wilk Test Statistic	0.745	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.866	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.307	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.246	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	1847	95% Adjusted-CLT UCL (Chen-1995)	1915
		95% Modified-t UCL (Johnson-1978)	1866

Gamma GOF Test

A-D Test Statistic	0.923	**Anderson-Darling Gamma GOF Test**

5% A-D Critical Value	0.764	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.24	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.245	Detected data appear Gamma Distributed at 5% Significance Level	

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

Gamma Statistics

k hat (MLE)	0.864	k star (bias corrected MLE)	0.716
Theta hat (MLE)	1363	Theta star (bias corrected MLE)	1645
nu hat (MLE)	22.45	nu star (bias corrected)	18.61
MLE Mean (bias corrected)	1177	MLE Sd (bias corrected)	1392
		Approximate Chi Square Value (0.05)	9.83
Adjusted Level of Significance	0.0301	Adjusted Chi Square Value	8.933

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	2228	95% Adjusted Gamma UCL (use when n<50)	2452

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.886	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.866	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.173	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.246	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.836	Mean of logged Data	6.391
Maximum of Logged Data	8.225	SD of logged Data	1.228

Assuming Lognormal Distribution

95% H-UCL	4020	90% Chebyshev (MVUE) UCL	2458
95% Chebyshev (MVUE) UCL	3047	97.5% Chebyshev (MVUE) UCL	3864
99% Chebyshev (MVUE) UCL	5469		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1796	95% Jackknife UCL	1847
95% Standard Bootstrap UCL	1779	95% Bootstrap-t UCL	2142
95% Hall's Bootstrap UCL	1679	95% Percentile Bootstrap UCL	1835
95% BCA Bootstrap UCL	1813		
90% Chebyshev(Mean, Sd) UCL	2305	95% Chebyshev(Mean, Sd) UCL	2816
97.5% Chebyshev(Mean, Sd) UCL	3525	99% Chebyshev(Mean, Sd) UCL	4918

Suggested UCL to Use

95% Adjusted Gamma UCL	2452

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.

C3 (oil storage shed)

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	54	Mean	458.2
Maximum	1686	Median	322
SD	463.4	Std. Error of Mean	139.7
Coefficient of Variation	1.011	Skewness	2.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.772	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.202	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.267	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	711.4	95% Adjusted-CLT UCL (Chen-1995)	782.6
		95% Modified-t UCL (Johnson-1978)	726.2

Gamma GOF Test

A-D Test Statistic	0.222	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.745	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.126	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.26	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.373	k star (bias corrected MLE)	1.059
Theta hat (MLE)	333.6	Theta star (bias corrected MLE)	432.5
nu hat (MLE)	30.22	nu star (bias corrected)	23.31
MLE Mean (bias corrected)	458.2	MLE Sd (bias corrected)	445.1
		Approximate Chi Square Value (0.05)	13.32
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	12.11

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	801.5	95% Adjusted Gamma UCL (use when n<50)	881.9

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.989	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0992	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.267	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.989	Mean of logged Data	5.721
Maximum of Logged Data	7.43	SD of logged Data	0.967

Assuming Lognormal Distribution

95% H-UCL	1196	90% Chebyshev (MVUE) UCL	886.5
95% Chebyshev (MVUE) UCL	1079	97.5% Chebyshev (MVUE) UCL	1347
99% Chebyshev (MVUE) UCL	1873		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	688	95% Jackknife UCL	711.4
95% Standard Bootstrap UCL	675.2	95% Bootstrap-t UCL	920.1
95% Hall's Bootstrap UCL	1618	95% Percentile Bootstrap UCL	700.8
95% BCA Bootstrap UCL	777.5		
90% Chebyshev(Mean, Sd) UCL	877.4	95% Chebyshev(Mean, Sd) UCL	1067
97.5% Chebyshev(Mean, Sd) UCL	1331	99% Chebyshev(Mean, Sd) UCL	1848

Suggested UCL to Use

95% Student's-t UCL	711.4

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:23:54 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3

General Statistics

Total Number of Observations	130	Number of Distinct Observations	124
		Number of Missing Observations	0
Minimum	6.9	Mean	473.4
Maximum	8662	Median	161.5
SD	993.3	Std. Error of Mean	87.12
Coefficient of Variation	2.098	Skewness	5.348

Normal GOF Test

Shapiro Wilk Test Statistic	0.471	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.319	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.0777	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	617.7	95% Adjusted-CLT UCL (Chen-1995)	660.3
		95% Modified-t UCL (Johnson-1978)	624.5

Gamma GOF Test

A-D Test Statistic	3.992	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.809	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.137	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.0858	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.611	k star (bias corrected MLE)	0.602
Theta hat (MLE)	774.3	Theta star (bias corrected MLE)	785.9
nu hat (MLE)	159	nu star (bias corrected)	156.6
MLE Mean (bias corrected)	473.4	MLE Sd (bias corrected)	609.9
		Approximate Chi Square Value (0.05)	128.7
Adjusted Level of Significance	0.0482	Adjusted Chi Square Value	128.4

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	576.1	95% Adjusted Gamma UCL (use when n<50)	577.4

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.981	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.481	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0558	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.0777	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.932	Mean of logged Data	5.152
Maximum of Logged Data	9.067	SD of logged Data	1.408

Assuming Lognormal Distribution

95% H-UCL	641.5	90% Chebyshev (MVUE) UCL	689.9
95% Chebyshev (MVUE) UCL	794.8	97.5% Chebyshev (MVUE) UCL	940.3
99% Chebyshev (MVUE) UCL	1226		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	616.7	95% Jackknife UCL	617.7
95% Standard Bootstrap UCL	618.4	95% Bootstrap-t UCL	713.2
95% Hall's Bootstrap UCL	829.3	95% Percentile Bootstrap UCL	629.5
95% BCA Bootstrap UCL	681.4		
90% Chebyshev(Mean, Sd) UCL	734.7	95% Chebyshev(Mean, Sd) UCL	853.1
97.5% Chebyshev(Mean, Sd) UCL	1017	99% Chebyshev(Mean, Sd) UCL	1340

Suggested UCL to Use

95% H-UCL	641.5

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.

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

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:25:59 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (subsurface)

General Statistics

Total Number of Observations	60	Number of Distinct Observations	58
		Number of Missing Observations	0
Minimum	6	Mean	367.4
Maximum	5223	Median	99.45
SD	770.5	Std. Error of Mean	99.47
Coefficient of Variation	2.097	Skewness	4.683

Normal GOF Test

Shapiro Wilk Test Statistic	0.503	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.32	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.114	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	533.6	95% Adjusted-CLT UCL (Chen-1995)	595.2
		95% Modified-t UCL (Johnson-1978)	543.6

Gamma GOF Test

A-D Test Statistic	1.707	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.824	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.15	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.122	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.464	k star (bias corrected MLE)	0.452
Theta hat (MLE)	791.4	Theta star (bias corrected MLE)	812.6
nu hat (MLE)	55.7	nu star (bias corrected)	54.25
MLE Mean (bias corrected)	367.4	MLE Sd (bias corrected)	546.4
		Approximate Chi Square Value (0.05)	38.33
Adjusted Level of Significance	0.046	Adjusted Chi Square Value	38

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	520	95% Adjusted Gamma UCL (use when n<50)	524.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.947	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.0213	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.082	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.114	Data appear Lognormal at 5% Significance Level	

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.792	Mean of logged Data	4.522
Maximum of Logged Data	8.561	SD of logged Data	1.771

Assuming Lognormal Distribution

95% H-UCL	1005	90% Chebyshev (MVUE) UCL	821.8
95% Chebyshev (MVUE) UCL	1006	97.5% Chebyshev (MVUE) UCL	1262
99% Chebyshev (MVUE) UCL	1765		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	531	95% Jackknife UCL	533.6
95% Standard Bootstrap UCL	528.1	95% Bootstrap-t UCL	675.1
95% Hall's Bootstrap UCL	1198	95% Percentile Bootstrap UCL	537.9
95% BCA Bootstrap UCL	609.3		
90% Chebyshev(Mean, Sd) UCL	665.8	95% Chebyshev(Mean, Sd) UCL	800.9
97.5% Chebyshev(Mean, Sd) UCL	988.5	99% Chebyshev(Mean, Sd) UCL	1357

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	800.9

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.

C3 (surface)

General Statistics

Total Number of Observations	52	Number of Distinct Observations	52
		Number of Missing Observations	0
Minimum	0.92	Mean	857.4
Maximum	8644	Median	264.5
SD	1572	Std. Error of Mean	218.1
Coefficient of Variation	1.834	Skewness	3.441

Normal GOF Test

Shapiro Wilk Test Statistic	0.569	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.293	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.123	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	1223	95% Adjusted-CLT UCL (Chen-1995)	1327
		95% Modified-t UCL (Johnson-1978)	1240

Gamma GOF Test

A-D Test Statistic	0.723	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.824	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0952	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.131	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.461	k star (bias corrected MLE)	0.448
Theta hat (MLE)	1859	Theta star (bias corrected MLE)	1916
nu hat (MLE)	47.97	nu star (bias corrected)	46.54
MLE Mean (bias corrected)	857.4	MLE Sd (bias corrected)	1282
		Approximate Chi Square Value (0.05)	31.89
Adjusted Level of Significance	0.0454	Adjusted Chi Square Value	31.54

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	1251	95% Adjusted Gamma UCL (use when n<50)	1265

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.965	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	0.232	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0875	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.123	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	-0.0834	Mean of logged Data	5.359
Maximum of Logged Data	9.065	SD of logged Data	1.968

Assuming Lognormal Distribution

95% H-UCL	3900	90% Chebyshev (MVUE) UCL	2931
95% Chebyshev (MVUE) UCL	3654	97.5% Chebyshev (MVUE) UCL	4658
99% Chebyshev (MVUE) UCL	6629		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1216	95% Jackknife UCL	1223
95% Standard Bootstrap UCL	1202	95% Bootstrap-t UCL	1502
95% Hall's Bootstrap UCL	1602	95% Percentile Bootstrap UCL	1245
95% BCA Bootstrap UCL	1339		
90% Chebyshev(Mean, Sd) UCL	1512	95% Chebyshev(Mean, Sd) UCL	1808
97.5% Chebyshev(Mean, Sd) UCL	2219	99% Chebyshev(Mean, Sd) UCL	3027

Suggested UCL to Use

95% Adjusted Gamma UCL 1265

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:12:43 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (chequamegon lighthouse)

General Statistics

Total Number of Observations	1	Number of Distinct Observations	1
		Number of Missing Observations	0
Minimum	18	Mean	18
Maximum	18	Median	18

Warning: This data set only has 1 observations!

Data set is too small to compute reliable and meaningful statistics and estimates!

The data set for variable C3 (chequamegon lighthouse) was not processed!

It is suggested to collect at least 8 to 10 observations before using these statistical methods!

If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

C3 (lapointe radio beacon)

General Statistics

Total Number of Observations	18	Number of Distinct Observations	17
		Number of Missing Observations	0
Minimum	6	Mean	18.56
Maximum	87.3	Median	11.15
SD	20.18	Std. Error of Mean	4.756
Coefficient of Variation	1.087	Skewness	2.729

Normal GOF Test

Shapiro Wilk Test Statistic	0.624	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.319	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.209	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	26.83	95% Adjusted-CLT UCL (Chen-1995)	29.65
		95% Modified-t UCL (Johnson-1978)	27.34

Gamma GOF Test

A-D Test Statistic	1.452	**Anderson-Darling Gamma GOF Test**

5% A-D Critical Value	0.755	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.27	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.207	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.695	k star (bias corrected MLE)	1.45
Theta hat (MLE)	10.95	Theta star (bias corrected MLE)	12.8
nu hat (MLE)	61.03	nu star (bias corrected)	52.19
MLE Mean (bias corrected)	18.56	MLE Sd (bias corrected)	15.42
		Approximate Chi Square Value (0.05)	36.6
Adjusted Level of Significance	0.0357	Adjusted Chi Square Value	35.34

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	26.47	95% Adjusted Gamma UCL (use when n<50)	27.41

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.865	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.897	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.216	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.209	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.792	Mean of logged Data	2.598
Maximum of Logged Data	4.469	SD of logged Data	0.733

Assuming Lognormal Distribution

95% H-UCL	26.36	90% Chebyshev (MVUE) UCL	26.82
95% Chebyshev (MVUE) UCL	31.14	97.5% Chebyshev (MVUE) UCL	37.15
99% Chebyshev (MVUE) UCL	48.95		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	26.38	95% Jackknife UCL	26.83
95% Standard Bootstrap UCL	26.15	95% Bootstrap-t UCL	39.69
95% Hall's Bootstrap UCL	56.54	95% Percentile Bootstrap UCL	26.74
95% BCA Bootstrap UCL	29.9		
90% Chebyshev(Mean, Sd) UCL	32.83	95% Chebyshev(Mean, Sd) UCL	39.29
97.5% Chebyshev(Mean, Sd) UCL	48.26	99% Chebyshev(Mean, Sd) UCL	65.88

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	39.29

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.

C3 (old chequamegon lighthouse)

General Statistics

Total Number of Observations	8	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	0.92	Mean	18.99
Maximum	40	Median	15.5
SD	11.97	Std. Error of Mean	4.232
Coefficient of Variation	0.63	Skewness	0.588

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.903	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.25	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	27.01	95% Adjusted-CLT UCL (Chen-1995)	26.89
		95% Modified-t UCL (Johnson-1978)	27.15

Gamma GOF Test

A-D Test Statistic	0.736	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.727	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.335	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.299	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.624	k star (bias corrected MLE)	1.098
Theta hat (MLE)	11.69	Theta star (bias corrected MLE)	17.29
nu hat (MLE)	25.98	nu star (bias corrected)	17.57
MLE Mean (bias corrected)	18.99	MLE Sd (bias corrected)	18.12
		Approximate Chi Square Value (0.05)	9.082
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	7.589

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	36.74	95% Adjusted Gamma UCL (use when n<50)	43.97

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.72	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.387	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.313	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	-0.0834	Mean of logged Data	2.605
Maximum of Logged Data	3.689	SD of logged Data	1.153

Assuming Lognormal Distribution

95% H-UCL	138.7	90% Chebyshev (MVUE) UCL	52.67
95% Chebyshev (MVUE) UCL	65.91	97.5% Chebyshev (MVUE) UCL	84.29
99% Chebyshev (MVUE) UCL	120.4		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	25.95	95% Jackknife UCL	27.01
95% Standard Bootstrap UCL	25.35	95% Bootstrap-t UCL	31.63
95% Hall's Bootstrap UCL	44.51	95% Percentile Bootstrap UCL	25.63
95% BCA Bootstrap UCL	26.25		
90% Chebyshev(Mean, Sd) UCL	31.69	95% Chebyshev(Mean, Sd) UCL	37.44
97.5% Chebyshev(Mean, Sd) UCL	45.42	99% Chebyshev(Mean, Sd) UCL	61.1

Suggested UCL to Use

95% Student's-t UCL	27.01

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.

C3 (original lapointe keeper's quarters)

General Statistics

Total Number of Observations	85	Number of Distinct Observations	83
		Number of Missing Observations	0
Minimum	7.6	Mean	777.9
Maximum	8644	Median	291
SD	1363	Std. Error of Mean	147.8
Coefficient of Variation	1.752	Skewness	3.723

Normal GOF Test

Shapiro Wilk Test Statistic	0.564	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.286	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.0961	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	1024	95% Adjusted-CLT UCL (Chen-1995)	1085

		95% Modified-t UCL (Johnson-1978)	1034

Gamma GOF Test

A-D Test Statistic	1.384	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.808	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.108	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.102	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.607	k star (bias corrected MLE)	0.594
Theta hat (MLE)	1280	Theta star (bias corrected MLE)	1310
nu hat (MLE)	103.3	nu star (bias corrected)	101
MLE Mean (bias corrected)	777.9	MLE Sd (bias corrected)	1009
		Approximate Chi Square Value (0.05)	78.78
Adjusted Level of Significance	0.0472	Adjusted Chi Square Value	78.44

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	996.9	95% Adjusted Gamma UCL (use when n<50)	1001

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.98	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.592	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.045	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.0961	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.028	Mean of logged Data	5.641
Maximum of Logged Data	9.065	SD of logged Data	1.525

Assuming Lognormal Distribution

95% H-UCL	1437	90% Chebyshev (MVUE) UCL	1479
95% Chebyshev (MVUE) UCL	1752	97.5% Chebyshev (MVUE) UCL	2131
99% Chebyshev (MVUE) UCL	2875		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1021	95% Jackknife UCL	1024
95% Standard Bootstrap UCL	1012	95% Bootstrap-t UCL	1144
95% Hall's Bootstrap UCL	1164	95% Percentile Bootstrap UCL	1034
95% BCA Bootstrap UCL	1094		
90% Chebyshev(Mean, Sd) UCL	1221	95% Chebyshev(Mean, Sd) UCL	1422
97.5% Chebyshev(Mean, Sd) UCL	1701	99% Chebyshev(Mean, Sd) UCL	2249

Suggested UCL to Use

95% H-UCL	1437

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.

ProUCL computes and outputs H-statistic based UCLs for historical reasons only.

H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.

It is therefore recommended to avoid the use of H-statistic based 95% UCLs.

Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:27:46 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (lapointe radio beacon)

General Statistics

Total Number of Observations	9	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	6	Mean	8.133
Maximum	11.3	Median	8.1
SD	1.552	Std. Error of Mean	0.517
Coefficient of Variation	0.191	Skewness	0.817

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.946	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.175	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	9.096	95% Adjusted-CLT UCL (Chen-1995)	9.135
		95% Modified-t UCL (Johnson-1978)	9.119

Gamma GOF Test

A-D Test Statistic	0.236	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.721	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.153	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.279	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	32.23	k star (bias corrected MLE)	21.56
Theta hat (MLE)	0.252	Theta star (bias corrected MLE)	0.377
nu hat (MLE)	580.2	nu star (bias corrected)	388.1
MLE Mean (bias corrected)	8.133	MLE Sd (bias corrected)	1.752
		Approximate Chi Square Value (0.05)	343.5
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	334.6

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	9.191	95% Adjusted Gamma UCL (use when n<50)	9.435

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.973	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.165	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.792	Mean of logged Data	2.08
Maximum of Logged Data	2.425	SD of logged Data	0.186

Assuming Lognormal Distribution

95% H-UCL	9.229	90% Chebyshev (MVUE) UCL	9.648
95% Chebyshev (MVUE) UCL	10.33	97.5% Chebyshev (MVUE) UCL	11.29
99% Chebyshev (MVUE) UCL	13.16		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	8.984	95% Jackknife UCL	9.096
95% Standard Bootstrap UCL	8.931	95% Bootstrap-t UCL	9.31
95% Hall's Bootstrap UCL	9.761	95% Percentile Bootstrap UCL	8.944
95% BCA Bootstrap UCL	9.011		
90% Chebyshev(Mean, Sd) UCL	9.686	95% Chebyshev(Mean, Sd) UCL	10.39
97.5% Chebyshev(Mean, Sd) UCL	11.36	99% Chebyshev(Mean, Sd) UCL	13.28

Suggested UCL to Use

95% Student's-t UCL	9.096

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.

C3 (old chequamegon lighthouse)

General Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	15	Mean	26.5
Maximum	40	Median	25.5
SD	11.56	Std. Error of Mean	5.781
Coefficient of Variation	0.436	Skewness	0.295

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use

guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.935	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.242	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	40.1	95% Adjusted-CLT UCL (Chen-1995)	36.92
		95% Modified-t UCL (Johnson-1978)	40.25

Gamma GOF Test

A-D Test Statistic	0.304	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.658	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.255	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.396	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	6.796	k star (bias corrected MLE)	1.866
Theta hat (MLE)	3.899	Theta star (bias corrected MLE)	14.2
nu hat (MLE)	54.37	nu star (bias corrected)	14.93
MLE Mean (bias corrected)	26.5	MLE Sd (bias corrected)	19.4
		Approximate Chi Square Value (0.05)	7.21
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	54.86	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.94	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.22	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.708	Mean of logged Data	3.202
Maximum of Logged Data	3.689	SD of logged Data	0.453

Assuming Lognormal Distribution

95% H-UCL	66.73	90% Chebyshev (MVUE) UCL	44.28
95% Chebyshev (MVUE) UCL	52.32	97.5% Chebyshev (MVUE) UCL	63.49
99% Chebyshev (MVUE) UCL	85.42		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	36.01	95% Jackknife UCL	40.1
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	43.84	95% Chebyshev(Mean, Sd) UCL	51.7
97.5% Chebyshev(Mean, Sd) UCL	62.6	99% Chebyshev(Mean, Sd) UCL	84.02

Suggested UCL to Use

95% Student's-t UCL	40.1

Recommended UCL exceeds the maximum observation

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.

C3 (original lapointe keeper's quarters)

General Statistics

Total Number of Observations	47	Number of Distinct Observations	46
		Number of Missing Observations	0
Minimum	7.6	Mean	465.2
Maximum	5223	Median	144
SD	846.3	Std. Error of Mean	123.4
Coefficient of Variation	1.819	Skewness	4.234

Normal GOF Test

Shapiro Wilk Test Statistic	0.543	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.946	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.294	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.129	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	672.4	95% Adjusted-CLT UCL (Chen-1995)	749.7
		95% Modified-t UCL (Johnson-1978)	685.1

Gamma GOF Test

A-D Test Statistic	0.929	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.805	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.154	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.136	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.595	k star (bias corrected MLE)	0.571
Theta hat (MLE)	782.3	Theta star (bias corrected MLE)	814.9
nu hat (MLE)	55.9	nu star (bias corrected)	53.66
MLE Mean (bias corrected)	465.2	MLE Sd (bias corrected)	615.7
		Approximate Chi Square Value (0.05)	37.83
Adjusted Level of Significance	0.0449	Adjusted Chi Square Value	37.41

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	659.8	95% Adjusted Gamma UCL (use when n<50)	667.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.979	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.946	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0697	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.129	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.028	Mean of logged Data	5.102
Maximum of Logged Data	8.561	SD of logged Data	1.53

Assuming Lognormal Distribution

95% H-UCL	1034	90% Chebyshev (MVUE) UCL	952.5
95% Chebyshev (MVUE) UCL	1156	97.5% Chebyshev (MVUE) UCL	1438
99% Chebyshev (MVUE) UCL	1992		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	668.2	95% Jackknife UCL	672.4
95% Standard Bootstrap UCL	670.5	95% Bootstrap-t UCL	881.8
95% Hall's Bootstrap UCL	1488	95% Percentile Bootstrap UCL	685.5
95% BCA Bootstrap UCL	792.2		
90% Chebyshev(Mean, Sd) UCL	835.5	95% Chebyshev(Mean, Sd) UCL	1003
97.5% Chebyshev(Mean, Sd) UCL	1236	99% Chebyshev(Mean, Sd) UCL	1693

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	1003

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:29:57 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (chequamegon lighthouse)

General Statistics

Total Number of Observations	1	Number of Distinct Observations	1
		Number of Missing Observations	0
Minimum	18	Mean	18
Maximum	18	Median	18

Warning: This data set only has 1 observations!

Data set is too small to compute reliable and meaningful statistics and estimates!

The data set for variable C3 (chequamegon lighthouse) was not processed!

It is suggested to collect at least 8 to 10 observations before using these statistical methods!

If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

C3 (lapointe radio beacon)

General Statistics

Total Number of Observations	9	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	11	Mean	28.99
Maximum	87.3	Median	20.6
SD	24.86	Std. Error of Mean	8.288
Coefficient of Variation	0.858	Skewness	1.932

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.758	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.239	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL | **95% UCLs (Adjusted for Skewness)**

95% Student's-t UCL	44.4	95% Adjusted-CLT UCL (Chen-1995)	48.32
		95% Modified-t UCL (Johnson-1978)	45.29

Gamma GOF Test

A-D Test Statistic	0.531	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.729	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.216	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.282	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.142	k star (bias corrected MLE)	1.502
Theta hat (MLE)	13.54	Theta star (bias corrected MLE)	19.3
nu hat (MLE)	38.55	nu star (bias corrected)	27.03
MLE Mean (bias corrected)	28.99	MLE Sd (bias corrected)	23.65
		Approximate Chi Square Value (0.05)	16.18
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	14.43

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	48.44	95% Adjusted Gamma UCL (use when n<50)	54.29

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.901	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.206	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.398	Mean of logged Data	3.116
Maximum of Logged Data	4.469	SD of logged Data	0.71

Assuming Lognormal Distribution

95% H-UCL	56.29	90% Chebyshev (MVUE) UCL	48.53
95% Chebyshev (MVUE) UCL	57.79	97.5% Chebyshev (MVUE) UCL	70.64
99% Chebyshev (MVUE) UCL	95.88		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	42.62	95% Jackknife UCL	44.4
95% Standard Bootstrap UCL	41.98	95% Bootstrap-t UCL	68.56
95% Hall's Bootstrap UCL	104.4	95% Percentile Bootstrap UCL	42.53
95% BCA Bootstrap UCL	47.61		
90% Chebyshev(Mean, Sd) UCL	53.85	95% Chebyshev(Mean, Sd) UCL	65.11
97.5% Chebyshev(Mean, Sd) UCL	80.74	99% Chebyshev(Mean, Sd) UCL	111.4

Suggested UCL to Use

95% Student's-t UCL	44.4

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.

C3 (old chequamegon lighthouse)

General Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	0.92	Mean	11.48
Maximum	16	Median	14.5
SD	7.087	Std. Error of Mean	3.544
Coefficient of Variation	0.617	Skewness	-1.921

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.736	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.389	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	19.82	95% Adjusted-CLT UCL (Chen-1995)	13.67
		95% Modified-t UCL (Johnson-1978)	19.25

Gamma GOF Test

A-D Test Statistic	0.856	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.664	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.45	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.401	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.3	k star (bias corrected MLE)	0.492
Theta hat (MLE)	8.83	Theta star (bias corrected MLE)	23.35
nu hat (MLE)	10.4	nu star (bias corrected)	3.933
MLE Mean (bias corrected)	11.48	MLE Sd (bias corrected)	16.37
		Approximate Chi Square Value (0.05)	0.696
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	64.92	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.667	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.748	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.424	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level	

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	-0.0834	Mean of logged Data	2.009
Maximum of Logged Data	2.773	SD of logged Data	1.396

Assuming Lognormal Distribution

95% H-UCL	32907	90% Chebyshev (MVUE) UCL	40.14
95% Chebyshev (MVUE) UCL	51.88	97.5% Chebyshev (MVUE) UCL	68.17
99% Chebyshev (MVUE) UCL	100.2		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	17.31	95% Jackknife UCL	19.82
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	22.11	95% Chebyshev(Mean, Sd) UCL	26.93
97.5% Chebyshev(Mean, Sd) UCL	33.61	99% Chebyshev(Mean, Sd) UCL	46.74

Suggested UCL to Use

95% Student's-t UCL	19.82

Recommended UCL exceeds the maximum observation

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

C3 (original lapointe keeper's quarters)

General Statistics

Total Number of Observations	38	Number of Distinct Observations	38
		Number of Missing Observations	0
Minimum	42.2	Mean	1165
Maximum	8644	Median	496.5
SD	1746	Std. Error of Mean	283.2
Coefficient of Variation	1.499	Skewness	2.998

Normal GOF Test

Shapiro Wilk Test Statistic	0.618	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.938	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.26	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.144	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	1642	95% Adjusted-CLT UCL (Chen-1995)	1778
		95% Modified-t UCL (Johnson-1978)	1665

Gamma GOF Test

A-D Test Statistic	1.012	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.787	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.143	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.149	Detected data appear Gamma Distributed at 5% Significance Level	

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

Gamma Statistics

k hat (MLE)	0.791	k star (bias corrected MLE)	0.746
Theta hat (MLE)	1473	Theta star (bias corrected MLE)	1562
nu hat (MLE)	60.1	nu star (bias corrected)	56.69
MLE Mean (bias corrected)	1165	MLE Sd (bias corrected)	1349
		Approximate Chi Square Value (0.05)	40.38
Adjusted Level of Significance	0.0434	Adjusted Chi Square Value	39.81

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	1635	95% Adjusted Gamma UCL (use when n<50)	1658

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.981	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.938	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0824	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.144	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.742	Mean of logged Data	6.309
Maximum of Logged Data	9.065	SD of logged Data	1.243

Assuming Lognormal Distribution

95% H-UCL	2059	90% Chebyshev (MVUE) UCL	2002
95% Chebyshev (MVUE) UCL	2388	97.5% Chebyshev (MVUE) UCL	2924
99% Chebyshev (MVUE) UCL	3978		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1630	95% Jackknife UCL	1642

95% Standard Bootstrap UCL	1629	95% Bootstrap-t UCL	2106
95% Hall's Bootstrap UCL	2380	95% Percentile Bootstrap UCL	1650
95% BCA Bootstrap UCL	1796		
90% Chebyshev(Mean, Sd) UCL	2014	95% Chebyshev(Mean, Sd) UCL	2399
97.5% Chebyshev(Mean, Sd) UCL	2933	99% Chebyshev(Mean, Sd) UCL	3982

Suggested UCL to Use

95% Adjusted Gamma UCL	1658

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 9:25:09 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3

General Statistics

Total Number of Observations	112	Number of Distinct Observations	107
		Number of Missing Observations	0
Minimum	0.92	Mean	594.9
Maximum	8644	Median	150.5
SD	1230	Std. Error of Mean	116.2
Coefficient of Variation	2.067	Skewness	4.214

Normal GOF Test

Shapiro Wilk Test Statistic	0.515	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.315	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.0837	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	787.6	95% Adjusted-CLT UCL (Chen-1995)	835.4
		95% Modified-t UCL (Johnson-1978)	795.3

Gamma GOF Test

A-D Test Statistic	2.342	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.834	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0973	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.0921	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.439	k star (bias corrected MLE)	0.433
Theta hat (MLE)	1356	Theta star (bias corrected MLE)	1374
nu hat (MLE)	98.29	nu star (bias corrected)	97
MLE Mean (bias corrected)	594.9	MLE Sd (bias corrected)	904
		Approximate Chi Square Value (0.05)	75.28
Adjusted Level of Significance	0.0479	Adjusted Chi Square Value	75.03

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	766.5	95% Adjusted Gamma UCL (use when n<50)	769

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.966	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.0549	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0783	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.0837	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	-0.0834	Mean of logged Data	4.911
Maximum of Logged Data	9.065	SD of logged Data	1.903

Assuming Lognormal Distribution

95% H-UCL	1482	90% Chebyshev (MVUE) UCL	1462
95% Chebyshev (MVUE) UCL	1764	97.5% Chebyshev (MVUE) UCL	2183
99% Chebyshev (MVUE) UCL	3007		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	786	95% Jackknife UCL	787.6
95% Standard Bootstrap UCL	791.6	95% Bootstrap-t UCL	878.3
95% Hall's Bootstrap UCL	876.1	95% Percentile Bootstrap UCL	788.8
95% BCA Bootstrap UCL	855.6		
90% Chebyshev(Mean, Sd) UCL	943.4	95% Chebyshev(Mean, Sd) UCL	1101
97.5% Chebyshev(Mean, Sd) UCL	1320	99% Chebyshev(Mean, Sd) UCL	1751

Suggested UCL to Use

95% H-UCL	1482

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.

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

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:45:26 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (subsurface)

General Statistics

Total Number of Observations	30	Number of Distinct Observations	30
		Number of Missing Observations	0
Minimum	28	Mean	273.5
Maximum	2009	Median	135
SD	445.9	Std. Error of Mean	81.4
Coefficient of Variation	1.63	Skewness	3.148

Normal GOF Test

Shapiro Wilk Test Statistic	0.539	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.299	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.162	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	411.8	95% Adjusted-CLT UCL (Chen-1995)	457.4
		95% Modified-t UCL (Johnson-1978)	419.6

Gamma GOF Test

A-D Test Statistic	1.616	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.782	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.18	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.166	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.866	k star (bias corrected MLE)	0.802
Theta hat (MLE)	315.7	Theta star (bias corrected MLE)	341
nu hat (MLE)	51.98	nu star (bias corrected)	48.12
MLE Mean (bias corrected)	273.5	MLE Sd (bias corrected)	305.4
		Approximate Chi Square Value (0.05)	33.2
Adjusted Level of Significance	0.041	Adjusted Chi Square Value	32.48

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	396.4	95% Adjusted Gamma UCL (use when n<50)	405.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.943	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.927	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.085	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.162	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.332	Mean of logged Data	4.933
Maximum of Logged Data	7.605	SD of logged Data	1.073

Assuming Lognormal Distribution

95% H-UCL	412	90% Chebyshev (MVUE) UCL	404.2
95% Chebyshev (MVUE) UCL	478.7	97.5% Chebyshev (MVUE) UCL	582
99% Chebyshev (MVUE) UCL	785		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	407.4	95% Jackknife UCL	411.8
95% Standard Bootstrap UCL	403.4	95% Bootstrap-t UCL	657.1
95% Hall's Bootstrap UCL	1018	95% Percentile Bootstrap UCL	416.9
95% BCA Bootstrap UCL	470.8		
90% Chebyshev(Mean, Sd) UCL	517.7	95% Chebyshev(Mean, Sd) UCL	628.3
97.5% Chebyshev(Mean, Sd) UCL	781.9	99% Chebyshev(Mean, Sd) UCL	1083

Suggested UCL to Use

95% H-UCL 412

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.

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

C3 (surface)

General Statistics

Total Number of Observations	73	Number of Distinct Observations	70
		Number of Missing Observations	0
Minimum	36	Mean	1076
Maximum	15078	Median	261
SD	2812	Std. Error of Mean	329.2
Coefficient of Variation	2.614	Skewness	3.96

Normal GOF Test

Shapiro Wilk Test Statistic	0.379	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.4	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.104	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	1624	95% Adjusted-CLT UCL (Chen-1995)	1780
		95% Modified-t UCL (Johnson-1978)	1650

Gamma GOF Test

A-D Test Statistic	7.967	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.816	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.257	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.11	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.516	k star (bias corrected MLE)	0.504
Theta hat (MLE)	2083	Theta star (bias corrected MLE)	2133
nu hat (MLE)	75.38	nu star (bias corrected)	73.62
MLE Mean (bias corrected)	1076	MLE Sd (bias corrected)	1515
		Approximate Chi Square Value (0.05)	54.86
Adjusted Level of Significance	0.0467	Adjusted Chi Square Value	54.53

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1444	95% Adjusted Gamma UCL (use when n<50)	1452

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.9	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	3.0261E-6	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.109	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.104	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.584	Mean of logged Data	5.757
Maximum of Logged Data	9.621	SD of logged Data	1.284

Assuming Lognormal Distribution

95% H-UCL	1061	90% Chebyshev (MVUE) UCL	1118
95% Chebyshev (MVUE) UCL	1304	97.5% Chebyshev (MVUE) UCL	1562
99% Chebyshev (MVUE) UCL	2069		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	1617	95% Jackknife UCL	1624
95% Standard Bootstrap UCL	1604	95% Bootstrap-t UCL	1924

95% Hall's Bootstrap UCL	1678	95% Percentile Bootstrap UCL	1649
95% BCA Bootstrap UCL	1799		
90% Chebyshev(Mean, Sd) UCL	2063	95% Chebyshev(Mean, Sd) UCL	2510
97.5% Chebyshev(Mean, Sd) UCL	3131	99% Chebyshev(Mean, Sd) UCL	4351

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	2510

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:54:31 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (assistant keeper's quarters)

General Statistics

Total Number of Observations	19	Number of Distinct Observations	19
		Number of Missing Observations	0
Minimum	37	Mean	314.5
Maximum	888	Median	212
SD	259.2	Std. Error of Mean	59.46
Coefficient of Variation	0.824	Skewness	1.028

Normal GOF Test

Shapiro Wilk Test Statistic	0.872	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.901	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.18	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.203	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	417.6	95% Adjusted-CLT UCL (Chen-1995)	427.3
		95% Modified-t UCL (Johnson-1978)	419.9

Gamma GOF Test

A-D Test Statistic	0.335	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.757	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.113	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.202	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.537	k star (bias corrected MLE)	1.329
Theta hat (MLE)	204.6	Theta star (bias corrected MLE)	236.6
nu hat (MLE)	58.4	nu star (bias corrected)	50.51
MLE Mean (bias corrected)	314.5	MLE Sd (bias corrected)	272.8
		Approximate Chi Square Value (0.05)	35.19
Adjusted Level of Significance	0.0369	Adjusted Chi Square Value	34.07

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	451.4	95% Adjusted Gamma UCL (use when n<50)	466.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.961	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.901	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.125	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.203	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.611	Mean of logged Data	5.392
Maximum of Logged Data	6.789	SD of logged Data	0.918

Assuming Lognormal Distribution

95% H-UCL	574.1	90% Chebyshev (MVUE) UCL	550.6
95% Chebyshev (MVUE) UCL	652.9	97.5% Chebyshev (MVUE) UCL	794.8
99% Chebyshev (MVUE) UCL	1074		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	412.3	95% Jackknife UCL	417.6
95% Standard Bootstrap UCL	410.2	95% Bootstrap-t UCL	440.5
95% Hall's Bootstrap UCL	424.1	95% Percentile Bootstrap UCL	415.6
95% BCA Bootstrap UCL	424.7		
90% Chebyshev(Mean, Sd) UCL	492.9	95% Chebyshev(Mean, Sd) UCL	573.7
97.5% Chebyshev(Mean, Sd) UCL	685.8	99% Chebyshev(Mean, Sd) UCL	906.1

Suggested UCL to Use

95% Student's-t UCL	417.6

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.

C3 (fog signal building)

General Statistics

Total Number of Observations	12	Number of Distinct Observations	12
		Number of Missing Observations	0
Minimum	41	Mean	205.3
Maximum	396	Median	209.5
SD	116.7	Std. Error of Mean	33.68
Coefficient of Variation	0.568	Skewness	0.238

Normal GOF Test

Shapiro Wilk Test Statistic	0.95	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.859	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.107	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.256	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	265.7	95% Adjusted-CLT UCL (Chen-1995)	263.1
		95% Modified-t UCL (Johnson-1978)	266.1

Gamma GOF Test

A-D Test Statistic	0.295	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.74	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.172	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.248	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.7	k star (bias corrected MLE)	2.081
Theta hat (MLE)	76.02	Theta star (bias corrected MLE)	98.65
nu hat (MLE)	64.8	nu star (bias corrected)	49.93
MLE Mean (bias corrected)	205.3	MLE Sd (bias corrected)	142.3
		Approximate Chi Square Value (0.05)	34.71
Adjusted Level of Significance	0.029	Adjusted Chi Square Value	32.78

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	295.3	95% Adjusted Gamma UCL (use when n<50)	312.7

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.924	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.859	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.183	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.256	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.714	Mean of logged Data	5.128
Maximum of Logged Data	5.981	SD of logged Data	0.716

Assuming Lognormal Distribution

95% H-UCL	368.8	90% Chebyshev (MVUE) UCL	349.9
95% Chebyshev (MVUE) UCL	412.1	97.5% Chebyshev (MVUE) UCL	498.5
99% Chebyshev (MVUE) UCL	668.3		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	260.6	95% Jackknife UCL	265.7
95% Standard Bootstrap UCL	259.1	95% Bootstrap-t UCL	267.1
95% Hall's Bootstrap UCL	265	95% Percentile Bootstrap UCL	258.5
95% BCA Bootstrap UCL	259		
90% Chebyshev(Mean, Sd) UCL	306.3	95% Chebyshev(Mean, Sd) UCL	352
97.5% Chebyshev(Mean, Sd) UCL	415.6	99% Chebyshev(Mean, Sd) UCL	540.3

Suggested UCL to Use

95% Student's-t UCL	265.7

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.

C3 (keeper's quarters)

General Statistics

Total Number of Observations	8	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	45	Mean	128.4
Maximum	372	Median	92.5
SD	105.8	Std. Error of Mean	37.41
Coefficient of Variation	0.824	Skewness	2.173

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.723	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.334	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.313	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	199.2	95% Adjusted-CLT UCL (Chen-1995)	220.6
		95% Modified-t UCL (Johnson-1978)	204

Gamma GOF Test

A-D Test Statistic	0.587	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.723	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.282	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.297	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.512	k star (bias corrected MLE)	1.654
Theta hat (MLE)	51.1	Theta star (bias corrected MLE)	77.63
nu hat (MLE)	40.2	nu star (bias corrected)	26.46
MLE Mean (bias corrected)	128.4	MLE Sd (bias corrected)	99.83
		Approximate Chi Square Value (0.05)	15.73
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	13.68

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	215.9	95% Adjusted Gamma UCL (use when n<50)	248.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.919	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.237	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.807	Mean of logged Data	4.643
Maximum of Logged Data	5.919	SD of logged Data	0.647

Assuming Lognormal Distribution

95% H-UCL	243.4	90% Chebyshev (MVUE) UCL	210.8
95% Chebyshev (MVUE) UCL	250	97.5% Chebyshev (MVUE) UCL	304.5
99% Chebyshev (MVUE) UCL	411.4		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	189.9	95% Jackknife UCL	199.2
95% Standard Bootstrap UCL	185.3	95% Bootstrap-t UCL	397.3
95% Hall's Bootstrap UCL	536.4	95% Percentile Bootstrap UCL	192.8
95% BCA Bootstrap UCL	226.8		
90% Chebyshev(Mean, Sd) UCL	240.6	95% Chebyshev(Mean, Sd) UCL	291.4
97.5% Chebyshev(Mean, Sd) UCL	362	99% Chebyshev(Mean, Sd) UCL	500.6

Suggested UCL to Use

95% Adjusted Gamma UCL	248.2

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.

C3 (lighthouse)

General Statistics

Total Number of Observations	18	Number of Distinct Observations	18
		Number of Missing Observations	0
Minimum	28	Mean	3485
Maximum	15078	Median	798
SD	5025	Std. Error of Mean	1185
Coefficient of Variation	1.442	Skewness	1.484

Normal GOF Test

Shapiro Wilk Test Statistic	0.707	**Shapiro Wilk GOF Test**

5% Shapiro Wilk Critical Value	0.897	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.338	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.209	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	5546	95% Adjusted-CLT UCL (Chen-1995)	5876
		95% Modified-t UCL (Johnson-1978)	5615

Gamma GOF Test

A-D Test Statistic	0.621	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.803	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.165	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.216	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.486	k star (bias corrected MLE)	0.442
Theta hat (MLE)	7176	Theta star (bias corrected MLE)	7889
nu hat (MLE)	17.48	nu star (bias corrected)	15.9
MLE Mean (bias corrected)	3485	MLE Sd (bias corrected)	5243
		Approximate Chi Square Value (0.05)	7.894
Adjusted Level of Significance	0.0357	Adjusted Chi Square Value	7.357

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	7021	95% Adjusted Gamma UCL (use when n<50)	7534

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.959	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.897	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.112	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.209	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.332	Mean of logged Data	6.842
Maximum of Logged Data	9.621	SD of logged Data	1.888

Assuming Lognormal Distribution

95% H-UCL	36603	90% Chebyshev (MVUE) UCL	11600
95% Chebyshev (MVUE) UCL	14837	97.5% Chebyshev (MVUE) UCL	19330
99% Chebyshev (MVUE) UCL	28154		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	5433	95% Jackknife UCL	5546
95% Standard Bootstrap UCL	5347	95% Bootstrap-t UCL	6530
95% Hall's Bootstrap UCL	5514	95% Percentile Bootstrap UCL	5524

95% BCA Bootstrap UCL	5739		
90% Chebyshev(Mean, Sd) UCL	7038	95% Chebyshev(Mean, Sd) UCL	8648
97.5% Chebyshev(Mean, Sd) UCL	10882	99% Chebyshev(Mean, Sd) UCL	15271

Suggested UCL to Use

95% Adjusted Gamma UCL	7534

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.

C3 (lighthouse/keeper's quarters)

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	54	Mean	152.1
Maximum	303	Median	147
SD	66.53	Std. Error of Mean	20.06
Coefficient of Variation	0.437	Skewness	0.814

Normal GOF Test

Shapiro Wilk Test Statistic	0.911	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.199	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.267	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	188.4	95% Adjusted-CLT UCL (Chen-1995)	190.3
		95% Modified-t UCL (Johnson-1978)	189.3

Gamma GOF Test

A-D Test Statistic	0.463	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.731	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.24	**Kolmogrov-Smirnoff Gamma GOF Test**
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

k hat (MLE)	5.492	k star (bias corrected MLE)	4.055
Theta hat (MLE)	27.69	Theta star (bias corrected MLE)	37.51
nu hat (MLE)	120.8	nu star (bias corrected)	89.2
MLE Mean (bias corrected)	152.1	MLE Sd (bias corrected)	75.53
		Approximate Chi Square Value (0.05)	68.43
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	65.47

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	198.3	95% Adjusted Gamma UCL (use when n<50)	207.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.924	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.266	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.267	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.989	Mean of logged Data	4.931
Maximum of Logged Data	5.714	SD of logged Data	0.473

Assuming Lognormal Distribution

95% H-UCL	213.4	90% Chebyshev (MVUE) UCL	220
95% Chebyshev (MVUE) UCL	250.2	97.5% Chebyshev (MVUE) UCL	292.2
99% Chebyshev (MVUE) UCL	374.7		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	185.1	95% Jackknife UCL	188.4
95% Standard Bootstrap UCL	183.4	95% Bootstrap-t UCL	192.9
95% Hall's Bootstrap UCL	205.7	95% Percentile Bootstrap UCL	186.7
95% BCA Bootstrap UCL	185.7		
90% Chebyshev(Mean, Sd) UCL	212.3	95% Chebyshev(Mean, Sd) UCL	239.5
97.5% Chebyshev(Mean, Sd) UCL	277.4	99% Chebyshev(Mean, Sd) UCL	351.7

Suggested UCL to Use

95% Student's-t UCL	188.4

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.

C3 (oil storage building)

General Statistics

Total Number of Observations	7	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	39.4	Mean	96.23
Maximum	147	Median	103.3
SD	45.39	Std. Error of Mean	17.15
Coefficient of Variation	0.472	Skewness	-0.14

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.885	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.803	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.195	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.335	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	129.6	95% Adjusted-CLT UCL (Chen-1995)	123.5
		95% Modified-t UCL (Johnson-1978)	129.4

Gamma GOF Test

A-D Test Statistic	0.447	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.71	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.216	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.313	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	4.523	k star (bias corrected MLE)	2.68
Theta hat (MLE)	21.28	Theta star (bias corrected MLE)	35.91
nu hat (MLE)	63.32	nu star (bias corrected)	37.52
MLE Mean (bias corrected)	96.23	MLE Sd (bias corrected)	58.78
		Approximate Chi Square Value (0.05)	24.49
Adjusted Level of Significance	0.0158	Adjusted Chi Square Value	21.37

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	147.4	95% Adjusted Gamma UCL (use when n<50)	168.9

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.881	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.803	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.206	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.335	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.674	Mean of logged Data	4.452
Maximum of Logged Data	4.99	SD of logged Data	0.54

Assuming Lognormal Distribution

95% H-UCL	174.1	90% Chebyshev (MVUE) UCL	156.9
95% Chebyshev (MVUE) UCL	184	97.5% Chebyshev (MVUE) UCL	221.6
99% Chebyshev (MVUE) UCL	295.4		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	124.4	95% Jackknife UCL	129.6
95% Standard Bootstrap UCL	122.6	95% Bootstrap-t UCL	127.1
95% Hall's Bootstrap UCL	116	95% Percentile Bootstrap UCL	122.3
95% BCA Bootstrap UCL	121		
90% Chebyshev(Mean, Sd) UCL	147.7	95% Chebyshev(Mean, Sd) UCL	171
97.5% Chebyshev(Mean, Sd) UCL	203.4	99% Chebyshev(Mean, Sd) UCL	266.9

Suggested UCL to Use

95% Student's-t UCL	129.6

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

C3 (outhouse)

General Statistics

Total Number of Observations	12	Number of Distinct Observations	12
		Number of Missing Observations	0
Minimum	36	Mean	443.6
Maximum	1582	Median	280.5
SD	466.5	Std. Error of Mean	134.7
Coefficient of Variation	1.052	Skewness	1.554

Normal GOF Test

Shapiro Wilk Test Statistic	0.827	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.859	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.207	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.256	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	685.4	95% Adjusted-CLT UCL (Chen-1995)	729.7
		95% Modified-t UCL (Johnson-1978)	695.5

Gamma GOF Test

A-D Test Statistic	0.229	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.757	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.151	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.252	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.998	k star (bias corrected MLE)	0.804

Theta hat (MLE)	444.5	Theta star (bias corrected MLE)	551.8
nu hat (MLE)	23.95	nu star (bias corrected)	19.29
MLE Mean (bias corrected)	443.6	MLE Sd (bias corrected)	494.7
		Approximate Chi Square Value (0.05)	10.33
Adjusted Level of Significance	0.029	Adjusted Chi Square Value	9.347

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	828.3	95% Adjusted Gamma UCL (use when n<50)	915.7

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.957	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.859	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.129	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.256	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.584	Mean of logged Data	5.516
Maximum of Logged Data	7.366	SD of logged Data	1.219

Assuming Lognormal Distribution

95% H-UCL	1779	90% Chebyshev (MVUE) UCL	1022
95% Chebyshev (MVUE) UCL	1269	97.5% Chebyshev (MVUE) UCL	1612
99% Chebyshev (MVUE) UCL	2286		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	665.1	95% Jackknife UCL	685.4
95% Standard Bootstrap UCL	650.6	95% Bootstrap-t UCL	862.2
95% Hall's Bootstrap UCL	1695	95% Percentile Bootstrap UCL	667.7
95% BCA Bootstrap UCL	706		
90% Chebyshev(Mean, Sd) UCL	847.6	95% Chebyshev(Mean, Sd) UCL	1031
97.5% Chebyshev(Mean, Sd) UCL	1285	99% Chebyshev(Mean, Sd) UCL	1784

Suggested UCL to Use

95% Student's-t UCL	685.4

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.

C3 (shed)

General Statistics

Total Number of Observations	16	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	94	Mean	429.2

Maximum	1457	Median	303
SD	362	Std. Error of Mean	90.51
Coefficient of Variation	0.844	Skewness	1.777

Normal GOF Test

Shapiro Wilk Test Statistic	0.815	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.21	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.222	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	587.8	95% Adjusted-CLT UCL (Chen-1995)	621
		95% Modified-t UCL (Johnson-1978)	594.5

Gamma GOF Test

A-D Test Statistic	0.312	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.751	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.132	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.218	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.874	k star (bias corrected MLE)	1.564
Theta hat (MLE)	229	Theta star (bias corrected MLE)	274.4
nu hat (MLE)	59.97	nu star (bias corrected)	50.06
MLE Mean (bias corrected)	429.2	MLE Sd (bias corrected)	343.2
		Approximate Chi Square Value (0.05)	34.81
Adjusted Level of Significance	0.0335	Adjusted Chi Square Value	33.37

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	617.1	95% Adjusted Gamma UCL (use when n<50)	643.9

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.971	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.115	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.222	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.543	Mean of logged Data	5.772
Maximum of Logged Data	7.284	SD of logged Data	0.786

Assuming Lognormal Distribution

95% H-UCL	710.5	90% Chebyshev (MVUE) UCL	695.8
95% Chebyshev (MVUE) UCL	817.6	97.5% Chebyshev (MVUE) UCL	986.7
99% Chebyshev (MVUE) UCL	1319		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	578.1	95% Jackknife UCL	587.8
95% Standard Bootstrap UCL	577.2	95% Bootstrap-t UCL	705.3
95% Hall's Bootstrap UCL	756.3	95% Percentile Bootstrap UCL	586.4
95% BCA Bootstrap UCL	615.1		
90% Chebyshev(Mean, Sd) UCL	700.7	95% Chebyshev(Mean, Sd) UCL	823.7
97.5% Chebyshev(Mean, Sd) UCL	994.4	99% Chebyshev(Mean, Sd) UCL	1330

Suggested UCL to Use

95% Student's-t UCL	587.8

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 11:00:24 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (assistant keeper's quarters)

General Statistics

Total Number of Observations	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	37	Mean	109.7
Maximum	155	Median	137
SD	63.57	Std. Error of Mean	36.7
Coefficient of Variation	0.58	Skewness	-1.577

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.861	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.333	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.512	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	216.8	95% Adjusted-CLT UCL (Chen-1995)	134.3
		95% Modified-t UCL (Johnson-1978)	211.3

Gamma GOF Test

Not Enough Data to Perform GOF Test

Gamma Statistics

k hat (MLE)	3.052	k star (bias corrected MLE)	N/A
Theta hat (MLE)	35.93	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	18.31	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.814	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.357	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.512	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.611	Mean of logged Data	4.525
Maximum of Logged Data	5.043	SD of logged Data	0.794

Assuming Lognormal Distribution

95% H-UCL	42154	90% Chebyshev (MVUE) UCL	256.6
95% Chebyshev (MVUE) UCL	321.8	97.5% Chebyshev (MVUE) UCL	412.3
99% Chebyshev (MVUE) UCL	590.1		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	170	95% Jackknife UCL	216.8
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	219.8	95% Chebyshev(Mean, Sd) UCL	269.7
97.5% Chebyshev(Mean, Sd) UCL	338.9	99% Chebyshev(Mean, Sd) UCL	474.9

Suggested UCL to Use

95% Student's-t UCL	216.8

Recommended UCL exceeds the maximum observation

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

C3 (fog signal building)

General Statistics

Total Number of Observations	5	Number of Distinct Observations	5
		Number of Missing Observations	0
Minimum	41	Mean	160.4
Maximum	278	Median	182
SD	104.5	Std. Error of Mean	46.75
Coefficient of Variation	0.652	Skewness	-0.187

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.908	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.762	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.222	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.396	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	260.1	95% Adjusted-CLT UCL (Chen-1995)	233.1
		95% Modified-t UCL (Johnson-1978)	259.4

Gamma GOF Test

A-D Test Statistic	0.409	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.684	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.261	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.36	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.208	k star (bias corrected MLE)	1.016
Theta hat (MLE)	72.65	Theta star (bias corrected MLE)	157.8
nu hat (MLE)	22.08	nu star (bias corrected)	10.16
MLE Mean (bias corrected)	160.4	MLE Sd (bias corrected)	159.1
		Approximate Chi Square Value (0.05)	4.045
Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	2.545

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	403.1	95% Adjusted Gamma UCL (use when n<50)	640.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.876	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.762	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.268	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.396	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.714	Mean of logged Data	4.834
Maximum of Logged Data	5.628	SD of logged Data	0.849

Assuming Lognormal Distribution

95% H-UCL	1099	90% Chebyshev (MVUE) UCL	348.8
95% Chebyshev (MVUE) UCL	431.7	97.5% Chebyshev (MVUE) UCL	546.9
99% Chebyshev (MVUE) UCL	773.1		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	237.3	95% Jackknife UCL	260.1
95% Standard Bootstrap UCL	231.6	95% Bootstrap-t UCL	249.5
95% Hall's Bootstrap UCL	203.6	95% Percentile Bootstrap UCL	227
95% BCA Bootstrap UCL	223.2		
90% Chebyshev(Mean, Sd) UCL	300.7	95% Chebyshev(Mean, Sd) UCL	364.2
97.5% Chebyshev(Mean, Sd) UCL	452.4	99% Chebyshev(Mean, Sd) UCL	625.6

Suggested UCL to Use

95% Student's-t UCL	260.1

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

C3 (keeper's quarters)

General Statistics

Total Number of Observations	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	45	Mean	70.67
Maximum	96	Median	71
SD	25.5	Std. Error of Mean	14.72
Coefficient of Variation	0.361	Skewness	-0.0588

**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0**

Normal GOF Test

Shapiro Wilk Test Statistic	1	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.176	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.512	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	113.7	95% Adjusted-CLT UCL (Chen-1995)	94.35
		95% Modified-t UCL (Johnson-1978)	113.6

Gamma GOF Test

Not Enough Data to Perform GOF Test

Gamma Statistics

k hat (MLE)	10.86	k star (bias corrected MLE)	N/A
Theta hat (MLE)	6.507	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	65.16	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.986	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.22	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.512	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.807	Mean of logged Data	4.211
Maximum of Logged Data	4.564	SD of logged Data	0.381

Assuming Lognormal Distribution

95% H-UCL	278.8	90% Chebyshev (MVUE) UCL	116.7
95% Chebyshev (MVUE) UCL	137.5	97.5% Chebyshev (MVUE) UCL	166.3
99% Chebyshev (MVUE) UCL	223		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	94.88	95% Jackknife UCL	113.7
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	114.8	95% Chebyshev(Mean, Sd) UCL	134.8
97.5% Chebyshev(Mean, Sd) UCL	162.6	99% Chebyshev(Mean, Sd) UCL	217.2

Suggested UCL to Use

95% Student's-t UCL	113.7

Recommended UCL exceeds the maximum observation

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be

reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

C3 (lighthouse)

General Statistics

Total Number of Observations	5	Number of Distinct Observations	5
		Number of Missing Observations	0
Minimum	28	Mean	881.2
Maximum	2009	Median	699
SD	899.8	Std. Error of Mean	402.4
Coefficient of Variation	1.021	Skewness	0.366

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.883	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.219	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	1739	95% Adjusted-CLT UCL (Chen-1995)	1614
		95% Modified-t UCL (Johnson-1978)	1750

Gamma GOF Test

A-D Test Statistic	0.408	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.705	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.246	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.369	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.622	k star (bias corrected MLE)	0.382
Theta hat (MLE)	1417	Theta star (bias corrected MLE)	2306
nu hat (MLE)	6.22	nu star (bias corrected)	3.821
MLE Mean (bias corrected)	881.2	MLE Sd (bias corrected)	1426
		Approximate Chi Square Value (0.05)	0.652
Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	0.263

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	5162	95% Adjusted Gamma UCL (use when n<50)	12815

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.861	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Lognormal at 5% Significance Level

Lilliefors Test Statistic	0.25	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.396	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.332	Mean of logged Data	5.793
Maximum of Logged Data	7.605	SD of logged Data	1.958

Assuming Lognormal Distribution

95% H-UCL	18046545	90% Chebyshev (MVUE) UCL	3709
95% Chebyshev (MVUE) UCL	4862	97.5% Chebyshev (MVUE) UCL	6462
99% Chebyshev (MVUE) UCL	9604		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1543	95% Jackknife UCL	1739
95% Standard Bootstrap UCL	1467	95% Bootstrap-t UCL	2319
95% Hall's Bootstrap UCL	1477	95% Percentile Bootstrap UCL	1460
95% BCA Bootstrap UCL	1533		
90% Chebyshev(Mean, Sd) UCL	2088	95% Chebyshev(Mean, Sd) UCL	2635
97.5% Chebyshev(Mean, Sd) UCL	3394	99% Chebyshev(Mean, Sd) UCL	4885

Suggested UCL to Use

95% Student's-t UCL	1739

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.

C3 (lighthouse/keeper's quarters)

General Statistics

Total Number of Observations	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	81	Mean	133.3
Maximum	174	Median	145
SD	47.59	Std. Error of Mean	27.47
Coefficient of Variation	0.357	Skewness	-1.037

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.955	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level	

Lilliefors Test Statistic	0.264	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.512	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	213.6	95% Adjusted-CLT UCL (Chen-1995)	160.9
		95% Modified-t UCL (Johnson-1978)	210.8

Gamma GOF Test

Not Enough Data to Perform GOF Test

Gamma Statistics

k hat (MLE)	10.28	k star (bias corrected MLE)	N/A
Theta hat (MLE)	12.97	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	61.66	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.916	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.297	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.512	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.394	Mean of logged Data	4.843
Maximum of Logged Data	5.159	SD of logged Data	0.399

Assuming Lognormal Distribution

95% H-UCL	598.8	90% Chebyshev (MVUE) UCL	224.5
95% Chebyshev (MVUE) UCL	265.5	97.5% Chebyshev (MVUE) UCL	322.6
99% Chebyshev (MVUE) UCL	434.6		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	178.5	95% Jackknife UCL	213.6
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	215.8	95% Chebyshev(Mean, Sd) UCL	253.1
97.5% Chebyshev(Mean, Sd) UCL	304.9	99% Chebyshev(Mean, Sd) UCL	406.7

Suggested UCL to Use

95% Student's-t UCL 213.6

Recommended UCL exceeds the maximum observation

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

C3 (oil storage building)

General Statistics

Total Number of Observations	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	39.4	Mean	64
Maximum	103.3	Median	49.3
SD	34.39	Std. Error of Mean	19.86
Coefficient of Variation	0.537	Skewness	1.572

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.863	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.332	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.512	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	122	95% Adjusted-CLT UCL (Chen-1995)	115.9
		95% Modified-t UCL (Johnson-1978)	125

Gamma GOF Test

Not Enough Data to Perform GOF Test

Gamma Statistics

k hat (MLE)	5.773	k star (bias corrected MLE)	N/A
Theta hat (MLE)	11.09	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	34.64	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.913	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.3	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.512	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.674	Mean of logged Data	4.07
Maximum of Logged Data	4.638	SD of logged Data	0.504

Assuming Lognormal Distribution

95% H-UCL	688	90% Chebyshev (MVUE) UCL	117.5
95% Chebyshev (MVUE) UCL	141.9	97.5% Chebyshev (MVUE) UCL	175.8
99% Chebyshev (MVUE) UCL	242.3		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	96.66	95% Jackknife UCL	122
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	123.6	95% Chebyshev(Mean, Sd) UCL	150.6
97.5% Chebyshev(Mean, Sd) UCL	188	99% Chebyshev(Mean, Sd) UCL	261.6

Suggested UCL to Use

95% Student's-t UCL	122

Recommended UCL exceeds the maximum observation

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.

C3 (outhouse)

General Statistics

Total Number of Observations	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	47	Mean	242
Maximum	489	Median	190
SD	225.5	Std. Error of Mean	130.2
Coefficient of Variation	0.932	Skewness	0.982

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.96	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.258	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.512	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	622.2	95% Adjusted-CLT UCL (Chen-1995)	535.1
		95% Modified-t UCL (Johnson-1978)	634.5

Gamma GOF Test

Not Enough Data to Perform GOF Test

Gamma Statistics

k hat (MLE)	1.418	k star (bias corrected MLE)	N/A
Theta hat (MLE)	170.7	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	8.506	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.988	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.217	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.512	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.85	Mean of logged Data	5.097
Maximum of Logged Data	6.192	SD of logged Data	1.178

Assuming Lognormal Distribution

95% H-UCL	1.212E+8	90% Chebyshev (MVUE) UCL	683.8
95% Chebyshev (MVUE) UCL	881.1	97.5% Chebyshev (MVUE) UCL	1155
99% Chebyshev (MVUE) UCL	1693		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	456.2	95% Jackknife UCL	622.2
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	632.6	95% Chebyshev(Mean, Sd) UCL	809.6
97.5% Chebyshev(Mean, Sd) UCL	1055	99% Chebyshev(Mean, Sd) UCL	1538

Suggested UCL to Use

95% Student's-t UCL	622.2

Recommended UCL exceeds the maximum observation

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.

C3 (shed)

General Statistics

Total Number of Observations	5	Number of Distinct Observations	5
		Number of Missing Observations	0
Minimum	107	Mean	227.6
Maximum	351	Median	233
SD	107.5	Std. Error of Mean	48.07
Coefficient of Variation	0.472	Skewness	-0.0256

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.917	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.211	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	330.1	95% Adjusted-CLT UCL (Chen-1995)	306.1
		95% Modified-t UCL (Johnson-1978)	330

Gamma GOF Test

A-D Test Statistic	0.343	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.681	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.229	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.358	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	5.029	k star (bias corrected MLE)	2.145
Theta hat (MLE)	45.26	Theta star (bias corrected MLE)	106.1
nu hat (MLE)	50.29	nu star (bias corrected)	21.45
MLE Mean (bias corrected)	227.6	MLE Sd (bias corrected)	155.4
		Approximate Chi Square Value (0.05)	11.93
Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	8.983

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	409.3	95% Adjusted Gamma UCL (use when n<50)	543.4

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.906	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.197	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.673	Mean of logged Data	5.325
Maximum of Logged Data	5.861	SD of logged Data	0.524

Assuming Lognormal Distribution

95% H-UCL	520	90% Chebyshev (MVUE) UCL	387.9
95% Chebyshev (MVUE) UCL	460	97.5% Chebyshev (MVUE) UCL	560
99% Chebyshev (MVUE) UCL	756.6		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	306.7	95% Jackknife UCL	330.1
95% Standard Bootstrap UCL	299.2	95% Bootstrap-t UCL	333.9
95% Hall's Bootstrap UCL	277.2	95% Percentile Bootstrap UCL	297.8
95% BCA Bootstrap UCL	289		
90% Chebyshev(Mean, Sd) UCL	371.8	95% Chebyshev(Mean, Sd) UCL	437.1
97.5% Chebyshev(Mean, Sd) UCL	527.8	99% Chebyshev(Mean, Sd) UCL	705.9

Suggested UCL to Use

95% Student's-t UCL	330.1

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:57:37 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3 (assistant keeper's quarters)

General Statistics

Total Number of Observations	16	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	72	Mean	352.9
Maximum	888	Median	323
SD	264.8	Std. Error of Mean	66.2
Coefficient of Variation	0.75	Skewness	0.809

Normal GOF Test

Shapiro Wilk Test Statistic	0.892	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.144	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.222	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	468.9	95% Adjusted-CLT UCL (Chen-1995)	476.1
		95% Modified-t UCL (Johnson-1978)	471.2

Gamma GOF Test

A-D Test Statistic	0.409	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.752	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.149	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.218	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.75	k star (bias corrected MLE)	1.464
Theta hat (MLE)	201.6	Theta star (bias corrected MLE)	241.1
nu hat (MLE)	56.01	nu star (bias corrected)	46.84
MLE Mean (bias corrected)	352.9	MLE Sd (bias corrected)	291.7
		Approximate Chi Square Value (0.05)	32.14
Adjusted Level of Significance	0.0335	Adjusted Chi Square Value	30.75

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	514.3	95% Adjusted Gamma UCL (use when n<50)	537.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.917	**Shapiro Wilk Lognormal GOF Test**			
5% Shapiro Wilk Critical Value	0.887	Data appear Lognormal at 5% Significance Level			
Lilliefors Test Statistic	0.148	**Lilliefors Lognormal GOF Test**			
5% Lilliefors Critical Value	0.222	Data appear Lognormal at 5% Significance Level			

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.277	Mean of logged Data	5.554
Maximum of Logged Data	6.789	SD of logged Data	0.865

Assuming Lognormal Distribution

95% H-UCL	656.9	90% Chebyshev (MVUE) UCL	619.7
95% Chebyshev (MVUE) UCL	735.3	97.5% Chebyshev (MVUE) UCL	895.9
99% Chebyshev (MVUE) UCL	1211		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	461.8	95% Jackknife UCL	468.9
95% Standard Bootstrap UCL	454.6	95% Bootstrap-t UCL	495.3
95% Hall's Bootstrap UCL	480.2	95% Percentile Bootstrap UCL	461.5
95% BCA Bootstrap UCL	463.3		
90% Chebyshev(Mean, Sd) UCL	551.5	95% Chebyshev(Mean, Sd) UCL	641.4
97.5% Chebyshev(Mean, Sd) UCL	766.3	99% Chebyshev(Mean, Sd) UCL	1012

Suggested UCL to Use

95% Student's-t UCL	468.9

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.

C3 (fog signal building)

General Statistics

Total Number of Observations	7	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	85	Mean	237.3
Maximum	396	Median	250
SD	121.6	Std. Error of Mean	45.97
Coefficient of Variation	0.513	Skewness	0.201

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.924	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.803	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.169	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.335	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	326.6	95% Adjusted-CLT UCL (Chen-1995)	316.6
		95% Modified-t UCL (Johnson-1978)	327.2

Gamma GOF Test

A-D Test Statistic	0.276	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.71	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.179	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.313	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	3.947	k star (bias corrected MLE)	2.351
Theta hat (MLE)	60.11	Theta star (bias corrected MLE)	100.9
nu hat (MLE)	55.26	nu star (bias corrected)	32.91
MLE Mean (bias corrected)	237.3	MLE Sd (bias corrected)	154.8
		Approximate Chi Square Value (0.05)	20.8
Adjusted Level of Significance	0.0158	Adjusted Chi Square Value	17.95

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	375.5	95% Adjusted Gamma UCL (use when n<50)	435.1

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.932	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.803	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.196	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.335	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.443	Mean of logged Data	5.337
Maximum of Logged Data	5.981	SD of logged Data	0.58

Assuming Lognormal Distribution

95% H-UCL	458.9	90% Chebyshev (MVUE) UCL	398.3
95% Chebyshev (MVUE) UCL	470.1	97.5% Chebyshev (MVUE) UCL	569.8
99% Chebyshev (MVUE) UCL	765.7		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	312.9	95% Jackknife UCL	326.6
95% Standard Bootstrap UCL	307	95% Bootstrap-t UCL	334.1

95% Hall's Bootstrap UCL	333.2	95% Percentile Bootstrap UCL	311
95% BCA Bootstrap UCL	312.9		
90% Chebyshev(Mean, Sd) UCL	375.2	95% Chebyshev(Mean, Sd) UCL	437.6
97.5% Chebyshev(Mean, Sd) UCL	524.3	99% Chebyshev(Mean, Sd) UCL	694.6

Suggested UCL to Use

95% Student's-t UCL	326.6

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.

C3 (keeper's quarters)

General Statistics

Total Number of Observations	5	Number of Distinct Observations	5
		Number of Missing Observations	0
Minimum	71	Mean	163
Maximum	372	Median	106
SD	123.6	Std. Error of Mean	55.26
Coefficient of Variation	0.758	Skewness	1.715

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.802	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.278	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	280.8	95% Adjusted-CLT UCL (Chen-1995)	299.2
		95% Modified-t UCL (Johnson-1978)	287.9

Gamma GOF Test

A-D Test Statistic	0.405	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.683	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.277	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.36	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.762	k star (bias corrected MLE)	1.238
Theta hat (MLE)	59.01	Theta star (bias corrected MLE)	131.6

nu hat (MLE)	27.62	nu star (bias corrected)	12.38
MLE Mean (bias corrected)	163	MLE Sd (bias corrected)	146.5
		Approximate Chi Square Value (0.05)	5.48
Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	3.656

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	368.3	95% Adjusted Gamma UCL (use when n<50)	552.1

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.919	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.241	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.263	Mean of logged Data	4.902
Maximum of Logged Data	5.919	SD of logged Data	0.661

Assuming Lognormal Distribution

95% H-UCL	533.6	90% Chebyshev (MVUE) UCL	298.4
95% Chebyshev (MVUE) UCL	361.4	97.5% Chebyshev (MVUE) UCL	448.8
99% Chebyshev (MVUE) UCL	620.4		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	253.9	95% Jackknife UCL	280.8
95% Standard Bootstrap UCL	244.6	95% Bootstrap-t UCL	696.9
95% Hall's Bootstrap UCL	687.5	95% Percentile Bootstrap UCL	258.6
95% BCA Bootstrap UCL	272.8		
90% Chebyshev(Mean, Sd) UCL	328.8	95% Chebyshev(Mean, Sd) UCL	403.9
97.5% Chebyshev(Mean, Sd) UCL	508.1	99% Chebyshev(Mean, Sd) UCL	712.8

Suggested UCL to Use

95% Student's-t UCL	280.8

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.

C3 (lighthouse)

General Statistics

Total Number of Observations	13	Number of Distinct Observations	13
		Number of Missing Observations	0
Minimum	162	Mean	4486
Maximum	15078	Median	897

SD	5621	Std. Error of Mean	1559
Coefficient of Variation	1.253	Skewness	1.002

Normal GOF Test

Shapiro Wilk Test Statistic	0.769	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.866	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.303	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.246	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	7265	95% Adjusted-CLT UCL (Chen-1995)	7514
		95% Modified-t UCL (Johnson-1978)	7337

Gamma GOF Test

A-D Test Statistic	0.774	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.787	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.212	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.249	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.54	k star (bias corrected MLE)	0.467
Theta hat (MLE)	8310	Theta star (bias corrected MLE)	9616
nu hat (MLE)	14.04	nu star (bias corrected)	12.13
MLE Mean (bias corrected)	4486	MLE Sd (bias corrected)	6568
		Approximate Chi Square Value (0.05)	5.313
Adjusted Level of Significance	0.0301	Adjusted Chi Square Value	4.686

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	10243	95% Adjusted Gamma UCL (use when n<50)	11614

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.878	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.866	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.174	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.246	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	5.088	Mean of logged Data	7.246
Maximum of Logged Data	9.621	SD of logged Data	1.771

Assuming Lognormal Distribution

95% H-UCL	59824	90% Chebyshev (MVUE) UCL	13958
95% Chebyshev (MVUE) UCL	17887	97.5% Chebyshev (MVUE) UCL	23342
99% Chebyshev (MVUE) UCL	34056		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	7051	95% Jackknife UCL	7265
95% Standard Bootstrap UCL	6974	95% Bootstrap-t UCL	8100
95% Hall's Bootstrap UCL	7040	95% Percentile Bootstrap UCL	7160
95% BCA Bootstrap UCL	7465		
90% Chebyshev(Mean, Sd) UCL	9163	95% Chebyshev(Mean, Sd) UCL	11282
97.5% Chebyshev(Mean, Sd) UCL	14222	99% Chebyshev(Mean, Sd) UCL	19998

Suggested UCL to Use

95% Adjusted Gamma UCL 11614

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.

C3 (lighthouse/keeper's quarters)

General Statistics

Total Number of Observations	8	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	54	Mean	159.1
Maximum	303	Median	157.5
SD	73.95	Std. Error of Mean	26.14
Coefficient of Variation	0.465	Skewness	0.707

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.932	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.218	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	208.7	95% Adjusted-CLT UCL (Chen-1995)	209.1
		95% Modified-t UCL (Johnson-1978)	209.7

Gamma GOF Test

A-D Test Statistic	0.343	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.719	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.236	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.295	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	4.865	k star (bias corrected MLE)	3.124
Theta hat (MLE)	32.71	Theta star (bias corrected MLE)	50.94
nu hat (MLE)	77.84	nu star (bias corrected)	49.98
MLE Mean (bias corrected)	159.1	MLE Sd (bias corrected)	90.03
		Approximate Chi Square Value (0.05)	34.75
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	31.57

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	228.9	95% Adjusted Gamma UCL (use when n<50)	252

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.928	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.266	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.989	Mean of logged Data	4.963
Maximum of Logged Data	5.714	SD of logged Data	0.519

Assuming Lognormal Distribution

95% H-UCL	261.6	90% Chebyshev (MVUE) UCL	250.2
95% Chebyshev (MVUE) UCL	290.8	97.5% Chebyshev (MVUE) UCL	347
99% Chebyshev (MVUE) UCL	457.5		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	202.1	95% Jackknife UCL	208.7
95% Standard Bootstrap UCL	200.1	95% Bootstrap-t UCL	213.5
95% Hall's Bootstrap UCL	237.1	95% Percentile Bootstrap UCL	200.1
95% BCA Bootstrap UCL	204.3		
90% Chebyshev(Mean, Sd) UCL	237.6	95% Chebyshev(Mean, Sd) UCL	273.1
97.5% Chebyshev(Mean, Sd) UCL	322.4	99% Chebyshev(Mean, Sd) UCL	419.3

Suggested UCL to Use

95% Student's-t UCL	208.7

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.

C3 (oil storage building)

General Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	63.3	Mean	120.4
Maximum	147	Median	135.7
SD	38.91	Std. Error of Mean	19.45
Coefficient of Variation	0.323	Skewness	-1.758

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.792	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.33	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	166.2	95% Adjusted-CLT UCL (Chen-1995)	134.1
		95% Modified-t UCL (Johnson-1978)	163.3

Gamma GOF Test

A-D Test Statistic	0.642	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.657	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.371	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.395	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	9.791	k star (bias corrected MLE)	2.614
Theta hat (MLE)	12.3	Theta star (bias corrected MLE)	46.05
nu hat (MLE)	78.33	nu star (bias corrected)	20.92
MLE Mean (bias corrected)	120.4	MLE Sd (bias corrected)	74.46
		Approximate Chi Square Value (0.05)	11.53
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	218.4	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.749	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.364	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.148	Mean of logged Data	4.739

Maximum of Logged Data	4.99	SD of logged Data	0.398

Assuming Lognormal Distribution

95% H-UCL	256.4	90% Chebyshev (MVUE) UCL	192.8
95% Chebyshev (MVUE) UCL	225.2	97.5% Chebyshev (MVUE) UCL	270.2
99% Chebyshev (MVUE) UCL	358.6		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	152.4	95% Jackknife UCL	166.2
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	178.8	95% Chebyshev(Mean, Sd) UCL	205.2
97.5% Chebyshev(Mean, Sd) UCL	241.9	99% Chebyshev(Mean, Sd) UCL	314

Suggested UCL to Use

95% Student's-t UCL	166.2

Recommended UCL exceeds the maximum observation

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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

C3 (outhouse)

General Statistics

Total Number of Observations	9	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	36	Mean	510.8
Maximum	1582	Median	371
SD	516	Std. Error of Mean	172
Coefficient of Variation	1.01	Skewness	1.279

**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0**

Normal GOF Test

Shapiro Wilk Test Statistic	0.864	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.189	**Lilliefors GOF Test**

5% Lilliefors Critical Value	0.295	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	830.6	95% Adjusted-CLT UCL (Chen-1995)	872
		95% Modified-t UCL (Johnson-1978)	842.8

Gamma GOF Test

A-D Test Statistic	0.182	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.744	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.159	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.287	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.996	k star (bias corrected MLE)	0.738
Theta hat (MLE)	512.8	Theta star (bias corrected MLE)	692
nu hat (MLE)	17.93	nu star (bias corrected)	13.29
MLE Mean (bias corrected)	510.8	MLE Sd (bias corrected)	594.5
		Approximate Chi Square Value (0.05)	6.086
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	5.096

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1115	95% Adjusted Gamma UCL (use when n<50)	1332

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.962	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.143	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.584	Mean of logged Data	5.656
Maximum of Logged Data	7.366	SD of logged Data	1.269

Assuming Lognormal Distribution

95% H-UCL	3621	90% Chebyshev (MVUE) UCL	1297
95% Chebyshev (MVUE) UCL	1631	97.5% Chebyshev (MVUE) UCL	2094
99% Chebyshev (MVUE) UCL	3005		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	793.7	95% Jackknife UCL	830.6
95% Standard Bootstrap UCL	772.9	95% Bootstrap-t UCL	1078
95% Hall's Bootstrap UCL	1260	95% Percentile Bootstrap UCL	784
95% BCA Bootstrap UCL	851.1		
90% Chebyshev(Mean, Sd) UCL	1027	95% Chebyshev(Mean, Sd) UCL	1260

97.5% Chebyshev(Mean, Sd) UCL	1585	99% Chebyshev(Mean, Sd) UCL	2222

Suggested UCL to Use

95% Student's-t UCL	830.6

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.

C3 (shed)

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	94	Mean	520.8
Maximum	1457	Median	442
SD	403	Std. Error of Mean	121.5
Coefficient of Variation	0.774	Skewness	1.346

Normal GOF Test

Shapiro Wilk Test Statistic	0.882	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.209	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.267	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	741.1	95% Adjusted-CLT UCL (Chen-1995)	773.4
		95% Modified-t UCL (Johnson-1978)	749.3

Gamma GOF Test

A-D Test Statistic	0.169	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.739	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.14	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.259	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.934	k star (bias corrected MLE)	1.467
Theta hat (MLE)	269.3	Theta star (bias corrected MLE)	354.9
nu hat (MLE)	42.55	nu star (bias corrected)	32.28
MLE Mean (bias corrected)	520.8	MLE Sd (bias corrected)	430
		Approximate Chi Square Value (0.05)	20.3
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	18.76

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	828.4	95% Adjusted Gamma UCL (use when n<50)	896.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.979	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.102	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.267	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.543	Mean of logged Data	5.975
Maximum of Logged Data	7.284	SD of logged Data	0.819

Assuming Lognormal Distribution

95% H-UCL	1098	90% Chebyshev (MVUE) UCL	940.8
95% Chebyshev (MVUE) UCL	1127	97.5% Chebyshev (MVUE) UCL	1385
99% Chebyshev (MVUE) UCL	1893		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	720.7	95% Jackknife UCL	741.1
95% Standard Bootstrap UCL	716.3	95% Bootstrap-t UCL	836.9
95% Hall's Bootstrap UCL	915.8	95% Percentile Bootstrap UCL	727.1
95% BCA Bootstrap UCL	766.4		
90% Chebyshev(Mean, Sd) UCL	885.3	95% Chebyshev(Mean, Sd) UCL	1050
97.5% Chebyshev(Mean, Sd) UCL	1280	99% Chebyshev(Mean, Sd) UCL	1730

Suggested UCL to Use

95% Student's-t UCL	741.1

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:44:27 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C3

General Statistics

Total Number of Observations	103	Number of Distinct Observations	99
		Number of Missing Observations	0
Minimum	28	Mean	842
Maximum	15078	Median	190
SD	2403	Std. Error of Mean	236.8
Coefficient of Variation	2.854	Skewness	4.728

Normal GOF Test

Shapiro Wilk Test Statistic	0.342	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.382	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.0873	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	1235	95% Adjusted-CLT UCL (Chen-1995)	1349
		95% Modified-t UCL (Johnson-1978)	1253

Gamma GOF Test

A-D Test Statistic	10.06	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.817	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.235	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.0937	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.518	k star (bias corrected MLE)	0.51
Theta hat (MLE)	1625	Theta star (bias corrected MLE)	1653
nu hat (MLE)	106.7	nu star (bias corrected)	105
MLE Mean (bias corrected)	842	MLE Sd (bias corrected)	1180
		Approximate Chi Square Value (0.05)	82.33
Adjusted Level of Significance	0.0477	Adjusted Chi Square Value	82.04

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1074	95% Adjusted Gamma UCL (use when n<50)	1077

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.921	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	1.1349E-6	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.101	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.0873	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.332	Mean of logged Data	5.517
Maximum of Logged Data	9.621	SD of logged Data	1.278

Assuming Lognormal Distribution

95% H-UCL	770.3	90% Chebyshev (MVUE) UCL	828.1
95% Chebyshev (MVUE) UCL	951.7	97.5% Chebyshev (MVUE) UCL	1123
99% Chebyshev (MVUE) UCL	1461		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	1231	95% Jackknife UCL	1235
95% Standard Bootstrap UCL	1244	95% Bootstrap-t UCL	1544
95% Hall's Bootstrap UCL	1279	95% Percentile Bootstrap UCL	1261
95% BCA Bootstrap UCL	1358		
90% Chebyshev(Mean, Sd) UCL	1552	95% Chebyshev(Mean, Sd) UCL	1874
97.5% Chebyshev(Mean, Sd) UCL	2321	99% Chebyshev(Mean, Sd) UCL	3198

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	1874

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:15:17 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C2 (subsurface)

General Statistics

Total Number of Observations	32	Number of Distinct Observations	31
		Number of Missing Observations	0
Minimum	20	Mean	310.9
Maximum	1314	Median	194
SD	340.2	Std. Error of Mean	60.14
Coefficient of Variation	1.094	Skewness	2.081

Normal GOF Test

Shapiro Wilk Test Statistic	0.711	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.93	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.232	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.157	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	412.9	95% Adjusted-CLT UCL (Chen-1995)	433.5
		95% Modified-t UCL (Johnson-1978)	416.6

Gamma GOF Test

A-D Test Statistic	0.707	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.771	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.122	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.159	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.222	k star (bias corrected MLE)	1.128
Theta hat (MLE)	254.5	Theta star (bias corrected MLE)	275.7
nu hat (MLE)	78.18	nu star (bias corrected)	72.18
MLE Mean (bias corrected)	310.9	MLE Sd (bias corrected)	292.8
		Approximate Chi Square Value (0.05)	53.62
Adjusted Level of Significance	0.0416	Adjusted Chi Square Value	52.76

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	418.5	95% Adjusted Gamma UCL (use when n<50)	425.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.978	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.93	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0748	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.157	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.996	Mean of logged Data	5.277
Maximum of Logged Data	7.181	SD of logged Data	0.983

Assuming Lognormal Distribution

95% H-UCL	485.7	90% Chebyshev (MVUE) UCL	496.6
95% Chebyshev (MVUE) UCL	580.8	97.5% Chebyshev (MVUE) UCL	697.7
99% Chebyshev (MVUE) UCL	927.3		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	409.8	95% Jackknife UCL	412.9
95% Standard Bootstrap UCL	409.6	95% Bootstrap-t UCL	445.1
95% Hall's Bootstrap UCL	434.2	95% Percentile Bootstrap UCL	415.2
95% BCA Bootstrap UCL	432.6		
90% Chebyshev(Mean, Sd) UCL	491.3	95% Chebyshev(Mean, Sd) UCL	573.1
97.5% Chebyshev(Mean, Sd) UCL	686.5	99% Chebyshev(Mean, Sd) UCL	909.3

Suggested UCL to Use

95% Adjusted Gamma UCL	425.3

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.

C2 (surface)

General Statistics

Total Number of Observations	72	Number of Distinct Observations	69
		Number of Missing Observations	0
Minimum	14	Mean	611.2
Maximum	7610	Median	344
SD	1029	Std. Error of Mean	121.3
Coefficient of Variation	1.684	Skewness	5.363

Normal GOF Test

Shapiro Wilk Test Statistic	0.445	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.32	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.104	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	813.3	95% Adjusted-CLT UCL (Chen-1995)	892.6
		95% Modified-t UCL (Johnson-1978)	826.1

Gamma GOF Test

A-D Test Statistic	2.511	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.779	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.164	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.108	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.074	k star (bias corrected MLE)	1.038
Theta hat (MLE)	569.3	Theta star (bias corrected MLE)	588.7
nu hat (MLE)	154.6	nu star (bias corrected)	149.5
MLE Mean (bias corrected)	611.2	MLE Sd (bias corrected)	599.8
		Approximate Chi Square Value (0.05)	122.2
Adjusted Level of Significance	0.0467	Adjusted Chi Square Value	121.7

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	747.5	95% Adjusted Gamma UCL (use when n<50)	750.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.956	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.0371	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.105	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.104	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.639	Mean of logged Data	5.882
Maximum of Logged Data	8.937	SD of logged Data	1.006

Assuming Lognormal Distribution

95% H-UCL	779.3	90% Chebyshev (MVUE) UCL	838.6
95% Chebyshev (MVUE) UCL	951.7	97.5% Chebyshev (MVUE) UCL	1109
99% Chebyshev (MVUE) UCL	1417		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	810.6	95% Jackknife UCL	813.3
95% Standard Bootstrap UCL	804.4	95% Bootstrap-t UCL	1102
95% Hall's Bootstrap UCL	1745	95% Percentile Bootstrap UCL	828.8
95% BCA Bootstrap UCL	950.3		
90% Chebyshev(Mean, Sd) UCL	975	95% Chebyshev(Mean, Sd) UCL	1140
97.5% Chebyshev(Mean, Sd) UCL	1369	99% Chebyshev(Mean, Sd) UCL	1818

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL 1140

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:34:18 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C2 (above ground storage tank)

General Statistics

Total Number of Observations	9	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	50	Mean	282.2
Maximum	920	Median	163
SD	293	Std. Error of Mean	97.66
Coefficient of Variation	1.038	Skewness	1.557

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.806	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.254	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	463.8	95% Adjusted-CLT UCL (Chen-1995)	497
		95% Modified-t UCL (Johnson-1978)	472.3

Gamma GOF Test

A-D Test Statistic	0.348	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.74	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.154	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.286	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.199	k star (bias corrected MLE)	0.873
Theta hat (MLE)	235.5	Theta star (bias corrected MLE)	323.2
nu hat (MLE)	21.57	nu star (bias corrected)	15.72
MLE Mean (bias corrected)	282.2	MLE Sd (bias corrected)	302
		Approximate Chi Square Value (0.05)	7.762
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	6.618

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	571.4	95% Adjusted Gamma UCL (use when n<50)	670.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.938	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.145	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.912	Mean of logged Data	5.171
Maximum of Logged Data	6.824	SD of logged Data	1.045

Assuming Lognormal Distribution

95% H-UCL	1043	90% Chebyshev (MVUE) UCL	583.1
95% Chebyshev (MVUE) UCL	720.5	97.5% Chebyshev (MVUE) UCL	911.1
99% Chebyshev (MVUE) UCL	1286		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	442.9	95% Jackknife UCL	463.8
95% Standard Bootstrap UCL	436.4	95% Bootstrap-t UCL	680.4
95% Hall's Bootstrap UCL	1259	95% Percentile Bootstrap UCL	447.3
95% BCA Bootstrap UCL	491.6		
90% Chebyshev(Mean, Sd) UCL	575.2	95% Chebyshev(Mean, Sd) UCL	707.9
97.5% Chebyshev(Mean, Sd) UCL	892.1	99% Chebyshev(Mean, Sd) UCL	1254

Suggested UCL to Use

95% Student's-t UCL	463.8

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.

C2 (fog signal building)

General Statistics

Total Number of Observations	35	Number of Distinct Observations	35
		Number of Missing Observations	0
Minimum	14	Mean	781.5
Maximum	7610	Median	433
SD	1422	Std. Error of Mean	240.4
Coefficient of Variation	1.82	Skewness	3.966

Normal GOF Test

Shapiro Wilk Test Statistic	0.49	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.934	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.326	**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	1188	95% Adjusted-CLT UCL (Chen-1995)	1349
		95% Modified-t UCL (Johnson-1978)	1215

Gamma GOF Test

A-D Test Statistic	1.078	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.791	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.171	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.155	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.712	k star (bias corrected MLE)	0.67
Theta hat (MLE)	1097	Theta star (bias corrected MLE)	1166
nu hat (MLE)	49.87	nu star (bias corrected)	46.93
MLE Mean (bias corrected)	781.5	MLE Sd (bias corrected)	954.4
		Approximate Chi Square Value (0.05)	32.21
Adjusted Level of Significance	0.0425	Adjusted Chi Square Value	31.63

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1139	95% Adjusted Gamma UCL (use when n<50)	1159

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.956	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.934	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.135	**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	2.639	Mean of logged Data	5.815
Maximum of Logged Data	8.937	SD of logged Data	1.375

Assuming Lognormal Distribution

95% H-UCL	1732	90% Chebyshev (MVUE) UCL	1540
95% Chebyshev (MVUE) UCL	1866	97.5% Chebyshev (MVUE) UCL	2318
99% Chebyshev (MVUE) UCL	3205		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1177	95% Jackknife UCL	1188
95% Standard Bootstrap UCL	1177	95% Bootstrap-t UCL	2097

95% Hall's Bootstrap UCL	3062	95% Percentile Bootstrap UCL	1239
95% BCA Bootstrap UCL	1412		
90% Chebyshev(Mean, Sd) UCL	1503	95% Chebyshev(Mean, Sd) UCL	1829
97.5% Chebyshev(Mean, Sd) UCL	2283	99% Chebyshev(Mean, Sd) UCL	3174

Suggested UCL to Use

95% H-UCL 1732

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.

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

C2 (lighthouse/keeper's quarters)

General Statistics

Total Number of Observations	36	Number of Distinct Observations	34
		Number of Missing Observations	0
Minimum	82	Mean	336
Maximum	1019	Median	255
SD	217.6	Std. Error of Mean	36.27
Coefficient of Variation	0.648	Skewness	1.341

Normal GOF Test

Shapiro Wilk Test Statistic	0.864	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.935	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.169	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.148	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	397.3	95% Adjusted-CLT UCL (Chen-1995)	404.3
		95% Modified-t UCL (Johnson-1978)	398.6

Gamma GOF Test

A-D Test Statistic	0.647	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.755	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.143	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.148	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.886	k star (bias corrected MLE)	2.664
Theta hat (MLE)	116.4	Theta star (bias corrected MLE)	126.1

nu hat (MLE)	207.8	nu star (bias corrected)	191.8
MLE Mean (bias corrected)	336	MLE Sd (bias corrected)	205.9
		Approximate Chi Square Value (0.05)	160.8
Adjusted Level of Significance	0.0428	Adjusted Chi Square Value	159.5

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	400.9	95% Adjusted Gamma UCL (use when n<50)	404.1

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.974	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.935	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.115	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.148	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.407	Mean of logged Data	5.634
Maximum of Logged Data	6.927	SD of logged Data	0.609

Assuming Lognormal Distribution

95% H-UCL	413.6	90% Chebyshev (MVUE) UCL	443.6
95% Chebyshev (MVUE) UCL	492.9	97.5% Chebyshev (MVUE) UCL	561.3
99% Chebyshev (MVUE) UCL	695.7		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	395.7	95% Jackknife UCL	397.3
95% Standard Bootstrap UCL	394.1	95% Bootstrap-t UCL	409.7
95% Hall's Bootstrap UCL	407.6	95% Percentile Bootstrap UCL	395.9
95% BCA Bootstrap UCL	401.4		
90% Chebyshev(Mean, Sd) UCL	444.8	95% Chebyshev(Mean, Sd) UCL	494.1
97.5% Chebyshev(Mean, Sd) UCL	562.5	99% Chebyshev(Mean, Sd) UCL	696.9

Suggested UCL to Use

95% Adjusted Gamma UCL	404.1

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.

C2 (oil storage building)

General Statistics

Total Number of Observations	16	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	62	Mean	588.3
Maximum	1881	Median	392

SD	566.8	Std. Error of Mean	141.7
Coefficient of Variation	0.963	Skewness	1.586

Normal GOF Test

Shapiro Wilk Test Statistic	0.786	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.235	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.222	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	836.7	95% Adjusted-CLT UCL (Chen-1995)	881.4
		95% Modified-t UCL (Johnson-1978)	846.1

Gamma GOF Test

A-D Test Statistic	0.339	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.758	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.124	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.22	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.312	k star (bias corrected MLE)	1.107
Theta hat (MLE)	448.6	Theta star (bias corrected MLE)	531.3
nu hat (MLE)	41.97	nu star (bias corrected)	35.43
MLE Mean (bias corrected)	588.3	MLE Sd (bias corrected)	559.1
		Approximate Chi Square Value (0.05)	22.81
Adjusted Level of Significance	0.0335	Adjusted Chi Square Value	21.66

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	913.8	95% Adjusted Gamma UCL (use when n<50)	962.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.956	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.143	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.222	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.127	Mean of logged Data	5.95
Maximum of Logged Data	7.54	SD of logged Data	1.006

Assuming Lognormal Distribution

95% H-UCL	1287	90% Chebyshev (MVUE) UCL	1114
95% Chebyshev (MVUE) UCL	1342	97.5% Chebyshev (MVUE) UCL	1660
99% Chebyshev (MVUE) UCL	2283		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	821.4	95% Jackknife UCL	836.7
95% Standard Bootstrap UCL	818.5	95% Bootstrap-t UCL	1019
95% Hall's Bootstrap UCL	1036	95% Percentile Bootstrap UCL	821.1
95% BCA Bootstrap UCL	891.6		
90% Chebyshev(Mean, Sd) UCL	1013	95% Chebyshev(Mean, Sd) UCL	1206
97.5% Chebyshev(Mean, Sd) UCL	1473	99% Chebyshev(Mean, Sd) UCL	1998

Suggested UCL to Use

95% Adjusted Gamma UCL	962.2

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.

C2 (outhouse)

General Statistics

Total Number of Observations	8	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	51	Mean	318.9
Maximum	742	Median	282.5
SD	210.9	Std. Error of Mean	74.57
Coefficient of Variation	0.661	Skewness	1.118

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.927	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.214	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	460.2	95% Adjusted-CLT UCL (Chen-1995)	473
		95% Modified-t UCL (Johnson-1978)	465.1

Gamma GOF Test

A-D Test Statistic	0.207	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.723	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.142	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.297	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.352	k star (bias corrected MLE)	1.553
Theta hat (MLE)	135.6	Theta star (bias corrected MLE)	205.3
nu hat (MLE)	37.63	nu star (bias corrected)	24.85
MLE Mean (bias corrected)	318.9	MLE Sd (bias corrected)	255.9
		Approximate Chi Square Value (0.05)	14.5
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	12.54

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	546.6	95% Adjusted Gamma UCL (use when n<50)	631.8

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.933	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.189	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.932	Mean of logged Data	5.537
Maximum of Logged Data	6.609	SD of logged Data	0.795

Assuming Lognormal Distribution

95% H-UCL	842	90% Chebyshev (MVUE) UCL	617.2
95% Chebyshev (MVUE) UCL	746.4	97.5% Chebyshev (MVUE) UCL	925.6
99% Chebyshev (MVUE) UCL	1278		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	441.5	95% Jackknife UCL	460.2
95% Standard Bootstrap UCL	436.2	95% Bootstrap-t UCL	529.9
95% Hall's Bootstrap UCL	1213	95% Percentile Bootstrap UCL	447.5
95% BCA Bootstrap UCL	471.9		
90% Chebyshev(Mean, Sd) UCL	542.6	95% Chebyshev(Mean, Sd) UCL	643.9
97.5% Chebyshev(Mean, Sd) UCL	784.6	99% Chebyshev(Mean, Sd) UCL	1061

Suggested UCL to Use

95% Student's-t UCL	460.2

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:38:33 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C2 (above ground storage tank)

General Statistics

Total Number of Observations	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	50	Mean	140
Maximum	300	Median	70
SD	138.9	Std. Error of Mean	80.21
Coefficient of Variation	0.992	Skewness	1.692

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.81	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.359	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.512	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	374.2	95% Adjusted-CLT UCL (Chen-1995)	355.6
		95% Modified-t UCL (Johnson-1978)	387.3

Gamma GOF Test

Not Enough Data to Perform GOF Test

Gamma Statistics

k hat (MLE)	1.709	k star (bias corrected MLE)	N/A
Theta hat (MLE)	81.91	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	10.26	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.885	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.319	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.512	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.912	Mean of logged Data	4.621
Maximum of Logged Data	5.704	SD of logged Data	0.952

Assuming Lognormal Distribution

95% H-UCL	688343	90% Chebyshev (MVUE) UCL	335.2
95% Chebyshev (MVUE) UCL	426	97.5% Chebyshev (MVUE) UCL	552
99% Chebyshev (MVUE) UCL	799.6		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	271.9	95% Jackknife UCL	374.2
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	380.6	95% Chebyshev(Mean, Sd) UCL	489.6
97.5% Chebyshev(Mean, Sd) UCL	640.9	99% Chebyshev(Mean, Sd) UCL	938.1

Suggested UCL to Use

95% Student's-t UCL	374.2

Recommended UCL exceeds the maximum observation

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.

C2 (fog signal building)

General Statistics

Total Number of Observations	10	Number of Distinct Observations	10
		Number of Missing Observations	0
Minimum	20	Mean	500.2
Maximum	1314	Median	295.5
SD	529.4	Std. Error of Mean	167.4
Coefficient of Variation	1.058	Skewness	0.876

Normal GOF Test

Shapiro Wilk Test Statistic	0.781	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Data Not Normal at 5% Significance Level	

Lilliefors Test Statistic	0.285	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.28	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	807.1	95% Adjusted-CLT UCL (Chen-1995)	825.2
		95% Modified-t UCL (Johnson-1978)	814.8

Gamma GOF Test

A-D Test Statistic	0.41	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.754	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.19	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.275	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.834	k star (bias corrected MLE)	0.651
Theta hat (MLE)	599.6	Theta star (bias corrected MLE)	768.8
nu hat (MLE)	16.68	nu star (bias corrected)	13.01
MLE Mean (bias corrected)	500.2	MLE Sd (bias corrected)	620.1
		Approximate Chi Square Value (0.05)	5.901
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	5.093

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	1103	95% Adjusted Gamma UCL (use when n<50)	1278

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.932	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.162	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.28	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.996	Mean of logged Data	5.507
Maximum of Logged Data	7.181	SD of logged Data	1.411

Assuming Lognormal Distribution

95% H-UCL	4377	90% Chebyshev (MVUE) UCL	1370
95% Chebyshev (MVUE) UCL	1734	97.5% Chebyshev (MVUE) UCL	2239
99% Chebyshev (MVUE) UCL	3231		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	775.6	95% Jackknife UCL	807.1
95% Standard Bootstrap UCL	760.8	95% Bootstrap-t UCL	887.7
95% Hall's Bootstrap UCL	712	95% Percentile Bootstrap UCL	763.6
95% BCA Bootstrap UCL	819.6		

90% Chebyshev(Mean, Sd) UCL	1002	95% Chebyshev(Mean, Sd) UCL	1230
97.5% Chebyshev(Mean, Sd) UCL	1546	99% Chebyshev(Mean, Sd) UCL	2166

Suggested UCL to Use

95% Adjusted Gamma UCL	1278

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.

C2 (lighthouse/keeper's quarters)

General Statistics

Total Number of Observations	13	Number of Distinct Observations	13
		Number of Missing Observations	0
Minimum	82	Mean	261.3
Maximum	661	Median	197
SD	167.4	Std. Error of Mean	46.42
Coefficient of Variation	0.641	Skewness	1.396

Normal GOF Test

Shapiro Wilk Test Statistic	0.843	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.866	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.263	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.246	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	344	95% Adjusted-CLT UCL (Chen-1995)	356.9
		95% Modified-t UCL (Johnson-1978)	347

Gamma GOF Test

A-D Test Statistic	0.47	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.739	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.225	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.238	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	3.153	k star (bias corrected MLE)	2.476
Theta hat (MLE)	82.88	Theta star (bias corrected MLE)	105.5
nu hat (MLE)	81.97	nu star (bias corrected)	64.39
MLE Mean (bias corrected)	261.3	MLE Sd (bias corrected)	166.1
		Approximate Chi Square Value (0.05)	46.93
Adjusted Level of Significance	0.0301	Adjusted Chi Square Value	44.81

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	358.5	95% Adjusted Gamma UCL (use when n<50)	375.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.961	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.866	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.189	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.246	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.407	Mean of logged Data	5.399
Maximum of Logged Data	6.494	SD of logged Data	0.593

Assuming Lognormal Distribution

95% H-UCL	385.7	90% Chebyshev (MVUE) UCL	392.1
95% Chebyshev (MVUE) UCL	452.1	97.5% Chebyshev (MVUE) UCL	535.4
99% Chebyshev (MVUE) UCL	699		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	337.7	95% Jackknife UCL	344
95% Standard Bootstrap UCL	335.7	95% Bootstrap-t UCL	380.7
95% Hall's Bootstrap UCL	363.6	95% Percentile Bootstrap UCL	345.6
95% BCA Bootstrap UCL	350.7		
90% Chebyshev(Mean, Sd) UCL	400.6	95% Chebyshev(Mean, Sd) UCL	463.7
97.5% Chebyshev(Mean, Sd) UCL	551.2	99% Chebyshev(Mean, Sd) UCL	723.2

Suggested UCL to Use

95% Adjusted Gamma UCL	375.5

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.

C2 (oil storage building)

General Statistics

Total Number of Observations	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	80	Mean	146.3
Maximum	263	Median	96
SD	101.4	Std. Error of Mean	58.52
Coefficient of Variation	0.693	Skewness	1.684

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.815	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.357	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.512	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	317.2	95% Adjusted-CLT UCL (Chen-1995)	303.4
		95% Modified-t UCL (Johnson-1978)	326.7

Gamma GOF Test

Not Enough Data to Perform GOF Test

Gamma Statistics

k hat (MLE)	3.574	k star (bias corrected MLE)	N/A
Theta hat (MLE)	40.94	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	21.44	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.862	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.333	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.512	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.382	Mean of logged Data	4.84
Maximum of Logged Data	5.572	SD of logged Data	0.641

Assuming Lognormal Distribution

95% H-UCL	6819	90% Chebyshev (MVUE) UCL	296.9
95% Chebyshev (MVUE) UCL	366	97.5% Chebyshev (MVUE) UCL	461.9
99% Chebyshev (MVUE) UCL	650.3		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	242.6	95% Jackknife UCL	317.2
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		

90% Chebyshev(Mean, Sd) UCL	321.9	95% Chebyshev(Mean, Sd) UCL	401.4
97.5% Chebyshev(Mean, Sd) UCL	511.8	99% Chebyshev(Mean, Sd) UCL	728.6

Suggested UCL to Use

95% Student's-t UCL	317.2

Recommended UCL exceeds the maximum observation

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.

C2 (outhouse)

General Statistics

Total Number of Observations	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	51	Mean	230.3
Maximum	467	Median	173
SD	213.8	Std. Error of Mean	123.5
Coefficient of Variation	0.928	Skewness	1.12

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.946	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.272	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.512	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	590.8	95% Adjusted-CLT UCL (Chen-1995)	518.7
		95% Modified-t UCL (Johnson-1978)	604.1

Gamma GOF Test

Not Enough Data to Perform GOF Test

Gamma Statistics

k hat (MLE)	1.525	k star (bias corrected MLE)	N/A
Theta hat (MLE)	151	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	9.15	nu star (bias corrected)	N/A
MLE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.996	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.194	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.512	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.932	Mean of logged Data	5.077
Maximum of Logged Data	6.146	SD of logged Data	1.109

Assuming Lognormal Distribution

95% H-UCL	25419634	90% Chebyshev (MVUE) UCL	624
95% Chebyshev (MVUE) UCL	801	97.5% Chebyshev (MVUE) UCL	1047
99% Chebyshev (MVUE) UCL	1529		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	433.4	95% Jackknife UCL	590.8
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	600.7	95% Chebyshev(Mean, Sd) UCL	768.5
97.5% Chebyshev(Mean, Sd) UCL	1001	99% Chebyshev(Mean, Sd) UCL	1459

Suggested UCL to Use

95% Student's-t UCL	590.8

Recommended UCL exceeds the maximum observation

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:36:35 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C2 (above ground storage tank)

General Statistics

Total Number of Observations	6	Number of Distinct Observations	6
		Number of Missing Observations	0
Minimum	54	Mean	353.3
Maximum	920	Median	230
SD	333.8	Std. Error of Mean	136.3
Coefficient of Variation	0.945	Skewness	1.168

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.875	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.788	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.234	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.362	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	627.9	95% Adjusted-CLT UCL (Chen-1995)	646.9
		95% Modified-t UCL (Johnson-1978)	638.7

Gamma GOF Test

A-D Test Statistic	0.211	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.71	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.185	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.339	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.327	k star (bias corrected MLE)	0.774
Theta hat (MLE)	266.4	Theta star (bias corrected MLE)	456.3
nu hat (MLE)	15.92	nu star (bias corrected)	9.292
MLE Mean (bias corrected)	353.3	MLE Sd (bias corrected)	401.5
		Approximate Chi Square Value (0.05)	3.505
Adjusted Level of Significance	0.0122	Adjusted Chi Square Value	2.349

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	936.9	95% Adjusted Gamma UCL (use when n<50)	1398

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.98	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.788	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.139	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.362	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.989	Mean of logged Data	5.445
Maximum of Logged Data	6.824	SD of logged Data	1.054

Assuming Lognormal Distribution

95% H-UCL	3096	90% Chebyshev (MVUE) UCL	812
95% Chebyshev (MVUE) UCL	1017	97.5% Chebyshev (MVUE) UCL	1303
99% Chebyshev (MVUE) UCL	1863		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	577.5	95% Jackknife UCL	627.9
95% Standard Bootstrap UCL	562.3	95% Bootstrap-t UCL	1010
95% Hall's Bootstrap UCL	1788	95% Percentile Bootstrap UCL	566.2
95% BCA Bootstrap UCL	614.2		
90% Chebyshev(Mean, Sd) UCL	762.1	95% Chebyshev(Mean, Sd) UCL	947.3
97.5% Chebyshev(Mean, Sd) UCL	1204	99% Chebyshev(Mean, Sd) UCL	1709

Suggested UCL to Use

95% Student's-t UCL	627.9

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.

C2 (fog signal building)

General Statistics

Total Number of Observations	25	Number of Distinct Observations	25
		Number of Missing Observations	0
Minimum	14	Mean	894
Maximum	7610	Median	478
SD	1648	Std. Error of Mean	329.5
Coefficient of Variation	1.843	Skewness	3.495

Normal GOF Test

Shapiro Wilk Test Statistic	0.478	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.405	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.177	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	1458	95% Adjusted-CLT UCL (Chen-1995)	1682
		95% Modified-t UCL (Johnson-1978)	1496

Gamma GOF Test

A-D Test Statistic	1.508	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.788	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.26	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.182	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.704	k star (bias corrected MLE)	0.646
Theta hat (MLE)	1270	Theta star (bias corrected MLE)	1383
nu hat (MLE)	35.2	nu star (bias corrected)	32.31
MLE Mean (bias corrected)	894	MLE Sd (bias corrected)	1112
		Approximate Chi Square Value (0.05)	20.32
Adjusted Level of Significance	0.0395	Adjusted Chi Square Value	19.67

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1422	95% Adjusted Gamma UCL (use when n<50)	1469

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.915	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.918	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.176	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.177	Data appear Lognormal at 5% Significance Level	

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.639	Mean of logged Data	5.938
Maximum of Logged Data	8.937	SD of logged Data	1.37

Assuming Lognormal Distribution

95% H-UCL	2245	90% Chebyshev (MVUE) UCL	1810
95% Chebyshev (MVUE) UCL	2219	97.5% Chebyshev (MVUE) UCL	2787
99% Chebyshev (MVUE) UCL	3903		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	1436	95% Jackknife UCL	1458
95% Standard Bootstrap UCL	1402	95% Bootstrap-t UCL	3423

95% Hall's Bootstrap UCL	3939	95% Percentile Bootstrap UCL	1470
95% BCA Bootstrap UCL	1715		
90% Chebyshev(Mean, Sd) UCL	1883	95% Chebyshev(Mean, Sd) UCL	2330
97.5% Chebyshev(Mean, Sd) UCL	2952	99% Chebyshev(Mean, Sd) UCL	4173

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	2330

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.

C2 (lighthouse/keeper's quarters)

General Statistics

Total Number of Observations	23	Number of Distinct Observations	23
		Number of Missing Observations	0
Minimum	122	Mean	378.2
Maximum	1019	Median	326
SD	234.3	Std. Error of Mean	48.86
Coefficient of Variation	0.62	Skewness	1.225

Normal GOF Test

Shapiro Wilk Test Statistic	0.878	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.914	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.182	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.185	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	462.1	95% Adjusted-CLT UCL (Chen-1995)	471.9
		95% Modified-t UCL (Johnson-1978)	464.2

Gamma GOF Test

A-D Test Statistic	0.392	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.75	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.135	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.183	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	3.123	k star (bias corrected MLE)	2.745
Theta hat (MLE)	121.1	Theta star (bias corrected MLE)	137.8
nu hat (MLE)	143.7	nu star (bias corrected)	126.2
MLE Mean (bias corrected)	378.2	MLE Sd (bias corrected)	228.3
		Approximate Chi Square Value (0.05)	101.3
Adjusted Level of Significance	0.0389	Adjusted Chi Square Value	99.68

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	471.4	95% Adjusted Gamma UCL (use when n<50)	479

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.971	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.914	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.118	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.185	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.804	Mean of logged Data	5.767
Maximum of Logged Data	6.927	SD of logged Data	0.589

Assuming Lognormal Distribution

95% H-UCL	492.2	90% Chebyshev (MVUE) UCL	523.3
95% Chebyshev (MVUE) UCL	589.6	97.5% Chebyshev (MVUE) UCL	681.7
99% Chebyshev (MVUE) UCL	862.5		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	458.6	95% Jackknife UCL	462.1
95% Standard Bootstrap UCL	457.6	95% Bootstrap-t UCL	484.1
95% Hall's Bootstrap UCL	479.3	95% Percentile Bootstrap UCL	462.2
95% BCA Bootstrap UCL	472.4		
90% Chebyshev(Mean, Sd) UCL	524.8	95% Chebyshev(Mean, Sd) UCL	591.2
97.5% Chebyshev(Mean, Sd) UCL	683.3	99% Chebyshev(Mean, Sd) UCL	864.3

Suggested UCL to Use

95% Student's-t UCL	462.1

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.

C2 (oil storage building)

General Statistics

Total Number of Observations	13	Number of Distinct Observations	13
		Number of Missing Observations	0
Minimum	62	Mean	690.3
Maximum	1881	Median	502
SD	582.8	Std. Error of Mean	161.7
Coefficient of Variation	0.844	Skewness	1.399

Normal GOF Test

Shapiro Wilk Test Statistic	0.808	**Shapiro Wilk GOF Test**

5% Shapiro Wilk Critical Value	0.866	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.239	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.246	Data appear Normal at 5% Significance Level	

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	978.4	95% Adjusted-CLT UCL (Chen-1995)	1023
		95% Modified-t UCL (Johnson-1978)	988.9

Gamma GOF Test

A-D Test Statistic	0.375	**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	0.147	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.24	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.658	k star (bias corrected MLE)	1.326
Theta hat (MLE)	416.5	Theta star (bias corrected MLE)	520.5
nu hat (MLE)	43.1	nu star (bias corrected)	34.48
MLE Mean (bias corrected)	690.3	MLE Sd (bias corrected)	599.4
		Approximate Chi Square Value (0.05)	22.05
Adjusted Level of Significance	0.0301	Adjusted Chi Square Value	20.64

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1079	95% Adjusted Gamma UCL (use when n<50)	1153

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.941	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.866	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.143	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.246	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.127	Mean of logged Data	6.206
Maximum of Logged Data	7.54	SD of logged Data	0.903

Assuming Lognormal Distribution

95% H-UCL	1502	90% Chebyshev (MVUE) UCL	1290
95% Chebyshev (MVUE) UCL	1551	97.5% Chebyshev (MVUE) UCL	1912
99% Chebyshev (MVUE) UCL	2622		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	956.2	95% Jackknife UCL	978.4
95% Standard Bootstrap UCL	945.8	95% Bootstrap-t UCL	1233
95% Hall's Bootstrap UCL	1207	95% Percentile Bootstrap UCL	968.2

95% BCA Bootstrap UCL	1004		
90% Chebyshev(Mean, Sd) UCL	1175	95% Chebyshev(Mean, Sd) UCL	1395
97.5% Chebyshev(Mean, Sd) UCL	1700	99% Chebyshev(Mean, Sd) UCL	2299

Suggested UCL to Use

95% Student's-t UCL 978.4

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.

C2 (outhouse)

General Statistics

Total Number of Observations	5	Number of Distinct Observations	5
		Number of Missing Observations	0
Minimum	215	Mean	372
Maximum	742	Median	325
SD	213.5	Std. Error of Mean	95.48
Coefficient of Variation	0.574	Skewness	1.898

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.767	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.363	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	575.6	95% Adjusted-CLT UCL (Chen-1995)	615.7
		95% Modified-t UCL (Johnson-1978)	589.1

Gamma GOF Test

A-D Test Statistic	0.515	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.681	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.323	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.358	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	4.905	k star (bias corrected MLE)	2.095
Theta hat (MLE)	75.85	Theta star (bias corrected MLE)	177.5
nu hat (MLE)	49.05	nu star (bias corrected)	20.95

MLE Mean (bias corrected)	372	MLE Sd (bias corrected)	257
		Approximate Chi Square Value (0.05)	11.56
Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	8.668

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	674.5	95% Adjusted Gamma UCL (use when n<50)	899.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.872	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.762	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.292	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.396	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	5.371	Mean of logged Data	5.813
Maximum of Logged Data	6.609	SD of logged Data	0.485

Assuming Lognormal Distribution

95% H-UCL	760.9	90% Chebyshev (MVUE) UCL	604.3
95% Chebyshev (MVUE) UCL	711.7	97.5% Chebyshev (MVUE) UCL	860.7
99% Chebyshev (MVUE) UCL	1153		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	529.1	95% Jackknife UCL	575.6
95% Standard Bootstrap UCL	512.2	95% Bootstrap-t UCL	919.6
95% Hall's Bootstrap UCL	1278	95% Percentile Bootstrap UCL	531.2
95% BCA Bootstrap UCL	560.8		
90% Chebyshev(Mean, Sd) UCL	658.4	95% Chebyshev(Mean, Sd) UCL	788.2
97.5% Chebyshev(Mean, Sd) UCL	968.3	99% Chebyshev(Mean, Sd) UCL	1322

Suggested UCL to Use

95% Student's-t UCL	575.6

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:14:30 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C2

General Statistics

Total Number of Observations	104	Number of Distinct Observations	98
		Number of Missing Observations	0
Minimum	14	Mean	518.8
Maximum	7610	Median	321
SD	885.6	Std. Error of Mean	86.84
Coefficient of Variation	1.707	Skewness	6.047

Normal GOF Test

Shapiro Wilk Test Statistic	0.451	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.284	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.0869	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	662.9	95% Adjusted-CLT UCL (Chen-1995)	716.6
		95% Modified-t UCL (Johnson-1978)	671.5

Gamma GOF Test

A-D Test Statistic	2.224	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.782	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.123	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.091	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.035	k star (bias corrected MLE)	1.012
Theta hat (MLE)	501.2	Theta star (bias corrected MLE)	512.9
nu hat (MLE)	215.3	nu star (bias corrected)	210.4
MLE Mean (bias corrected)	518.8	MLE Sd (bias corrected)	515.8
		Approximate Chi Square Value (0.05)	177.8
Adjusted Level of Significance	0.0477	Adjusted Chi Square Value	177.4

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	613.8	95% Adjusted Gamma UCL (use when n<50)	615.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.98	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.529	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0663	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.0869	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.639	Mean of logged Data	5.696
Maximum of Logged Data	8.937	SD of logged Data	1.033

Assuming Lognormal Distribution

95% H-UCL	637.5	90% Chebyshev (MVUE) UCL	689.2
95% Chebyshev (MVUE) UCL	773.2	97.5% Chebyshev (MVUE) UCL	889.9
99% Chebyshev (MVUE) UCL	1119		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	661.6	95% Jackknife UCL	662.9
95% Standard Bootstrap UCL	659.9	95% Bootstrap-t UCL	826.6
95% Hall's Bootstrap UCL	1340	95% Percentile Bootstrap UCL	680.9
95% BCA Bootstrap UCL	725.8		
90% Chebyshev(Mean, Sd) UCL	779.3	95% Chebyshev(Mean, Sd) UCL	897.3
97.5% Chebyshev(Mean, Sd) UCL	1061	99% Chebyshev(Mean, Sd) UCL	1383

Suggested UCL to Use

95% H-UCL	637.5

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.

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

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:02:23 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C2 (subsurface)

General Statistics

Total Number of Observations	60	Number of Distinct Observations	57
		Number of Missing Observations	0
Minimum	16	Mean	373
Maximum	2239	Median	229.5
SD	443.3	Std. Error of Mean	57.23
Coefficient of Variation	1.189	Skewness	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.687	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	2.220E-16	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.223	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.114	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	468.6	95% Adjusted-CLT UCL (Chen-1995)	488.8
		95% Modified-t UCL (Johnson-1978)	472

Gamma GOF Test

A-D Test Statistic	0.772	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.777	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.118	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.118	Data Not Gamma Distributed at 5% Significance Level

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

Gamma Statistics

k hat (MLE)	1.092	k star (bias corrected MLE)	1.048
Theta hat (MLE)	341.7	Theta star (bias corrected MLE)	355.8
nu hat (MLE)	131	nu star (bias corrected)	125.8
MLE Mean (bias corrected)	373	MLE Sd (bias corrected)	364.3
		Approximate Chi Square Value (0.05)	100.9
Adjusted Level of Significance	0.046	Adjusted Chi Square Value	100.3

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	465	95% Adjusted Gamma UCL (use when n<50)	467.6

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.985	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.871	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0659	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.114	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.773	Mean of logged Data	5.398
Maximum of Logged Data	7.714	SD of logged Data	1.059

Assuming Lognormal Distribution

95% H-UCL	542.5	90% Chebyshev (MVUE) UCL	569.8
95% Chebyshev (MVUE) UCL	655.1	97.5% Chebyshev (MVUE) UCL	773.4
99% Chebyshev (MVUE) UCL	1006		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	467.1	95% Jackknife UCL	468.6
95% Standard Bootstrap UCL	467.1	95% Bootstrap-t UCL	504.9
95% Hall's Bootstrap UCL	505.9	95% Percentile Bootstrap UCL	466.8
95% BCA Bootstrap UCL	487		
90% Chebyshev(Mean, Sd) UCL	544.7	95% Chebyshev(Mean, Sd) UCL	622.4
97.5% Chebyshev(Mean, Sd) UCL	730.4	99% Chebyshev(Mean, Sd) UCL	942.4

Suggested UCL to Use

95% Approximate Gamma UCL	465

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.

C2 (surface)

General Statistics

Total Number of Observations	116	Number of Distinct Observations	108
		Number of Missing Observations	0
Minimum	34	Mean	527.1
Maximum	4877	Median	338.5
SD	680.5	Std. Error of Mean	63.18
Coefficient of Variation	1.291	Skewness	4.091

Normal GOF Test

Shapiro Wilk Test Statistic	0.584	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.239	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.0823	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	631.9	95% Adjusted-CLT UCL (Chen-1995)	656.7
		95% Modified-t UCL (Johnson-1978)	635.9

Gamma GOF Test

A-D Test Statistic	2.232	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.776	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.122	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.0873	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.276	k star (bias corrected MLE)	1.248
Theta hat (MLE)	413.2	Theta star (bias corrected MLE)	422.2
nu hat (MLE)	295.9	nu star (bias corrected)	289.6
MLE Mean (bias corrected)	527.1	MLE Sd (bias corrected)	471.8
		Approximate Chi Square Value (0.05)	251.2
Adjusted Level of Significance	0.0479	Adjusted Chi Square Value	250.7

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	607.7	95% Adjusted Gamma UCL (use when n<50)	608.8

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.984	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	0.733	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0516	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.0823	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.526	Mean of logged Data	5.827
Maximum of Logged Data	8.492	SD of logged Data	0.91

Assuming Lognormal Distribution

95% H-UCL	615.2	90% Chebyshev (MVUE) UCL	662.2
95% Chebyshev (MVUE) UCL	730.8	97.5% Chebyshev (MVUE) UCL	826.1
99% Chebyshev (MVUE) UCL	1013		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	631	95% Jackknife UCL	631.9
95% Standard Bootstrap UCL	631.2	95% Bootstrap-t UCL	683.4
95% Hall's Bootstrap UCL	696.5	95% Percentile Bootstrap UCL	632.3
95% BCA Bootstrap UCL	660.8		
90% Chebyshev(Mean, Sd) UCL	716.6	95% Chebyshev(Mean, Sd) UCL	802.5
97.5% Chebyshev(Mean, Sd) UCL	921.7	99% Chebyshev(Mean, Sd) UCL	1156

Suggested UCL to Use

95% H-UCL	615.2

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.

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

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:03:34 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C2 (drainage swale)

General Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	34	Mean	147.8
Maximum	270	Median	143.5
SD	101	Std. Error of Mean	50.48
Coefficient of Variation	0.683	Skewness	0.208

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.995	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.157	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	266.6	95% Adjusted-CLT UCL (Chen-1995)	236.4
		95% Modified-t UCL (Johnson-1978)	267.4

Gamma GOF Test

A-D Test Statistic	0.229	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.66	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.2	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.398	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.169	k star (bias corrected MLE)	0.709
Theta hat (MLE)	68.12	Theta star (bias corrected MLE)	208.4
nu hat (MLE)	17.35	nu star (bias corrected)	5.671
MLE Mean (bias corrected)	147.8	MLE Sd (bias corrected)	175.5
		Approximate Chi Square Value (0.05)	1.474
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	568.4	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.944	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.217	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.526	Mean of logged Data	4.748
Maximum of Logged Data	5.598	SD of logged Data	0.898

Assuming Lognormal Distribution

95% H-UCL	3924	90% Chebyshev (MVUE) UCL	348.2
95% Chebyshev (MVUE) UCL	436.4	97.5% Chebyshev (MVUE) UCL	558.8
99% Chebyshev (MVUE) UCL	799.3		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	230.8	95% Jackknife UCL	266.6
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	299.2	95% Chebyshev(Mean, Sd) UCL	367.8
97.5% Chebyshev(Mean, Sd) UCL	463	99% Chebyshev(Mean, Sd) UCL	650.1

Suggested UCL to Use

95% Student's-t UCL	266.6

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.

C2 (fog signal building)

General Statistics

Total Number of Observations	22	Number of Distinct Observations	22
		Number of Missing Observations	0
Minimum	88	Mean	603.7
Maximum	1744	Median	602.5
SD	437	Std. Error of Mean	93.18
Coefficient of Variation	0.724	Skewness	0.765

Normal GOF Test

Shapiro Wilk Test Statistic	0.924	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.911	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.12	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.189	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	764	95% Adjusted-CLT UCL (Chen-1995)	773.2
		95% Modified-t UCL (Johnson-1978)	766.5

Gamma GOF Test

A-D Test Statistic	0.475	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.758	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.137	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.188	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.655	k star (bias corrected MLE)	1.459
Theta hat (MLE)	364.8	Theta star (bias corrected MLE)	413.6
nu hat (MLE)	72.81	nu star (bias corrected)	64.22
MLE Mean (bias corrected)	603.7	MLE Sd (bias corrected)	499.7
		Approximate Chi Square Value (0.05)	46.78
Adjusted Level of Significance	0.0386	Adjusted Chi Square Value	45.67

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	828.7	95% Adjusted Gamma UCL (use when n<50)	848.9

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.916	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.911	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.168	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.189	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.477	Mean of logged Data	6.071
Maximum of Logged Data	7.464	SD of logged Data	0.922

Assuming Lognormal Distribution

95% H-UCL	1090	90% Chebyshev (MVUE) UCL	1068
95% Chebyshev (MVUE) UCL	1260	97.5% Chebyshev (MVUE) UCL	1526
99% Chebyshev (MVUE) UCL	2048		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	756.9	95% Jackknife UCL	764
95% Standard Bootstrap UCL	749.1	95% Bootstrap-t UCL	785.5

95% Hall's Bootstrap UCL	788.3	95% Percentile Bootstrap UCL	757.2
95% BCA Bootstrap UCL	773.1		
90% Chebyshev(Mean, Sd) UCL	883.2	95% Chebyshev(Mean, Sd) UCL	1010
97.5% Chebyshev(Mean, Sd) UCL	1186	99% Chebyshev(Mean, Sd) UCL	1531

Suggested UCL to Use

95% Student's-t UCL	764

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.

C2 (garden)

General Statistics

Total Number of Observations	2	Number of Distinct Observations	2
		Number of Missing Observations	0
Minimum	36	Mean	50.95
Maximum	65.9	Median	50.95

Warning: This data set only has 2 observations!
Data set is too small to compute reliable and meaningful statistics and estimates!
The data set for variable C2 (garden) was not processed!

It is suggested to collect at least 8 to 10 observations before using these statistical methods!
If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

C2 (lighthouse/keeper's quarters)

General Statistics

Total Number of Observations	42	Number of Distinct Observations	41
		Number of Missing Observations	0
Minimum	42	Mean	550.5
Maximum	4877	Median	285
SD	949.5	Std. Error of Mean	146.5
Coefficient of Variation	1.725	Skewness	3.665

Normal GOF Test

Shapiro Wilk Test Statistic	0.467	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.942	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.376	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.137	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	797	95% Adjusted-CLT UCL (Chen-1995)	880

		95% Modified-t UCL (Johnson-1978)	810.8

Gamma GOF Test

A-D Test Statistic	3.183	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.781	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.244	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.141	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.943	k star (bias corrected MLE)	0.891
Theta hat (MLE)	584	Theta star (bias corrected MLE)	617.7
nu hat (MLE)	79.18	nu star (bias corrected)	74.86
MLE Mean (bias corrected)	550.5	MLE Sd (bias corrected)	583.1
		Approximate Chi Square Value (0.05)	55.93
Adjusted Level of Significance	0.0443	Adjusted Chi Square Value	55.35

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	736.8	95% Adjusted Gamma UCL (use when n<50)	744.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.904	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.942	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.145	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.137	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.738	Mean of logged Data	5.694
Maximum of Logged Data	8.492	SD of logged Data	0.989

Assuming Lognormal Distribution

95% H-UCL	696.4	90% Chebyshev (MVUE) UCL	730.9
95% Chebyshev (MVUE) UCL	846.1	97.5% Chebyshev (MVUE) UCL	1006
99% Chebyshev (MVUE) UCL	1320		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	791.5	95% Jackknife UCL	797
95% Standard Bootstrap UCL	788.6	95% Bootstrap-t UCL	1193
95% Hall's Bootstrap UCL	1236	95% Percentile Bootstrap UCL	798.3
95% BCA Bootstrap UCL	895.2		
90% Chebyshev(Mean, Sd) UCL	990	95% Chebyshev(Mean, Sd) UCL	1189
97.5% Chebyshev(Mean, Sd) UCL	1465	99% Chebyshev(Mean, Sd) UCL	2008

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	1189

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.

C2 (oil storage building)

General Statistics

Total Number of Observations	24	Number of Distinct Observations	23
		Number of Missing Observations	0
Minimum	29	Mean	298.6
Maximum	734	Median	266
SD	195.1	Std. Error of Mean	39.83
Coefficient of Variation	0.654	Skewness	0.399

Normal GOF Test

Shapiro Wilk Test Statistic	0.946	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.916	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.12	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.181	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	366.9	95% Adjusted-CLT UCL (Chen-1995)	367.6
		95% Modified-t UCL (Johnson-1978)	367.4

Gamma GOF Test

A-D Test Statistic	0.417	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.757	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.136	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.18	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.849	k star (bias corrected MLE)	1.646
Theta hat (MLE)	161.4	Theta star (bias corrected MLE)	181.4
nu hat (MLE)	88.77	nu star (bias corrected)	79.01
MLE Mean (bias corrected)	298.6	MLE Sd (bias corrected)	232.7
		Approximate Chi Square Value (0.05)	59.53
Adjusted Level of Significance	0.0392	Adjusted Chi Square Value	58.34

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	396.3	95% Adjusted Gamma UCL (use when n<50)	404.4

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.917	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.916	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.138	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.181	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.367	Mean of logged Data	5.405
Maximum of Logged Data	6.599	SD of logged Data	0.889

Assuming Lognormal Distribution

95% H-UCL	515.1	90% Chebyshev (MVUE) UCL	518.4
95% Chebyshev (MVUE) UCL	606.9	97.5% Chebyshev (MVUE) UCL	729.7
99% Chebyshev (MVUE) UCL	970.9		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	364.1	95% Jackknife UCL	366.9
95% Standard Bootstrap UCL	362.6	95% Bootstrap-t UCL	367.8
95% Hall's Bootstrap UCL	369.5	95% Percentile Bootstrap UCL	364.7
95% BCA Bootstrap UCL	364.3		
90% Chebyshev(Mean, Sd) UCL	418.1	95% Chebyshev(Mean, Sd) UCL	472.2
97.5% Chebyshev(Mean, Sd) UCL	547.3	99% Chebyshev(Mean, Sd) UCL	694.9

Suggested UCL to Use

95% Student's-t UCL	366.9

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.

C2 (outhouse)

General Statistics

Total Number of Observations	20	Number of Distinct Observations	20
		Number of Missing Observations	0
Minimum	55	Mean	396.7
Maximum	1088	Median	278
SD	308.4	Std. Error of Mean	68.96
Coefficient of Variation	0.777	Skewness	1.078

Normal GOF Test

Shapiro Wilk Test Statistic	0.84	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.905	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.225	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.198	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	515.9	95% Adjusted-CLT UCL (Chen-1995)	527.9
		95% Modified-t UCL (Johnson-1978)	518.7

Gamma GOF Test

A-D Test Statistic	0.662	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.753	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.148	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.196	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.908	k star (bias corrected MLE)	1.655
Theta hat (MLE)	207.9	Theta star (bias corrected MLE)	239.7
nu hat (MLE)	76.32	nu star (bias corrected)	66.2
MLE Mean (bias corrected)	396.7	MLE Sd (bias corrected)	308.4
		Approximate Chi Square Value (0.05)	48.48
Adjusted Level of Significance	0.038	Adjusted Chi Square Value	47.28

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	541.7	95% Adjusted Gamma UCL (use when n<50)	555.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.946	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.905	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.137	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.198	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.007	Mean of logged Data	5.699
Maximum of Logged Data	6.992	SD of logged Data	0.789

Assuming Lognormal Distribution

95% H-UCL	622.6	90% Chebyshev (MVUE) UCL	628.1
95% Chebyshev (MVUE) UCL	731.6	97.5% Chebyshev (MVUE) UCL	875.4
99% Chebyshev (MVUE) UCL	1158		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	510.1	95% Jackknife UCL	515.9
95% Standard Bootstrap UCL	505.7	95% Bootstrap-t UCL	533.5
95% Hall's Bootstrap UCL	518.5	95% Percentile Bootstrap UCL	516.6
95% BCA Bootstrap UCL	522.3		
90% Chebyshev(Mean, Sd) UCL	603.6	95% Chebyshev(Mean, Sd) UCL	697.3
97.5% Chebyshev(Mean, Sd) UCL	827.4	99% Chebyshev(Mean, Sd) UCL	1083

Suggested UCL to Use

95% Adjusted Gamma UCL	555.5

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.

C2 (shed)

General Statistics

Total Number of Observations	62	Number of Distinct Observations	59
		Number of Missing Observations	0
Minimum	16	Mean	505.3
Maximum	3157	Median	315
SD	569.5	Std. Error of Mean	72.33
Coefficient of Variation	1.127	Skewness	2.689

Normal GOF Test

Shapiro Wilk Test Statistic	0.709	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	5.551E-16	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.206	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.113	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	626.1	95% Adjusted-CLT UCL (Chen-1995)	650.6
		95% Modified-t UCL (Johnson-1978)	630.2

Gamma GOF Test

A-D Test Statistic	0.772	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.775	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0922	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.116	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.195	k star (bias corrected MLE)	1.148
Theta hat (MLE)	422.8	Theta star (bias corrected MLE)	440.1
nu hat (MLE)	148.2	nu star (bias corrected)	142.3
MLE Mean (bias corrected)	505.3	MLE Sd (bias corrected)	471.6
		Approximate Chi Square Value (0.05)	115.8
Adjusted Level of Significance	0.0461	Adjusted Chi Square Value	115.2

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	621.2	95% Adjusted Gamma UCL (use when n<50)	624.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.987	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	0.928	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0768	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.113	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.773	Mean of logged Data	5.752
Maximum of Logged Data	8.057	SD of logged Data	1.013

Assuming Lognormal Distribution

95% H-UCL	704.9	90% Chebyshev (MVUE) UCL	757.9
95% Chebyshev (MVUE) UCL	866	97.5% Chebyshev (MVUE) UCL	1016
99% Chebyshev (MVUE) UCL	1310		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	624.2	95% Jackknife UCL	626.1
95% Standard Bootstrap UCL	620.3	95% Bootstrap-t UCL	664.3
95% Hall's Bootstrap UCL	674.5	95% Percentile Bootstrap UCL	632.5
95% BCA Bootstrap UCL	650.9		
90% Chebyshev(Mean, Sd) UCL	722.2	95% Chebyshev(Mean, Sd) UCL	820.5
97.5% Chebyshev(Mean, Sd) UCL	957	99% Chebyshev(Mean, Sd) UCL	1225

Suggested UCL to Use

95% Approximate Gamma UCL	621.2

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:09:49 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C2 (fog signal building)

General Statistics

Total Number of Observations	9	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	89	Mean	473.7
Maximum	927	Median	390
SD	295.9	Std. Error of Mean	98.62
Coefficient of Variation	0.625	Skewness	0.415

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.94	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.167	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	657.1	95% Adjusted-CLT UCL (Chen-1995)	650.5
		95% Modified-t UCL (Johnson-1978)	659.3

Gamma GOF Test

A-D Test Statistic	0.185	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.728	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.127	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.282	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.432	k star (bias corrected MLE)	1.695
Theta hat (MLE)	194.8	Theta star (bias corrected MLE)	279.4
nu hat (MLE)	43.78	nu star (bias corrected)	30.52
MLE Mean (bias corrected)	473.7	MLE Sd (bias corrected)	363.8
		Approximate Chi Square Value (0.05)	18.9
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	17

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	764.8	95% Adjusted Gamma UCL (use when n<50)	850.4

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.948	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.137	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.489	Mean of logged Data	5.941
Maximum of Logged Data	6.832	SD of logged Data	0.762

Assuming Lognormal Distribution

95% H-UCL	1063	90% Chebyshev (MVUE) UCL	872.1
95% Chebyshev (MVUE) UCL	1046	97.5% Chebyshev (MVUE) UCL	1286
99% Chebyshev (MVUE) UCL	1759		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	635.9	95% Jackknife UCL	657.1
95% Standard Bootstrap UCL	623.5	95% Bootstrap-t UCL	683.9
95% Hall's Bootstrap UCL	665.5	95% Percentile Bootstrap UCL	627.6
95% BCA Bootstrap UCL	645.4		
90% Chebyshev(Mean, Sd) UCL	769.5	95% Chebyshev(Mean, Sd) UCL	903.5
97.5% Chebyshev(Mean, Sd) UCL	1090	99% Chebyshev(Mean, Sd) UCL	1455

Suggested UCL to Use

95% Student's-t UCL	657.1

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.

C2 (lighthouse/keeper's quarters)

General Statistics

Total Number of Observations	13	Number of Distinct Observations	13
		Number of Missing Observations	0
Minimum	42	Mean	468.8
Maximum	2239	Median	243
SD	597.9	Std. Error of Mean	165.8
Coefficient of Variation	1.275	Skewness	2.532

Normal GOF Test

Shapiro Wilk Test Statistic	0.669	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.866	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.284	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.246	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	764.4	95% Adjusted-CLT UCL (Chen-1995)	866
		95% Modified-t UCL (Johnson-1978)	783.8

Gamma GOF Test

A-D Test Statistic	0.487	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.757	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.214	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.243	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.063	k star (bias corrected MLE)	0.869
Theta hat (MLE)	441.2	Theta star (bias corrected MLE)	539.7
nu hat (MLE)	27.63	nu star (bias corrected)	22.59
MLE Mean (bias corrected)	468.8	MLE Sd (bias corrected)	503
		Approximate Chi Square Value (0.05)	12.78
Adjusted Level of Significance	0.0301	Adjusted Chi Square Value	11.74

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	828.7	95% Adjusted Gamma UCL (use when n<50)	902.1

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.983	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.866	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.151	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.246	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.738	Mean of logged Data	5.611
Maximum of Logged Data	7.714	SD of logged Data	1.058

Assuming Lognormal Distribution

95% H-UCL	1178	90% Chebyshev (MVUE) UCL	879.9
95% Chebyshev (MVUE) UCL	1074	97.5% Chebyshev (MVUE) UCL	1344
99% Chebyshev (MVUE) UCL	1875		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	741.6	95% Jackknife UCL	764.4
95% Standard Bootstrap UCL	724	95% Bootstrap-t UCL	1342

95% Hall's Bootstrap UCL	1946	95% Percentile Bootstrap UCL	771.4
95% BCA Bootstrap UCL	842.7		
90% Chebyshev(Mean, Sd) UCL	966.3	95% Chebyshev(Mean, Sd) UCL	1192
97.5% Chebyshev(Mean, Sd) UCL	1504	99% Chebyshev(Mean, Sd) UCL	2119

Suggested UCL to Use

95% Adjusted Gamma UCL	902.1

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.

C2 (oil storage building)

General Statistics

Total Number of Observations	8	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	29	Mean	153.5
Maximum	454	Median	88.5
SD	148.5	Std. Error of Mean	52.49
Coefficient of Variation	0.967	Skewness	1.425

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.828	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.283	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	253	95% Adjusted-CLT UCL (Chen-1995)	268.1
		95% Modified-t UCL (Johnson-1978)	257.4

Gamma GOF Test

A-D Test Statistic	0.305	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.73	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.223	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.299	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.384	k star (bias corrected MLE)	0.949
Theta hat (MLE)	110.9	Theta star (bias corrected MLE)	161.8

nu hat (MLE)	22.15	nu star (bias corrected)	15.18
MLE Mean (bias corrected)	153.5	MLE Sd (bias corrected)	157.6
		Approximate Chi Square Value (0.05)	7.384
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	6.063

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	315.5	95% Adjusted Gamma UCL (use when n<50)	384.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.96	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.165	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.313	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.367	Mean of logged Data	4.631
Maximum of Logged Data	6.118	SD of logged Data	0.968

Assuming Lognormal Distribution

95% H-UCL	557.8	90% Chebyshev (MVUE) UCL	311.3
95% Chebyshev (MVUE) UCL	383.5	97.5% Chebyshev (MVUE) UCL	483.6
99% Chebyshev (MVUE) UCL	680.4		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	239.8	95% Jackknife UCL	253
95% Standard Bootstrap UCL	234.1	95% Bootstrap-t UCL	369.8
95% Hall's Bootstrap UCL	518.8	95% Percentile Bootstrap UCL	239.4
95% BCA Bootstrap UCL	263.9		
90% Chebyshev(Mean, Sd) UCL	311	95% Chebyshev(Mean, Sd) UCL	382.3
97.5% Chebyshev(Mean, Sd) UCL	481.3	99% Chebyshev(Mean, Sd) UCL	675.8

Suggested UCL to Use

95% Student's-t UCL	253

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.

C2 (outhouse)

General Statistics

Total Number of Observations	9	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	55	Mean	340.6
Maximum	970	Median	234

SD	305.6	Std. Error of Mean	101.9
Coefficient of Variation	0.897	Skewness	1.507

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.793	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.287	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	530	95% Adjusted-CLT UCL (Chen-1995)	562.8
		95% Modified-t UCL (Johnson-1978)	538.5

Gamma GOF Test

A-D Test Statistic	0.437	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.733	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.218	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.283	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.68	k star (bias corrected MLE)	1.194
Theta hat (MLE)	202.7	Theta star (bias corrected MLE)	285.2
nu hat (MLE)	30.24	nu star (bias corrected)	21.49
MLE Mean (bias corrected)	340.6	MLE Sd (bias corrected)	311.6
		Approximate Chi Square Value (0.05)	11.96
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	10.49

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	612	95% Adjusted Gamma UCL (use when n<50)	697.7

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.954	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.17	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.295	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.007	Mean of logged Data	5.504
Maximum of Logged Data	6.877	SD of logged Data	0.863

Assuming Lognormal Distribution

95% H-UCL	874.3	90% Chebyshev (MVUE) UCL	639.8

95% Chebyshev (MVUE) UCL	776.3	97.5% Chebyshev (MVUE) UCL	965.7
99% Chebyshev (MVUE) UCL	1338		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	508.1	95% Jackknife UCL	530
95% Standard Bootstrap UCL	498.4	95% Bootstrap-t UCL	934
95% Hall's Bootstrap UCL	1588	95% Percentile Bootstrap UCL	512.4
95% BCA Bootstrap UCL	545.3		
90% Chebyshev(Mean, Sd) UCL	646.1	95% Chebyshev(Mean, Sd) UCL	784.5
97.5% Chebyshev(Mean, Sd) UCL	976.6	99% Chebyshev(Mean, Sd) UCL	1354

Suggested UCL to Use

95% Student's-t UCL	530

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.

C2 (shed)

General Statistics

Total Number of Observations	21	Number of Distinct Observations	21
		Number of Missing Observations	0
Minimum	16	Mean	367.9
Maximum	2212	Median	183
SD	504.9	Std. Error of Mean	110.2
Coefficient of Variation	1.372	Skewness	2.859

Normal GOF Test

Shapiro Wilk Test Statistic	0.636	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.908	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.275	**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	557.9	95% Adjusted-CLT UCL (Chen-1995)	622.6
		95% Modified-t UCL (Johnson-1978)	569.4

Gamma GOF Test

A-D Test Statistic	0.531	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.773	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.159	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.195	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.928	k star (bias corrected MLE)	0.827
Theta hat (MLE)	396.6	Theta star (bias corrected MLE)	445
nu hat (MLE)	38.96	nu star (bias corrected)	34.73
MLE Mean (bias corrected)	367.9	MLE Sd (bias corrected)	404.6
		Approximate Chi Square Value (0.05)	22.25
Adjusted Level of Significance	0.0383	Adjusted Chi Square Value	21.48

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	574.3	95% Adjusted Gamma UCL (use when n<50)	594.8

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.987	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.908	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.105	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.193	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.773	Mean of logged Data	5.28
Maximum of Logged Data	7.702	SD of logged Data	1.167

Assuming Lognormal Distribution

95% H-UCL	805.4	90% Chebyshev (MVUE) UCL	693.9
95% Chebyshev (MVUE) UCL	841	97.5% Chebyshev (MVUE) UCL	1045
99% Chebyshev (MVUE) UCL	1447		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	549.1	95% Jackknife UCL	557.9
95% Standard Bootstrap UCL	542.5	95% Bootstrap-t UCL	799.1
95% Hall's Bootstrap UCL	1319	95% Percentile Bootstrap UCL	556.1
95% BCA Bootstrap UCL	627.9		
90% Chebyshev(Mean, Sd) UCL	698.5	95% Chebyshev(Mean, Sd) UCL	848.2
97.5% Chebyshev(Mean, Sd) UCL	1056	99% Chebyshev(Mean, Sd) UCL	1464

Suggested UCL to Use

95% Adjusted Gamma UCL	594.8

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:07:21 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C2 (drainage swale)

General Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	34	Mean	147.8
Maximum	270	Median	143.5
SD	101	Std. Error of Mean	50.48
Coefficient of Variation	0.683	Skewness	0.208

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0

Normal GOF Test

Shapiro Wilk Test Statistic	0.995	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.157	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	266.6	95% Adjusted-CLT UCL (Chen-1995)	236.4
		95% Modified-t UCL (Johnson-1978)	267.4

Gamma GOF Test

A-D Test Statistic	0.229	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.66	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.2	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.398	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.169	k star (bias corrected MLE)	0.709
Theta hat (MLE)	68.12	Theta star (bias corrected MLE)	208.4
nu hat (MLE)	17.35	nu star (bias corrected)	5.671
MLE Mean (bias corrected)	147.8	MLE Sd (bias corrected)	175.5
		Approximate Chi Square Value (0.05)	1.474
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	568.4	95% Adjusted Gamma UCL (use when n<50)	N/A

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.944	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.217	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.443	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.526	Mean of logged Data	4.748
Maximum of Logged Data	5.598	SD of logged Data	0.898

Assuming Lognormal Distribution

95% H-UCL	3924	90% Chebyshev (MVUE) UCL	348.2
95% Chebyshev (MVUE) UCL	436.4	97.5% Chebyshev (MVUE) UCL	558.8
99% Chebyshev (MVUE) UCL	799.3		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	230.8	95% Jackknife UCL	266.6
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A		
90% Chebyshev(Mean, Sd) UCL	299.2	95% Chebyshev(Mean, Sd) UCL	367.8
97.5% Chebyshev(Mean, Sd) UCL	463	99% Chebyshev(Mean, Sd) UCL	650.1

Suggested UCL to Use

95% Student's-t UCL	266.6

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.

C2 (fog signal building)

General Statistics

Total Number of Observations	13	Number of Distinct Observations	13
		Number of Missing Observations	0
Minimum	88	Mean	693.7
Maximum	1744	Median	684
SD	504.4	Std. Error of Mean	139.9
Coefficient of Variation	0.727	Skewness	0.469

Normal GOF Test

Shapiro Wilk Test Statistic	0.931	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.866	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.148	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.246	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	943	95% Adjusted-CLT UCL (Chen-1995)	943.3
		95% Modified-t UCL (Johnson-1978)	946.1

Gamma GOF Test

A-D Test Statistic	0.566	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.751	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.194	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.241	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.459	k star (bias corrected MLE)	1.174
Theta hat (MLE)	475.5	Theta star (bias corrected MLE)	591.1
nu hat (MLE)	37.93	nu star (bias corrected)	30.51
MLE Mean (bias corrected)	693.7	MLE Sd (bias corrected)	640.4
		Approximate Chi Square Value (0.05)	18.9
Adjusted Level of Significance	0.0301	Adjusted Chi Square Value	17.6

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1120	95% Adjusted Gamma UCL (use when n<50)	1202

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.87	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.866	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.233	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.246	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.477	Mean of logged Data	6.162
Maximum of Logged Data	7.464	SD of logged Data	1.038

Assuming Lognormal Distribution

95% H-UCL	1946	90% Chebyshev (MVUE) UCL	1484
95% Chebyshev (MVUE) UCL	1808	97.5% Chebyshev (MVUE) UCL	2259
99% Chebyshev (MVUE) UCL	3144		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	923.8	95% Jackknife UCL	943
95% Standard Bootstrap UCL	908.6	95% Bootstrap-t UCL	967.1

95% Hall's Bootstrap UCL	971.4	95% Percentile Bootstrap UCL	909.4
95% BCA Bootstrap UCL	941.7		
90% Chebyshev(Mean, Sd) UCL	1113	95% Chebyshev(Mean, Sd) UCL	1304
97.5% Chebyshev(Mean, Sd) UCL	1567	99% Chebyshev(Mean, Sd) UCL	2086

Suggested UCL to Use

95% Student's-t UCL	943

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.

C2 (garden)

General Statistics

Total Number of Observations	2	Number of Distinct Observations	2
		Number of Missing Observations	0
Minimum	36	Mean	50.95
Maximum	65.9	Median	50.95

Warning: This data set only has 2 observations!
Data set is too small to compute reliable and meaningful statistics and estimates!
The data set for variable C2 (garden) was not processed!

It is suggested to collect at least 8 to 10 observations before using these statistical methods!
If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

C2 (lighthouse/keeper's quarters)

General Statistics

Total Number of Observations	29	Number of Distinct Observations	28
		Number of Missing Observations	0
Minimum	51	Mean	587.1
Maximum	4877	Median	290
SD	1078	Std. Error of Mean	200.2
Coefficient of Variation	1.836	Skewness	3.505

Normal GOF Test

Shapiro Wilk Test Statistic	0.427	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.926	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.412	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.165	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	927.6	95% Adjusted-CLT UCL (Chen-1995)	1056

		95% Modified-t UCL (Johnson-1978)	949.4

Gamma GOF Test

A-D Test Statistic	3.273	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.778	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.294	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.168	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.907	k star (bias corrected MLE)	0.836
Theta hat (MLE)	647.1	Theta star (bias corrected MLE)	701.9
nu hat (MLE)	52.62	nu star (bias corrected)	48.51
MLE Mean (bias corrected)	587.1	MLE Sd (bias corrected)	641.9
		Approximate Chi Square Value (0.05)	33.52
Adjusted Level of Significance	0.0407	Adjusted Chi Square Value	32.78

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	849.5	95% Adjusted Gamma UCL (use when n<50)	868.9

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.869	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.926	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.192	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.165	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.932	Mean of logged Data	5.731
Maximum of Logged Data	8.492	SD of logged Data	0.974

Assuming Lognormal Distribution

95% H-UCL	775.9	90% Chebyshev (MVUE) UCL	784.1
95% Chebyshev (MVUE) UCL	919.9	97.5% Chebyshev (MVUE) UCL	1108
99% Chebyshev (MVUE) UCL	1479		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	916.4	95% Jackknife UCL	927.6
95% Standard Bootstrap UCL	913.6	95% Bootstrap-t UCL	2384
95% Hall's Bootstrap UCL	2384	95% Percentile Bootstrap UCL	943.1
95% BCA Bootstrap UCL	1123		
90% Chebyshev(Mean, Sd) UCL	1188	95% Chebyshev(Mean, Sd) UCL	1460
97.5% Chebyshev(Mean, Sd) UCL	1837	99% Chebyshev(Mean, Sd) UCL	2579

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	1460

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.

C2 (oil storage building)

General Statistics

Total Number of Observations	16	Number of Distinct Observations	15
		Number of Missing Observations	0
Minimum	113	Mean	371.1
Maximum	734	Median	365.5
SD	176.8	Std. Error of Mean	44.2
Coefficient of Variation	0.476	Skewness	0.297

Normal GOF Test

Shapiro Wilk Test Statistic	0.954	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.142	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.222	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	448.6	95% Adjusted-CLT UCL (Chen-1995)	447.3
		95% Modified-t UCL (Johnson-1978)	449.2

Gamma GOF Test

A-D Test Statistic	0.352	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.742	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.161	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.216	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	4.174	k star (bias corrected MLE)	3.433
Theta hat (MLE)	88.91	Theta star (bias corrected MLE)	108.1
nu hat (MLE)	133.6	nu star (bias corrected)	109.9
MLE Mean (bias corrected)	371.1	MLE Sd (bias corrected)	200.3
		Approximate Chi Square Value (0.05)	86.66
Adjusted Level of Significance	0.0335	Adjusted Chi Square Value	84.32

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	470.4	95% Adjusted Gamma UCL (use when n<50)	483.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.942	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.165	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.222	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.727	Mean of logged Data	5.792
Maximum of Logged Data	6.599	SD of logged Data	0.543

Assuming Lognormal Distribution

95% H-UCL	509.2	90% Chebyshev (MVUE) UCL	534.3
95% Chebyshev (MVUE) UCL	606.2	97.5% Chebyshev (MVUE) UCL	705.8
99% Chebyshev (MVUE) UCL	901.7		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	443.8	95% Jackknife UCL	448.6
95% Standard Bootstrap UCL	440.6	95% Bootstrap-t UCL	451.6
95% Hall's Bootstrap UCL	449.2	95% Percentile Bootstrap UCL	439.9
95% BCA Bootstrap UCL	444.6		
90% Chebyshev(Mean, Sd) UCL	503.7	95% Chebyshev(Mean, Sd) UCL	563.8
97.5% Chebyshev(Mean, Sd) UCL	647.2	99% Chebyshev(Mean, Sd) UCL	810.9

Suggested UCL to Use

95% Student's-t UCL	448.6

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.

C2 (outhouse)

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	148	Mean	442.6
Maximum	1088	Median	338
SD	317.6	Std. Error of Mean	95.76
Coefficient of Variation	0.717	Skewness	0.994

Normal GOF Test

Shapiro Wilk Test Statistic	0.862	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.192	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.267	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	616.2	95% Adjusted-CLT UCL (Chen-1995)	630.8
		95% Modified-t UCL (Johnson-1978)	621

Gamma GOF Test

A-D Test Statistic	0.439	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.737	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.181	**Kolmogrov-Smirnoff Gamma GOF Test**	
5% K-S Critical Value	0.258	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.281	k star (bias corrected MLE)	1.72
Theta hat (MLE)	194	Theta star (bias corrected MLE)	257.4
nu hat (MLE)	50.19	nu star (bias corrected)	37.83
MLE Mean (bias corrected)	442.6	MLE Sd (bias corrected)	337.5
		Approximate Chi Square Value (0.05)	24.75
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	23.04

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	676.6	95% Adjusted Gamma UCL (use when n<50)	727

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.911	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.17	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.267	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.997	Mean of logged Data	5.858
Maximum of Logged Data	6.992	SD of logged Data	0.724

Assuming Lognormal Distribution

95% H-UCL	807.2	90% Chebyshev (MVUE) UCL	743
95% Chebyshev (MVUE) UCL	879.3	97.5% Chebyshev (MVUE) UCL	1068
99% Chebyshev (MVUE) UCL	1440		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	600.1	95% Jackknife UCL	616.2
95% Standard Bootstrap UCL	596.9	95% Bootstrap-t UCL	703.7
95% Hall's Bootstrap UCL	614.8	95% Percentile Bootstrap UCL	609.5
95% BCA Bootstrap UCL	628.7		
90% Chebyshev(Mean, Sd) UCL	729.9	95% Chebyshev(Mean, Sd) UCL	860
97.5% Chebyshev(Mean, Sd) UCL	1041	99% Chebyshev(Mean, Sd) UCL	1395

Suggested UCL to Use

95% Student's-t UCL	616.2

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.

C2 (shed)

General Statistics

Total Number of Observations	41	Number of Distinct Observations	39
		Number of Missing Observations	0
Minimum	79	Mean	575.6
Maximum	3157	Median	398
SD	593.5	Std. Error of Mean	92.68
Coefficient of Variation	1.031	Skewness	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.711	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.941	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.208	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.138	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	731.7	95% Adjusted-CLT UCL (Chen-1995)	770.5
		95% Modified-t UCL (Johnson-1978)	738.3

Gamma GOF Test

A-D Test Statistic	0.656	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.766	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.103	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.14	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.525	k star (bias corrected MLE)	1.43
Theta hat (MLE)	377.4	Theta star (bias corrected MLE)	402.6
nu hat (MLE)	125.1	nu star (bias corrected)	117.2
MLE Mean (bias corrected)	575.6	MLE Sd (bias corrected)	481.4
		Approximate Chi Square Value (0.05)	93.24
Adjusted Level of Significance	0.0441	Adjusted Chi Square Value	92.46

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	723.8	95% Adjusted Gamma UCL (use when n<50)	729.9

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.985	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.941	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0612	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.138	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.369	Mean of logged Data	5.993
Maximum of Logged Data	8.057	SD of logged Data	0.842

Assuming Lognormal Distribution

95% H-UCL	763.9	90% Chebyshev (MVUE) UCL	815
95% Chebyshev (MVUE) UCL	928.4	97.5% Chebyshev (MVUE) UCL	1086
99% Chebyshev (MVUE) UCL	1395		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	728.1	95% Jackknife UCL	731.7
95% Standard Bootstrap UCL	724.1	95% Bootstrap-t UCL	818.5
95% Hall's Bootstrap UCL	950.6	95% Percentile Bootstrap UCL	730.7
95% BCA Bootstrap UCL	784.7		
90% Chebyshev(Mean, Sd) UCL	853.7	95% Chebyshev(Mean, Sd) UCL	979.6
97.5% Chebyshev(Mean, Sd) UCL	1154	99% Chebyshev(Mean, Sd) UCL	1498

Suggested UCL to Use

95% Adjusted Gamma UCL	729.9

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.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	3/6/2014 10:01:35 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C2

General Statistics

Total Number of Observations	176	Number of Distinct Observations	160
		Number of Missing Observations	0
Minimum	16	Mean	474.5
Maximum	4877	Median	287.5
SD	613.1	Std. Error of Mean	46.22
Coefficient of Variation	1.292	Skewness	4.117

Normal GOF Test

Shapiro Wilk Test Statistic	0.607	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.228	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.0668	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	551	95% Adjusted-CLT UCL (Chen-1995)	565.9
		95% Modified-t UCL (Johnson-1978)	553.4

Gamma GOF Test

A-D Test Statistic	2.406	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.779	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0996	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.0716	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.176	k star (bias corrected MLE)	1.16
Theta hat (MLE)	403.4	Theta star (bias corrected MLE)	409
nu hat (MLE)	414.1	nu star (bias corrected)	408.4
MLE Mean (bias corrected)	474.5	MLE Sd (bias corrected)	440.6
		Approximate Chi Square Value (0.05)	362.5
Adjusted Level of Significance	0.0486	Adjusted Chi Square Value	362.2

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	534.6	95% Adjusted Gamma UCL (use when n<50)	535.1

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.987	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.844	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0492	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.0668	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.773	Mean of logged Data	5.681
Maximum of Logged Data	8.492	SD of logged Data	0.982

Assuming Lognormal Distribution

95% H-UCL	556.6	90% Chebyshev (MVUE) UCL	598.9
95% Chebyshev (MVUE) UCL	656	97.5% Chebyshev (MVUE) UCL	735.4
99% Chebyshev (MVUE) UCL	891.3		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	550.6	95% Jackknife UCL	551
95% Standard Bootstrap UCL	549.8	95% Bootstrap-t UCL	575.5
95% Hall's Bootstrap UCL	575.8	95% Percentile Bootstrap UCL	553.8
95% BCA Bootstrap UCL	572.9		
90% Chebyshev(Mean, Sd) UCL	613.2	95% Chebyshev(Mean, Sd) UCL	676
97.5% Chebyshev(Mean, Sd) UCL	763.2	99% Chebyshev(Mean, Sd) UCL	934.4

Suggested UCL to Use

95% H-UCL 556.6

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.

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

APPENDIX C

SUMMARY OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Engineering Evaluation/Cost Analysis
for Lead Impacted Soils at Light Stations on
Michigan, Outer, Raspberry, Devils, and Long Islands
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Table C-1 Potential Chemical Specific ARARs

Regulations	Requirements	Comments and Analysis
FEDERAL		
Occupational Safety and Health Standards (29 CFR Part 1910, Subpart Z – Toxic and Hazardous Substances)	Remedial action may require specific training and monitoring based on contaminant concentrations and risk.	May be applicable to worker exposures during implementation of remedial alternatives if contaminants are encountered during remediation at the Site.
Clean Air Act, National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50)	Establishes air quality standards for pollutants considered harmful to public health and the environment.	Sets an ambient air quality standard for lead that is not to be exceeded at any time.
Water Quality Standards (WQS) (40 CFR Part 131)	Sets criteria for surface water quality	WQSs may be applicable for alternatives which include discharge of water into adjacent surface waters. State specific ARARs will govern if more stringent than Federal ARARs.
CWA Toxic Pollutant Effluent Standards (40 CFR Part 129)	Establishes effluent standards for toxic compounds.	May be applicable for alternatives which include discharge of water to surface waters.
Releases from Solid Waste Management Units, Concentration Limits (40 CFR Part 264, Section 264.94)	Standards for 14 toxic compounds to be monitored in the groundwater at RCRA facilities.	Monitoring and response requirements may be relevant and appropriate.
Identification of Hazardous Waste (40 CFR Part 261)	Defines those solid wastes that are subject to regulation as hazardous waste under RCRA Subpart C.	Defines hazardous waste. Since there are potential hazardous wastes, these regulations are applicable, relevant, and appropriate.
STATE		
Wisconsin Administrative Code, Chapter NR 720, Soil Cleanup Standards.	Establishes the cleanup standards for the remediation of soil contamination that are protective of public health, safety, welfare, and the environment.	Applicable to the determination of cleanup standards for impacted soil.
Wisconsin Lead Emissions Rule	Categorizes lead air contaminant sources and establishes emission limitations for these sources in order to protect air quality.	Any substantive requirements more stringent than Federal standards wil be applicable.
Wisconsin Particulate Emission Rule (NR 415)	Categorizes particulate matter and air contaminant sources and establishes emission limitations to protect air quality.	Applicable for alternatives that involve excavation or other activities may release particulates into the air.
TO BE CONSIDERED (TBC) STANDARDS		
Soil Screening Guidance (U.S. EPA Document Number: EPA540/R-96/018, July 1996)	Guidance designed to help standardize remediation at National Priorities List (NPL) sites that risk-based soil screening levels.	To be considered.

Engineering Evaluation/Cost Analysis
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Table C-2 Potential Location Specific ARARs

Regulations	Requirements	Comments and Analysis
FEDERAL		
Resource Conservation and Recovery Act (RCRA) U.S.C. Title 42 - The Public Health and Welfare, Chapter 1 National Parks, Military Parks, Monuments, and Seashores, Subchapter 82 - Solid Waste Disposal	Gives the EPA the authority to control hazardous waste from "cradle-to-grave" including generation, transportation, treatment, storage, and disposal of hazardous and non-hazardous wastes.	Applicable to the management, storage and disposal of wastes generated by remediation activities.
National Historic Preservation Act (NHPA) Section 106	Requires federal agencies to take into account the effects of their undertakings on historic properties. This includes comment/review by the Advisory Council on Historic Preservation, and public parties.	Requirement is applicable as the APIS light station complexes are listed on the National Registry of Historic Places.
NPS Organic Act, U.S.C. Title 16, Chapter 1 - National Parks, Military Parks, Monuments, and Seashores, Subchapter 1 - National Park Service	Establishes the National Park Service (NPS) and grants it the authority to regulate the use of the Federal National Park areas.	Applicable to the removal activities completed at the project sites.
Apostle Islands Enabling Legislation - U.S.C. Title 16 - Conservation, Chapter 1 National Parks, Military Parks, Monuments, and Seashores, Subchapter LXXXI - Apostle Island National Lakeshore, Section 460w	Establishes the Apostle Islands National Lakeshore in Ashland and Bayfield Counties in Wisconsin. Gives provision for the administration, protection and development of the lakeshore.	Applicable to the performance of any removal activities completed at the project sites and to the development of the remedial designs of any proposed removal action.
Clean Water Act - U.S.C. Title 33 -Conservation, Chapter 26 - Water Pollution, Prevention and Control	Establishes the basic structure for regulating discharges of pollutants into the waters of the US and regulating surface water quality standards. Also ensures that dredged or fill material is not discharged into wetlands and other waters of the US except as authorized by permit.	Applicable to the performance of any removal activities completed at the project sites.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities - 40 CFR Subpart B (264.18)	A facility located in a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of hazardous waste by a 100-year flood.	Relevant and Appropriate. Alternatives located in areas onsite with potential flooding will be designed according to these requirements.
Endangered Species Act of 1973 (16 U.S.C. 1531, et seq.)	Establishes requirements to protect species threatened by extinction and habitats critical to their survival.	No endangered or listed species are known to inhabit the project area. However, if found, the requirments of Section 9 concerning harming or harassing endangered species will be applicable.
STATE		
Wisconsin Shoreland Management Program	Establishes minimum standards for city and village shoreland wetland zoning ordinances to protect wetlands.	Substantive requirements relating to construction and operation of remedial actions would be applicable.
Wisconsin Administrative Rule Chapter NR 27 - Endangered and Threatened Species	Governs the taking, transportation, possession, processing, or sale of any wild animal or wild plant specified by the department's list of endangered and threatened wild animals and wild plants.	Applicable to the protection of endangered or threatened species and their habitats, to be considered during planning and implementation of proposed removal alternatives.
ASHLAND COUNTY		
Shoreline Amendatory Ordinance	Provides requirements for removal of shore cover, and for filling, grading, dredging, ditching and excavating in shoreland-wetland districts. Details circumstances requiring permit for work in areas within a certain distance of the normal highwater line.	Applicable to planning of soil removal on shorelines.
TO BE CONSIDERED (TBC) STANDARDS		
Superintendents Compendium	The Superintendent’s Compendium is the summary of park specific rules implemented under 36 Code of Federal Regulations (36 CFR).	Outlines APIS-specific rules related to human activities, vessels, and permits.
Tribal Interests and Concurrent Jurisdication	The State of Wisconsin, Township constables, and other non-Federal agencies share jurisdiction of the park lands and waters. This includes tribal officers as all of the park is either a part of the local Indian Reservation or within an area defined as ceded Indian Territory.	Relevent and appropriate as the lakeshore is managed under Concurrent Jurisdication and consultation with necessary agencies should be incorporated into the design and planning phases of the proposed removal alternatives.

Engineering Evaluation/Cost Analysis
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Table C-3 Potential Action Specific ARARs

Regulations	Requirements	Comments and Analysis
FEDERAL		
Identification of Hazardous Waste (40 CFR Part 261)	Identifies those wastes subject to regulation as hazardous wastes.	Waste generated as a result of remediation activities may require management under these rules.
Treatment, Storage, and Disposal of Hazardous Waste (40 CFR Parts 262, 264, 265, and 266)	Regulates the treatment, storage, and disposal of hazardous waste. Also provides the standards that are applicable to generators of hazardous waste.	Waste generated as a result of remediation activities may require management under these rules.
Standards Applicable to Transporters of Hazardous Waste (40 CFR Part 263)	Requires that transporters must be licensed hazardous waste haulers. In the event of a discharge during transportation, the transporter must take immediate action to protect human health and the environment and cleanup the discharge such that it no longer presents a hazard.	These regulations would be applicable to transportation of hazardous waste offsite.
Releases from Solid Waste Management Units (SWMUs) (40 CFR Part 264 Subpart F, Sections 264.91 through 264.99)	These regulations establish groundwater protection standards and groundwater monitoring requirements for on-site solid waste management units (SWMUs).	These requirements may be relevant and appropriate if a groundwater monitoring program is implemented or if land-based storage or disposal units are established on-site.
Use and Management of Containers (40 CFR Part 264 Subpart I, Sections 264.171 through 264.178)	Regulations cited under 40 CFR 264.171 to 264.178 (Subpart I) concern permanent on-site storage of hazardous wastes or temporary storage phases used during various cleanup actions such as removal or incineration.	The storage regulations are relevant and appropriate to storage of hazardous wastes.
Waste Piles (40 CFR Part 264, Subpart L Sections 264.251 through 264.256)	Establishes minimum technology requirements for waste piles that would be used to place RCRA hazardous waste.	These requirements could be relevant and appropriate if excavated material is a RCRA hazardous waste and is temporarily stored in waste piles before transportation to disposal site.
Special Provisions For Cleanup (40 CFR Part 264 Subpart S, Sections 264.550 through 264.555)	Establishes minimum requirements for designating, designing, and operating a corrective action management unit (CAMU)	These requirements would be relevant and appropriate if excavated material is disposed in an on-site cell.
Miscellaneous Units (40 CFR Part 264 Subpart X)	Standards for environmental performance of miscellaneous treatment units.	Miscellaneous treatment units may include temporary waste holding units or effluent pretreatment units but do not include incinerators, landfills, containers, underground injection wells, wastewater pretreatment units, or similar methods for which specific management rules have been promulgated under other subparts of 40 CFR 264.
DOT Rules for Hazardous Materials Transport (49 CFR Parts 107 and 171-180)	Establishes requirements for off-site transportation of site-generated waste. Regulates the packaging, shipping, placarding, and transport of hazardous waste materials.	Applicable to off-site transportation of contaminated waste for treatment or disposal.
49 CFR Part 176	Establishes requirements for transportation by barge including the packaging, shipping, placarding and transport of hazardous waste materials.	Applicable to off-site transportation of contaminated waste for treatment or disposal.
STATE		
Wisconsin Administrative Code, Chapter NR 216, Storm water discharge permits	Regulates the discharge of storm water in Wisconsin from construction sites, industrial facilities, and municipal systems.	This regulation impacts any storm water discharged from the remediation site.
Wisconsin Hazardous Management Regulations (NR 660, 665, 670, 675, 680, 685)	Provides regulations governing the generation, transportation, recycling, storage, treatment and disposal of hazardous waste. Establishes requirements for preparedness and prevention; contingency plan and emergency procedures; manifest system, record keeping and reporting; groundwater and leachate monitoring; corrective actions; and closure, long-term care, and financial responsibility. Provides standards for use and management of containers, tanks, waste piles, surface impoundments, landfills, and incinerators. Establishes land disposal restrictions.	Criteria would be used to ensure that proper management of the media takes place on site. Any substantive requirements for the selected remedial action would have to be met if they are more stringent than federal standards.
Wisconsin Regulations on Identification, Investigation, and Remediation of Environmental Contamination (NR 700, 708, 710, 714, 716, 720, 722, 724)	Provides standards and procedures for the screening and ranking of sites; conducting investigations and analyses to determine extent of contamination; establishing soil cleanup standards; identifying, evaluating and selecting remedial actions; public participation and notification, and conducting response actions, including design, implementation, operation, maintenance, and monitoring requirements.	Applicable to the determination of cleanup standards and extent of cleanup.
Wisconsin NR 718: Management of Contaminated Soil or Solid Wastes Excavated During Response Actions	Provides the requirements for the storage, transportation, treatment and disposal of contaminated soil associated with response actions. Identifies areas in which soil cannot be disposed.	Applicable to the transportation and disposal of contaminated soil.
Wisconsin NR 502: Solid Waste Storage, Transportation, Transfer, Incineration, Air Curtain Destructors, Processing, Wood Burning, Composting, and Municipal Solid Waste Combustors (502.06 - Collection and Transportation Services)	Details the circumstances that would require a permit to transport and/or transfer waste, and the exemptions from the permit requirements. Exemption "j" provides for hauling of contaminated soil associated with remedial activities provided it is non-hazardous.	Applicable to determining need for a license to haul/transport/transfer waste. Advised to contact DNR to verify license is not required.
Wisconsin State Statute 182.0175: One-Call System	Provides the requirements for utility location services prior to excavation activities. At least three days prior to the start of any excavation activity, or any time there is a break in work greater than 10 days a request must be made using the one-call system to have underground utilities located. Also details the required clearance distances that must be maintained from marked utilities.	Applicable to the planning and implementation of the remedial action.
TO BE CONSIDERED (TBC) STANDARDS		
Utility one-call		
National Park Service Management Policies 2006 (Section 9.1.6 Waste Management and Containment Issues)	Describes the National Park Values that impact the disposal of wastes (hazardous and non-hazardous) and garbage on National Park land. All activities must be conducted in a manner that does not deteriorate the quality of the air, water or other natural resources.	To be considered. Applicable to the disposal of wastes generated on site.

APPENDIX D

SITE INVESTIGATION SCREENING RESULT SUMMARY

Table B-1. Michigan Island XRF Results

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
MI-FS1-SB001	APISSB0059	0.0 - 0.5	9/17/11	**382**	13
MI-FS1-SB001	APISSB0060	0.5 - 1.0	9/17/11	182	9
MI-FS1-SB002	APISSB0061	0.0 - 0.5	9/17/11	**396**	14
MI-FS1-SB002	APISSB0062	0.5 - 1.0	9/17/11	**278**	11
MI-FS1-SB003	APISSB0063	0.0 - 0.5	9/17/11	**261**	11
MI-FS1-SB003	APISSB0064	0.5 - 1.0	9/17/11	41	5
MI-FS1-SB004	APISSB0065	0.0 - 0.5	9/17/11	120	8
MI-FS1-SB004	APISSB0066	0.5 - 1.0	9/17/11	237	11
MI-FS1-SB005	APISSB0067	0.0 - 0.5	9/17/11	250	11
MI-FS1-SB006	APISSB0068	0.0 - 0.5	9/17/11	167	9
MI-FS1-SB006	APISSB0069	0.5 - 1.0	9/17/11	64	6
MI-FS1-SB007	APISSB0070	0.0 - 0.5	9/17/11	85	7
MI-KQ1-SB001	APISSB0071	0.0 - 0.5	9/17/11	**372**	13
MI-KQ1-SB001	APISSB0072	0.5 - 1.0	9/17/11	96	7
MI-KQ1-SB002	APISSB0073	0.0 - 0.5	9/17/11	71	6
MI-KQ1-SB002	APISSB0074	0.5 - 1.0	9/17/11	45	6
MI-KQ1-SB003	APISSB0075	0.0 - 0.5	9/17/11	89	6
MI-KQ1-SB003	APISSB0076	0.5 - 1.0	9/17/11	71	6
MI-KQ1-SB004	APISSB0077	0.0 - 0.5	9/17/11	104	7
MI-KQ1-SB005	APISSB0078	0.0 - 0.5	9/17/11	177	9
MI-KQ2-SB001	APISSB0001	0.0 - 0.5	9/16/11	**827**	22
MI-KQ2-SB002	APISSB0002	0.5 - 1.0	9/16/11	155	8
MI-KQ2-SB002	APISSB0003	0.0 - 0.5	9/16/11	**423**	14
MI-KQ2-SB003	APISSB0004	0.0 - 0.5	9/16/11	**454**	15
MI-KQ2-SB003	APISSB0007	0.5 - 1.0	9/16/11	37	5
MI-KQ2-SB004	APISSB0005	0.0 - 0.5	9/16/11	**888**	23
MI-KQ2-SB004	APISSB0006	0.5 - 1.0	9/16/11	137	8
MI-KQ2-SB005	APISSB0023	0.0 - 0.5	9/16/11	**287**	11
MI-KQ2-SB006	APISSB0024	0.0 - 0.5	9/16/11	88	6
MI-KQ2-SB007	APISSB0025	0.0 - 0.5	9/16/11	**359**	13
MI-KQ2-SB008	APISSB0026	0.0 - 0.5	9/16/11	**482**	15
MI-KQ2-SB009	APISSB0027	0.0 - 0.5	9/16/11	79	6
MI-KQ2-SB010	APISSB0028	0.0 - 0.5	9/16/11	194	9
MI-KQ2-SB011	APISSB0029	0.0 - 0.5	9/16/11	**678**	20
MI-KQ2-SB012	APISSB0030	0.0 - 0.5	9/16/11	**401**	14
MI-KQ2-SB013	APISSB0031	0.0 - 0.5	9/16/11	72	6
MI-KQ2-SB014	APISSB0032	0.0 - 0.5	9/16/11	115	7
MI-KQ2-SB015	APISSB0033	0.0 - 0.5	9/16/11	212	10
MI-KQ2-SB016	APISSB0034	0.0 - 0.5	9/16/11	87	6
MI-LH1-SB001	APISSB0048	0.0 - 0.5	9/17/11	146	8
MI-LH1-SB002	APISSB0049	0.0 - 0.5	9/17/11	168	9
MI-LH1-SB003	APISSB0050	0.0 - 0.5	9/17/11	**303**	12
MI-LH1-SB004	APISSB0051	0.0 - 0.5	9/17/11	189	9
MI-LH1-SB004	APISSB0052	0.5 - 1.0	9/17/11	145	8
MI-LH1-SB005	APISSB0053	0.0 - 0.5	9/17/11	54	6
MI-LH1-SB005	APISSB0054	0.5 - 1.0	9/17/11	81	7

Table B-1. Michigan Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
MI-LH1-SB006	APISSB0055	0.0 - 0.5	9/17/11	177	9
MI-LH1-SB006	APISSB0056	0.5 - 1.0	9/17/11	174	9
MI-LH1-SB007	APISSB0057	0.0 - 0.5	9/17/11	89	7
MI-LH1-SB008	APISSB0058	0.0 - 0.5	9/17/11	147	8
MI-LH2-SB001	APISSB0079	0.0 - 0.5	9/17/11	**8,703**	170
MI-LH2-SB001	APISSB0080	0.5 - 1.0	9/17/11	**2,009**	44
MI-LH2-SB002	APISSB0081	0.0 - 0.5	9/17/11	**5,847**	112
MI-LH2-SB003	APISSB0082	0.0 - 0.5	9/17/11	**14,012**	273
MI-LH2-SB004	APISSB0083	0.0 - 0.5	9/17/11	**1,732**	38
MI-LH2-SB004	APISSB0084	0.5 - 1.0	9/17/11	**1,361**	31
MI-LH2-SB005	APISSB0085	0.0 - 0.5	9/17/11	**897**	23
MI-LH2-SB006	APISSB0086	0.0 - 0.5	9/17/11	**561**	18
MI-LH2-SB007	APISSB0087	0.0 - 0.5	9/17/11	**10,130**	193
MI-LH2-SB008	APISSB0088	0.0 - 0.5	9/18/11	**293**	12
MI-LH2-SB009	APISSB0089	0.0 - 0.5	9/18/11	**543**	17
MI-LH2-SB010	APISSB0090	0.0 - 0.5	9/18/11	172	9
MI-LH2-SB011	APISSB0091	0.0 - 0.5	9/18/11	193	9
MI-LH2-SB012	APISSB0092	0.0 - 0.5	9/18/11	162	9
MI-LH2-SB013	APISSB0093	0.0 - 0.5	9/18/11	**15,078**	293
MI-LH2-SB013	APISSB0094	0.5 - 1.0	9/18/11	**699**	19
MI-LH2-SB013	APISSB0095	1.0 - 1.5	9/18/11	28	5
MI-LH2-SB013	APISSB0096	1.5 - 2.0	9/18/11	60	6
MI-OH1-SB001	APISSB0008	0.0 - 0.5	9/16/11	**1,582**	35
MI-OH1-SB002	APISSB0009	0.0 - 0.5	9/16/11	**1,038**	26
MI-OH1-SB002	APISSB0010	0.5 - 1.0	9/16/11	190	10
MI-OH1-SB003	APISSB0011	0.0 - 0.5	9/16/11	**629**	18
MI-OH1-SB003	APISSB0012	0.5 - 1.0	9/16/11	**489**	16
MI-OH1-SB004	APISSB0013	0.0 - 0.5	9/16/11	**554**	17
MI-OH1-SB004	APISSB0014	0.5 - 1.0	9/16/11	47	6
MI-OH1-SB005	APISSB0041	0.0 - 0.5	9/17/11	**371**	13
MI-OH1-SB006	APISSB0042	0.0 - 0.5	9/17/11	151	8
MI-OH1-SB007	APISSB0043	0.0 - 0.5	9/17/11	36	5
MI-OH1-SB008	APISSB0044	0.0 - 0.5	9/17/11	171	9
MI-OH1-SB009	APISSB0046	0.0 - 0.5	9/17/11	65	6
MI-OS1-SB001	APISSB0973	0.0 - 0.5	6/22/12	143	2
MI-OS1-SB001	APISSB0974	0.5 - 1.0	6/22/12	39.4	1.3
MI-OS1-SB002	APISSB0975	0.0 - 0.5	6/22/12	63.3	1.5
MI-OS1-SB002	APISSB0976	0.5 - 1.0	6/22/12	49.3	1.4
MI-OS1-SB003	APISSB0977	0.0 - 0.5	6/22/12	128.3	2
MI-OS1-SB004	APISSB0978	0.0 - 0.5	6/22/12	147	2
MI-OS1-SB004	APISSB0979	0.5 - 1.0	6/22/12	103.3	1.9
MI-SH1-SB001	APISSB0015	0.0 - 0.5	9/16/11	**292**	12
MI-SH1-SB001	APISSB0016	0.5 - 1.0	9/16/11	**314**	12
MI-SH1-SB002	APISSB0017	0.0 - 0.5	9/16/11	246	11
MI-SH1-SB002	APISSB0022	0.5 - 1.0	9/16/11	233	11
MI-SH1-SB003	APISSB0018	0.0 - 0.5	9/16/11	**1,457**	32
MI-SH1-SB003	APISSB0019	0.5 - 1.0	9/16/11	**351**	13
MI-SH1-SB004	APISSB0020	0.0 - 0.5	9/16/11	**523**	16

Table B-1. Michigan Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
MI-SH1-SB004	APISSB0021	0.5 - 1.0	9/16/11	133	8
MI-SH1-SB005	APISSB0035	0.0 - 0.5	9/16/11	**442**	14
MI-SH1-SB006	APISSB0036	0.0 - 0.5	9/16/11	**800**	21
MI-SH1-SB007	APISSB0037	0.0 - 0.5	9/16/11	94	7
MI-SH1-SB008	APISSB0038	0.0 - 0.5	9/17/11	135	8
MI-SH1-SB008	APISSB0039	0.5 - 1.0	9/17/11	107	8
MI-SH1-SB009	APISSB0040	0.0 - 0.5	9/17/11	**539**	16
MI-SH1-SB010	APISSB0045	0.0 - 0.5	9/17/11	**291**	11
MI-SH1-SB011	APISSB0047	0.0 - 0.5	9/17/11	**910**	23

Note:
Bolded value exceeds Wisconsin Department of Natural Resources Cleanup Standard of 250 mg/kg.
bgs = below ground surface
XRF = X-Ray Fluorescence

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Table B-2. Outer Island XRF Results

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
OI-AS1-SB001	APISSB0121	0.0 - 0.5	9/19/11	**920**	23
OI-AS1-SB001	APISSB0122	0.5 - 1.0	9/19/11	**300**	11
OI-AS1-SB002	APISSB0123	0.0 - 0.5	9/19/11	**574**	16
OI-AS1-SB002	APISSB0124	0.5 - 1.0	9/19/11	70	6
OI-AS1-SB003	APISSB0125	0.0 - 0.5	9/19/11	54	5
OI-AS1-SB003	APISSB0126	0.5 - 1.0	9/19/11	Non-detect	10
OI-AS1-SB004	APISSB0142	0.0 - 0.5	9/19/11	163	8
OI-AS1-SB004	APISSB0143	0.5 - 1.0	9/19/11	50	5
OI-AS1-SB005	APISSB0144	0.0 - 0.5	9/19/11	**297**	11
OI-AS1-SB006	APISSB0150	0.0 - 0.5	9/19/11	112	7
OI-FS1-SB001	APISSB0151	0.0 - 0.5	9/19/11	**4,491**	83
OI-FS1-SB001	APISSB0152	0.5 - 1.0	9/19/11	**1,276**	29
OI-FS1-SB002	APISSB0153	0.0 - 0.5	9/19/11	**676**	19
OI-FS1-SB002	APISSB0154	0.5 - 1.0	9/19/11	**328**	11
OI-FS1-SB003	APISSB0155	0.0 - 0.5	9/19/11	**524**	15
OI-FS1-SB003	APISSB0156	0.5 - 1.0	9/19/11	**387**	13
OI-FS1-SB004	APISSB0157	0.0 - 0.5	9/19/11	**791**	20
OI-FS1-SB004	APISSB0158	0.5 - 1.0	9/19/11	118	7
OI-FS1-SB005	APISSB0159	0.0 - 0.5	9/19/11	123	7
OI-FS1-SB005	APISSB0160	0.5 - 1.0	9/19/11	**1,148**	26
OI-FS1-SB006	APISSB0161	0.0 - 0.5	9/19/11	**704**	19
OI-FS1-SB006	APISSB0162	0.5 - 1.0	9/19/11	**1,314**	29
OI-FS1-SB007	APISSB0163	0.0 - 0.5	9/19/11	**433**	14
OI-FS1-SB007	APISSB0164	0.5 - 1.0	9/19/11	77	6
OI-FS1-SB008	APISSB0167	0.0 - 0.5	9/20/11	**715**	19
OI-FS1-SB008	APISSB0168	0.5 - 1.0	9/20/11	20	4
OI-FS1-SB009	APISSB0169	0.0 - 0.5	9/20/11	**323**	11
OI-FS1-SB010	APISSB0170	0.0 - 0.5	9/20/11	**528**	15
OI-FS1-SB011	APISSB0171	0.0 - 0.5	9/20/11	**1,844**	38
OI-FS1-SB012	APISSB0172	0.0 - 0.5	9/20/11	**642**	17
OI-FS1-SB013	APISSB0173	0.0 - 0.5	9/20/11	**512**	15
OI-FS1-SB013	APISSB0174	0.5 - 1.0	9/20/11	**263**	10
OI-FS1-SB014	APISSB0183	0.0 - 0.5	9/20/11	**297**	11
OI-FS1-SB015	APISSB0184	0.0 - 0.5	9/20/11	155	8
OI-FS1-SB016	APISSB0185	0.0 - 0.5	9/20/11	**478**	15
OI-FS1-SB016	APISSB0186	0.5 - 1.0	9/20/11	71	6
OI-FS1-SB017	APISSB0187	0.0 - 0.5	9/20/11	**270**	11
OI-FS1-SB018	APISSB0188	0.0 - 0.5	9/20/11	**1,561**	34
OI-FS1-SB019	APISSB0189	0.0 - 0.5	9/20/11	**474**	15
OI-FS1-SB020	APISSB0196	0.0 - 0.5	9/20/11	112	7
OI-FS1-SB021	APISSB0197	0.0 - 0.5	9/20/11	**510**	15
OI-FS1-SB022	APISSB0198	0.0 - 0.5	9/20/11	14	4
OI-FS1-SB023	APISSB0199	0.0 - 0.5	9/20/11	17	4
OI-FS1-SB024	APISSB0200	0.0 - 0.5	9/20/11	**255**	10
OI-FS1-SB025	APISSB0206	0.0 - 0.5	9/20/11	135	7

Table B-2. Outer Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
OI-LH1-SB001	APISSB0107	0.0 - 0.5	9/19/11	**761**	20
OI-LH1-SB001	APISSB0108	0.5 - 1.0	9/19/11	**447**	14
OI-LH1-SB001	APISSB0129	1.0 - 1.5	9/19/11	191	9
OI-LH1-SB002	APISSB0109	0.0 - 0.5	9/19/11	**1,019**	24
OI-LH1-SB002	APISSB0110	0.5 - 1.0	9/19/11	**472**	14
OI-LH1-SB002	APISSB0130	1.0 - 1.5	9/19/11	**661**	18
OI-LH1-SB003	APISSB0111	0.0 - 0.5	9/19/11	**332**	12
OI-LH1-SB004	APISSB0112	0.0 - 0.5	9/19/11	**562**	16
OI-LH1-SB004	APISSB0113	0.5 - 1.0	9/19/11	197	9
OI-LH1-SB005	APISSB0114	0.0 - 0.5	9/19/11	161	8
OI-LH1-SB005	APISSB0115	0.5 - 1.0	9/19/11	82	6
OI-LH1-SB006	APISSB0116	0.0 - 0.5	9/19/11	**261**	10
OI-LH1-SB006	APISSB0117	0.5 - 1.0	9/19/11	105	7
OI-LH1-SB007	APISSB0118	0.0 - 0.5	9/19/11	198	9
OI-LH1-SB008	APISSB0119	0.0 - 0.5	9/19/11	**422**	13
OI-LH1-SB008	APISSB0120	0.5 - 1.0	9/19/11	**290**	11
OI-LH1-SB009	APISSB0127	0.0 - 0.5	9/19/11	**476**	14
OI-LH1-SB009	APISSB0128	0.5 - 1.0	9/19/11	143	8
OI-LH1-SB010	APISSB0131	0.0 - 0.5	9/19/11	**382**	13
OI-LH1-SB010	APISSB0132	0.5 - 1.0	9/19/11	177	9
OI-LH1-SB011	APISSB0133	0.0 - 0.5	9/19/11	**703**	19
OI-LH1-SB011	APISSB0134	0.5 - 1.0	9/19/11	249	10
OI-LH1-SB012	APISSB0135	0.0 - 0.5	9/19/11	**335**	12
OI-LH1-SB012	APISSB0136	0.5 - 1.0	9/19/11	198	9
OI-LH1-SB013	APISSB0137	0.0 - 0.5	9/19/11	177	9
OI-LH1-SB014	APISSB0138	0.0 - 0.5	9/19/11	180	8
OI-LH1-SB015	APISSB0139	0.0 - 0.5	9/19/11	**699**	18
OI-LH1-SB015	APISSB0140	0.5 - 1.0	9/19/11	185	9
OI-LH1-SB016	APISSB0141	0.0 - 0.5	9/19/11	**319**	12
OI-LH1-SB017	APISSB0145	0.0 - 0.5	9/19/11	204	9
OI-LH1-SB018	APISSB0146	0.0 - 0.5	9/19/11	134	8
OI-LH1-SB019	APISSB0147	0.0 - 0.5	9/19/11	**479**	14
OI-LH1-SB020	APISSB0148	0.0 - 0.5	9/19/11	**326**	11
OI-LH1-SB021	APISSB0149	0.0 - 0.5	9/19/11	224	10
OI-LH1-SB022	APISSB0165	0.0 - 0.5	9/19/11	223	9
OI-LH1-SB023	APISSB0166	0.0 - 0.5	9/19/11	122	7
OI-OH1-SB001	APISSB0179	0.0 - 0.5	9/20/11	**742**	19
OI-OH1-SB001	APISSB0180	0.5 - 1.0	9/20/11	**467**	14
OI-OH1-SB002	APISSB0181	0.0 - 0.5	9/20/11	**325**	11
OI-OH1-SB002	APISSB0182	0.5 - 1.0	9/20/11	173	8
OI-OH1-SB003	APISSB0193	0.0 - 0.5	9/20/11	**338**	11
OI-OH1-SB003	APISSB0194	0.5 - 1.0	9/20/11	51	5
OI-OH1-SB004	APISSB0195	0.0 - 0.5	9/20/11	215	9
OI-OH1-SB005	APISSB0203	0.0 - 0.5	9/20/11	240	10
OI-OS1-SB001	APISSB0175	0.0 - 0.5	9/20/11	**1,741**	35
OI-OS1-SB001	APISSB0176	0.5 - 1.0	9/20/11	80	6
OI-OS1-SB002	APISSB0177	0.0 - 0.5	9/20/11	**1,116**	24
OI-OS1-SB002	APISSB0178	0.5 - 1.0	9/20/11	**263**	10

Table B-2. Outer Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
OI-OS1-SB003	APISSB0190	0.0 - 0.5	9/20/11	**335**	11
OI-OS1-SB004	APISSB0191	0.0 - 0.5	9/20/11	**434**	14
OI-OS1-SB004	APISSB0192	0.5 - 1.0	9/20/11	96	6
OI-OS1-SB005	APISSB0201	0.0 - 0.5	9/20/11	**521**	14
OI-OS1-SB006	APISSB0202	0.0 - 0.5	9/20/11	**291**	10
OI-OS1-SB007	APISSB0204	0.0 - 0.5	9/20/11	**622**	17
OI-OS1-SB008	APISSB0205	0.0 - 0.5	9/20/11	**502**	14
OI-OS1-SB009	APISSB0207	0.0 - 0.5	9/20/11	**1,881**	38
OI-OS1-SB010	APISSB0208	0.0 - 0.5	9/20/11	62	6
OI-OS1-SB011	APISSB0209	0.0 - 0.5	9/20/11	247	9
OI-OS1-SB012	APISSB0210	0.0 - 0.5	9/20/11	**350**	12
OI-OS1-SB013	APISSB0211	0.0 - 0.5	9/20/11	**763**	19

Note:
Bolded value exceeds Wisconsin Department of Natural Resources Cleanup Standard of 250 mg/kg.
bgs = below ground surface
XRF = X-Ray Fluorescence

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Table B-3. Raspberry Island XRF Results

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
RI-BH1-SB001	APISSB0390	0.0 - 0.5	9/25/11	Non-detect	11
RI-BH1-SB002	APISSB0391	0.0 - 0.5	9/25/11	Non-detect	11
RI-FS1-SB001	APISSB0317	0.0 - 0.5	9/24/11	191	9
RI-FS1-SB002	APISSB0318	0.0 - 0.5	9/24/11	**947**	25
RI-FS1-SB002	APISSB0319	0.5 - 1.0	9/24/11	**927**	24
RI-FS1-SB003	APISSB0320	0.0 - 0.5	9/24/11	**1,184**	28
RI-FS1-SB003	APISSB0321	0.5 - 1.0	9/24/11	**390**	13
RI-FS1-SB004	APISSB0322	0.0 - 0.5	9/24/11	**647**	18
RI-FS1-SB005	APISSB0323	0.0 - 0.5	9/24/11	**934**	24
RI-FS1-SB005	APISSB0324	0.5 - 1.0	9/24/11	**558**	17
RI-FS1-SB006	APISSB0357	0.0 - 0.5	9/24/11	**853**	22
RI-FS1-SB006	APISSB0358	0.5 - 1.0	9/24/11	**660**	19
RI-FS1-SB007	APISSB0359	0.0 - 0.5	9/24/11	**1,744**	38
RI-FS1-SB007	APISSB0360	0.5 - 1.0	9/24/11	193	9
RI-FS1-SB008	APISSB0361	0.0 - 0.5	9/24/11	**684**	18
RI-FS1-SB008	APISSB0362	0.5 - 1.0	9/24/11	**863**	22
RI-FS1-SB009	APISSB0366	0.0 - 0.5	9/25/11	**1,114**	27
RI-FS1-SB009	APISSB0367	0.5 - 1.0	9/25/11	**267**	11
RI-FS1-SB010	APISSB0369	0.0 - 0.5	9/25/11	88	6
RI-FS1-SB010	APISSB0370	0.5 - 1.0	9/25/11	**316**	12
RI-FS1-SB011	APISSB0368	0.0 - 0.5	9/25/11	**417**	14
RI-FS1-SB012	APISSB0493	0.0 - 0.5	9/25/11	120	7
RI-FS1-SB012	APISSB0494	0.5 - 1.0	9/25/11	89	7
RI-FS1-SB013	APISSB0495	0.0 - 0.5	9/25/11	95	7
RI-FS1-SB014	APISSB0382	0.0 - 0.5	9/25/11	Non-detect	11
RI-LH1-SB001	APISSB0325	0.0 - 0.5	9/24/11	**312**	12
RI-LH1-SB001	APISSB0326	0.5 - 1.0	9/24/11	139	8
RI-LH1-SB002	APISSB0327	0.0 - 0.5	9/24/11	**544**	17
RI-LH1-SB002	APISSB0328	0.5 - 1.0	9/24/11	**2,239**	46
RI-LH1-SB003	APISSB0329	0.0 - 0.5	9/24/11	**4,877**	93
RI-LH1-SB003	APISSB0330	0.5 - 1.0	9/24/11	**563**	17
RI-LH1-SB004	APISSB0331	0.0 - 0.5	9/24/11	**361**	13
RI-LH1-SB004	APISSB0332	0.5 - 1.0	9/24/11	**1,067**	26
RI-LH1-SB005	APISSB0333	0.0 - 0.5	9/24/11	**321**	12
RI-LH1-SB005	APISSB0334	0.5 - 1.0	9/24/11	174	9
RI-LH1-SB006	APISSB0335	0.0 - 0.5	9/24/11	232	10
RI-LH1-SB006	APISSB0336	0.5 - 1.0	9/24/11	**466**	15
RI-LH1-SB007	APISSB0337	0.0 - 0.5	9/24/11	**290**	11
RI-LH1-SB008	APISSB0338	0.0 - 0.5	9/24/11	103	7
RI-LH1-SB008	APISSB0339	0.5 - 1.0	9/24/11	85	7
RI-LH1-SB009	APISSB0340	0.0 - 0.5	9/24/11	**297**	12
RI-LH1-SB009	APISSB0341	0.5 - 1.0	9/24/11	243	11
RI-LH1-SB010	APISSB0342	0.0 - 0.5	9/24/11	**286**	11
RI-LH1-SB010	APISSB0343	0.5 - 1.0	9/24/11	241	11
RI-LH1-SB011	APISSB0344	0.0 - 0.5	9/24/11	**409**	14
RI-LH1-SB012	APISSB0345	0.0 - 0.5	9/24/11	**347**	13

Table B-3. Raspberry Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
RI-LH1-SB013	APISSB0346	0.0 - 0.5	9/24/11	51	5
RI-LH1-SB014	APISSB0347	0.0 - 0.5	9/24/11	168	9
RI-LH1-SB015	APISSB0348	0.0 - 0.5	9/24/11	225	10
RI-LH1-SB015	APISSB0349	0.5 - 1.0	9/24/11	133	8
RI-LH1-SB016	APISSB0350	0.0 - 0.5	9/24/11	242	11
RI-LH1-SB017	APISSB0351	0.0 - 0.5	9/24/11	225	10
RI-LH1-SB018	APISSB0371	0.0 - 0.5	9/25/11	**483**	15
RI-LH1-SB019	APISSB0372	0.0 - 0.5	9/25/11	**432**	14
RI-LH1-SB019	APISSB0373	0.5 - 1.0	9/25/11	42	5
RI-LH1-SB020	APISSB0488	0.0 - 0.5	9/25/11	**3,907**	78
RI-LH1-SB020	APISSB0489	0.5 - 1.0	9/25/11	**454**	15
RI-LH1-SB021	APISSB0490	0.0 - 0.5	9/25/11	**352**	13
RI-LH1-SB022	APISSB0383	0.0 - 0.5	9/25/11	240	10
RI-LH1-SB023	APISSB0384	0.0 - 0.5	9/25/11	**275**	11
RI-LH1-SB024	APISSB0385	0.0 - 0.5	9/25/11	**1,057**	25
RI-LH1-SB025	APISSB0386	0.0 - 0.5	9/25/11	69	6
RI-LH1-SB025	APISSB0387	0.5 - 1.0	9/25/11	249	11
RI-LH1-SB026	APISSB0388	0.0 - 0.5	9/25/11	**390**	14
RI-LH1-SB027	APISSB0389	0.0 - 0.5	9/25/11	**284**	11
RI-LH1-SB028	APISSB0392	0.0 - 0.5	9/25/11	66	6
RI-LH1-SB029	APISSB0393	0.0 - 0.5	9/25/11	180	9
RI-OH1-SB001	APISSB0222	0.0 - 0.5	9/23/11	**471**	15
RI-OH1-SB001	APISSB0223	0.5 - 1.0	9/23/11	247	11
RI-OH1-SB002	APISSB0224	0.0 - 0.5	9/23/11	**1,088**	27
RI-OH1-SB002	APISSB0225	0.5 - 1.0	9/23/11	**733**	20
RI-OH1-SB002	APISSB0238	1.0 - 1.5	9/23/11	55	6
RI-OH1-SB003	APISSB0239	0.0 - 0.5	9/23/11	155	9
RI-OH1-SB004	APISSB0240	0.0 - 0.5	9/23/11	**309**	12
RI-OH1-SB004	APISSB0241	0.5 - 1.0	9/23/11	149	8
RI-OH1-SB005	APISSB0264	0.0 - 0.5	9/23/11	187	9
RI-OH2-SB001	APISSB0234	0.0 - 0.5	9/23/11	**338**	12
RI-OH2-SB001	APISSB0235	0.5 - 1.0	9/23/11	234	10
RI-OH2-SB002	APISSB0236	0.0 - 0.5	9/23/11	**801**	20
RI-OH2-SB002	APISSB0237	0.5 - 1.0	9/23/11	**970**	24
RI-OH2-SB003	APISSB0246	0.0 - 0.5	9/23/11	**783**	21
RI-OH2-SB003	APISSB0247	0.5 - 1.0	9/23/11	**337**	13
RI-OH2-SB003	APISSB0248	1.0 - 1.5	9/23/11	179	9
RI-OH2-SB004	APISSB0265	0.0 - 0.5	9/23/11	**435**	14
RI-OH2-SB005	APISSB0266	0.0 - 0.5	9/23/11	148	8
RI-OH2-SB005	APISSB0267	0.5 - 1.0	9/23/11	161	9
RI-OH2-SB006	APISSB0279	0.0 - 0.5	9/24/11	154	8
RI-OS1-SB001	APISSB0282	0.0 - 0.5	9/24/11	**540**	16
RI-OS1-SB001	APISSB0283	0.5 - 1.0	9/24/11	**283**	11
RI-OS1-SB002	APISSB0284	0.0 - 0.5	9/24/11	**322**	12
RI-OS1-SB002	APISSB0285	0.5 - 1.0	9/24/11	37	5
RI-OS1-SB003	APISSB0286	0.0 - 0.5	9/24/11	**512**	16
RI-OS1-SB003	APISSB0287	0.5 - 1.0	9/24/11	187	9
RI-OS1-SB004	APISSB0288	0.0 - 0.5	9/24/11	**256**	11

Table B-3. Raspberry Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
RI-OS1-SB004	APISSB0289	0.5 - 1.0	9/24/11	93	7
RI-OS1-SB005	APISSB0290	0.0 - 0.5	9/24/11	**276**	11
RI-OS1-SB006	APISSB0291	0.0 - 0.5	9/24/11	**734**	20
RI-OS1-SB006	APISSB0292	0.5 - 1.0	9/24/11	61	6
RI-OS1-SB007	APISSB0293	0.0 - 0.5	9/24/11	238	10
RI-OS1-SB007	APISSB0294	0.5 - 1.0	9/24/11	29	5
RI-OS1-SB008	APISSB0295	0.0 - 0.5	9/24/11	**455**	14
RI-OS1-SB008	APISSB0296	0.5 - 1.0	9/24/11	84	6
RI-OS1-SB009	APISSB0300	0.0 - 0.5	9/24/11	229	10
RI-OS1-SB010	APISSB0301	0.0 - 0.5	9/24/11	**409**	13
RI-OS1-SB011	APISSB0313	0.0 - 0.5	9/24/11	**562**	17
RI-OS1-SB011	APISSB0314	0.5 - 1.0	9/24/11	**454**	14
RI-OS1-SB012	APISSB0315	0.0 - 0.5	9/24/11	113	7
RI-OS1-SB013	APISSB0316	0.0 - 0.5	9/24/11	132	8
RI-OS1-SB014	APISSB0356	0.0 - 0.5	9/24/11	**484**	15
RI-OS1-SB015	APISSB0365	0.0 - 0.5	9/25/11	**484**	16
RI-OS1-SB016	APISSB0492	0.0 - 0.5	9/25/11	192	9
RI-SH1-SB001	APISSB0249	0.0 - 0.5	9/23/11	**526**	15
RI-SH1-SB001	APISSB0250	0.5 - 1.0	9/23/11	**291**	11
RI-SH1-SB002	APISSB0251	0.0 - 0.5	9/23/11	**1,213**	28
RI-SH1-SB002	APISSB0252	0.5 - 1.0	9/23/11	**398**	13
RI-SH1-SB003	APISSB0253	0.0 - 0.5	9/23/11	**1,053**	25
RI-SH1-SB003	APISSB0254	0.5 - 1.0	9/23/11	**271**	11
RI-SH1-SB004	APISSB0255	0.0 - 0.5	9/23/11	**339**	13
RI-SH1-SB005	APISSB0277	0.0 - 0.5	9/24/11	186	9
RI-SH1-SB005	APISSB0278	0.5 - 1.0	9/24/11	29	5
RI-SH1-SB006	APISSB0307	0.0 - 0.5	9/24/11	**346**	13
RI-SH1-SB006	APISSB0308	0.5 - 1.0	9/24/11	225	10
RI-SH1-SB007	APISSB0309	0.0 - 0.5	9/24/11	**263**	10
RI-SH1-SB007	APISSB0310	0.5 - 1.0	9/24/11	16	4
RI-SH1-SB008	APISSB0311	0.0 - 0.5	9/24/11	**366**	13
RI-SH1-SB008	APISSB0312	0.5 - 1.0	9/24/11	161	9
RI-SH1-SB009	APISSB0352	0.0 - 0.5	9/24/11	111	7
RI-SH1-SB010	APISSB0353	0.0 - 0.5	9/24/11	79	6
RI-SH2-SB001	APISSB0226	0.0 - 0.5	9/23/11	**780**	21
RI-SH2-SB001	APISSB0227	0.5 - 1.0	9/23/11	86	7
RI-SH2-SB002	APISSB0228	0.0 - 0.5	9/23/11	**2,226**	45
RI-SH2-SB002	APISSB0229	0.5 - 1.0	9/23/11	**586**	17
RI-SH2-SB003	APISSB0230	0.0 - 0.5	9/23/11	**3,157**	62
RI-SH2-SB003	APISSB0231	0.5 - 1.0	9/23/11	**2,212**	46
RI-SH2-SB003	APISSB0243	1.0 - 1.5	9/23/11	181	9
RI-SH2-SB004	APISSB0232	0.0 - 0.5	9/23/11	**1,133**	26
RI-SH2-SB004	APISSB0233	0.5 - 1.0	9/23/11	166	8
RI-SH2-SB005	APISSB0242	0.0 - 0.5	9/23/11	**289**	11
RI-SH2-SB006	APISSB0244	0.0 - 0.5	9/23/11	**488**	15
RI-SH2-SB006	APISSB0245	0.5 - 1.0	9/23/11	100	7
RI-SH2-SB007	APISSB0268	0.0 - 0.5	9/23/11	**853**	21
RI-SH2-SB007	APISSB0269	0.5 - 1.0	9/23/11	203	9

Table B-3. Raspberry Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
RI-SH2-SB008	APISSB0270	0.0 - 0.5	9/23/11	**910**	22
RI-SH2-SB009	APISSB0271	0.0 - 0.5	9/23/11	**278**	11
RI-SH2-SB010	APISSB0273	0.0 - 0.5	9/24/11	187	9
RI-SH2-SB011	APISSB0274	0.0 - 0.5	9/24/11	173	9
RI-SH2-SB012	APISSB0275	0.0 - 0.5	9/24/11	118	7
RI-SH2-SB013	APISSB0276	0.0 - 0.5	9/24/11	**350**	13
RI-SH2-SB014	APISSB0297	0.0 - 0.5	9/24/11	169	9
RI-SH3-SB001	APISSB0256	0.0 - 0.5	9/23/11	**415**	14
RI-SH3-SB001	APISSB0257	0.5 - 1.0	9/23/11	183	9
RI-SH3-SB002	APISSB0258	0.0 - 0.5	9/23/11	**1,404**	32
RI-SH3-SB002	APISSB0259	0.5 - 1.0	9/23/11	**713**	20
RI-SH3-SB003	APISSB0260	0.0 - 0.5	9/23/11	**654**	19
RI-SH3-SB003	APISSB0261	0.5 - 1.0	9/23/11	**1,196**	28
RI-SH3-SB004	APISSB0262	0.0 - 0.5	9/23/11	**446**	14
RI-SH3-SB004	APISSB0263	0.5 - 1.0	9/23/11	**437**	14
RI-SH3-SB005	APISSB0272	0.0 - 0.5	9/23/11	**822**	22
RI-SH3-SB006	APISSB0280	0.0 - 0.5	9/24/11	**398**	13
RI-SH3-SB006	APISSB0281	0.5 - 1.0	9/24/11	76	6
RI-SH3-SB007	APISSB0299	0.0 - 0.5	9/24/11	244	10
RI-SH3-SB008	APISSB0298	0.0 - 0.5	9/24/11	**280**	11
RI-SH3-SB009	APISSB0302	0.0 - 0.5	9/24/11	87	7
RI-SH3-SB010	APISSB0303	0.0 - 0.5	9/24/11	**656**	18
RI-SH3-SB010	APISSB0304	0.5 - 1.0	9/24/11	142	8
RI-SH3-SB011	APISSB0305	0.0 - 0.5	9/24/11	**547**	16
RI-SH3-SB011	APISSB0306	0.5 - 1.0	9/24/11	54	6
RI-SH3-SB012	APISSB0354	0.0 - 0.5	9/24/11	**424**	14
RI-SH3-SB013	APISSB0355	0.0 - 0.5	9/24/11	**575**	17
RI-SH3-SB014	APISSB0364	0.0 - 0.5	9/25/11	**466**	15
RI-SH3-SB015	APISSB0363	0.0 - 0.5	9/25/11	173	9
RI-SH3-SB016	APISSB0491	0.0 - 0.5	9/25/11	172	9
RI-SW1-SB001	APISSB0394	0.0 - 0.5	9/25/11	180	9
RI-SW1-SB002	APISSB0395	0.0 - 0.5	9/25/11	34	5
RI-SW1-SB003	APISSB0396	0.0 - 0.5	9/25/11	107	7
RI-SW1-SB004	APISSB0397	0.0 - 0.5	9/25/11	**270**	11
RI-GARDEN-N	RI-GARDEN-N	0.0 1.0	6/22/12	36	1
RI-GARDEN-S	RI-GARDEN-S	0.0 1.0	6/22/12	65.9	2

Note:
Bolded value exceeds Wisconsin Department of Natural Resources Cleanup Standard of 250 mg/kg.
bgs = below ground surface
XRF = X-Ray Fluorescence

Table B-4. Devil's Island XRF Results

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
DI-FS1-SB001	APISSB0951	0.0 - 0.5	6/21/12	**657**	4
DI-FS1-SB001	APISSB0952	0.5 - 1.0	6/21/12	**638**	4
DI-FS1-SB002	APISSB0953	0.0 - 0.5	6/21/12	**989**	5
DI-FS1-SB003	APISSB0955	0.0 - 0.5	6/21/12	**1489**	7
DI-FS1-SB004	APISSB0956	0.0 - 0.5	6/21/12	**296**	3
DI-FS1-SB004	APISSB0957	0.5 - 1.0	6/21/12	39.3	1.2
DI-FS1-SB005	APISSB0958	0.0 - 0.5	6/21/12	124.8	1.8
DI-FS1-SB006	APISSB0959	0.0 - 0.5	6/21/12	**3,310**	12
DI-FS1-SB007	APISSB0960	0.0 - 0.5	6/21/12	**1,903**	8
DI-FS1-SB007	APISSB0961	0.5 - 1.0	6/21/12	**379**	3
DI-FS1-SB008	APISSB0962	0.0 - 0.5	6/21/12	**3,095**	11
DI-FS1-SB009	APISSB0963	0.0 - 0.5	6/21/12	**1,816**	8
DI-FS1-SB010	APISSB0954	0.0 - 0.5	6/21/12	**587**	4
DI-FS1-SB011	APISSB0994	0.0 - 0.5	6/23/12	**612**	4
DI-FS1-SB012	APISSB0995	0.0 - 0.5	6/23/12	**369**	3
DI-FS1-SB013	APISSB0996	0.0 - 0.5	6/23/12	**628**	4
DI-FS1-SB014	APISSB0997	0.0 - 0.5	6/23/12	**618**	4
DI-FS1-SB015	APISSB0998	0.0 - 0.5	6/23/12	**1,385**	6
DI-FS1-SB016	APISSB0999	0.0 - 0.5	6/23/12	**401**	3
DI-FS1-SB016	APISSB1000	0.5 - 1.0	6/23/12	177	2
DI-FS1-SB017	APISSB1001	0.0 - 0.5	6/23/12	**263**	2
DI-FS1-SB018	APISSB1002	0.0 - 0.5	6/23/12	**267**	3
DI-FS1-SB019	APISSB1037	0.0 - 0.5	6/24/12	135.3	1.8
DI-FS1-SB020	APISSB1038	0.0 - 0.5	6/24/12	**407**	3
DI-FS1-SB021	APISSB1039	0.0 - 0.5	6/24/12	**307**	3
DI-FS1-SB022	APISSB1040	0.0 - 0.5	6/24/12	**481**	3
DI-FS1-SB023	APISSB1041	0.0 - 0.5	6/24/12	**1,025**	5
DI-FS1-SB024	APISSB1042	0.0 - 0.5	6/24/12	**365**	3
DI-FS1-SB025	APISSB1043	0.0 - 0.5	6/24/12	77.1	1.5
DI-FS1-SB026	APISSB1044	0.0 - 0.5	6/24/12	**906**	5
DI-FS1-SB027	APISSB1045	0.0 - 0.5	6/24/12	136.8	1.9
DI-FS1-SB028	APISSB1046	0.0 - 0.5	6/24/12	**624**	4
DI-FS1-SB029	APISSB1047	0.0 - 0.5	6/24/12	72.6	1.5
DI-FS1-SB030	APISSB1053	0.0 - 0.5	6/24/12	**2,227**	9
DI-FS1-SB031	APISSB1054	0.0 - 0.5	6/24/12	**624**	4
DI-FS1-SB032	APISSB1055	0.0 - 0.5	6/25/12	32.3	1.1
DI-FS1-SB033	APISSB1056	0.0 - 0.5	6/25/12	**546**	4
DI-KQ1-SB001	APISSB0810	0.0 - 0.5	6/17/12	71.4	1.4
DI-KQ1-SB001	APISSB0811	0.5 - 1.0	6/17/12	112	1.7

Table B-4. Devil's Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
DI-KQ1-SB002	APISSB0812	0.0 - 0.5	6/17/12	48.3	1.3
DI-KQ1-SB003	APISSB0813	0.0 - 0.5	6/17/12	26.6	1.1
DI-KQ1-SB003	APISSB0814	0.5 - 1.0	6/17/12	22.2	1.1
DI-KQ1-SB004	APISSB0815	0.0 - 0.5	6/17/12	26.6	1.1
DI-KQ1-SB004	APISSB0816	0.5 - 1.0	6/17/12	28.9	1.1
DI-KQ1-SB005	APISSB0817	0.0 - 0.5	6/17/12	75.8	1.5
DI-KQ1-SB006	APISSB0818	0.0 - 0.5	6/17/12	121.2	1.8
DI-KQ1-SB006	APISSB0819	0.5 - 1.0	6/17/12	111.4	1.7
DI-KQ1-SB007	APISSB0820	0.0 - 0.5	6/17/12	229	2
DI-KQ1-SB007	APISSB0821	0.5 - 1.0	6/17/12	249	2
DI-KQ1-SB008	APISSB0822	0.0 - 0.5	6/17/12	145	1.9
DI-KQ1-SB008	APISSB0823	0.5 - 1.0	6/17/12	120.4	1.8
DI-KQ1-SB009	APISSB0826	0.0 - 0.5	6/17/12	**678**	4
DI-KQ1-SB009	APISSB0827	0.5 - 1.0	6/17/12	176	2
DI-KQ1-SB010	APISSB0824	0.0 - 0.5	6/17/12	131.5	1.8
DI-KQ1-SB010	APISSB0825	0.5 - 1.0	6/17/12	73.8	1.5
DI-KQ1-SB011	APISSB0828	0.0 - 0.5	6/17/12	25.7	1.1
DI-KQ1-SB011	APISSB0829	0.5 - 1.0	6/17/12	93.8	1.6
DI-KQ1-SB012	APISSB0853	0.0 - 0.5	6/17/12	**913**	5
DI-KQ1-SB013	APISSB0881	0.0 - 0.5	6/18/12	**677**	4
DI-KQ1-SB014	APISSB0886	0.0 - 0.5	6/18/12	66.3	1.4
DI-KQ2-SB001	APISSB0830	0.0 - 0.5	6/17/12	**770**	4
DI-KQ2-SB001	APISSB0831	0.5 - 1.0	6/17/12	**2,282**	9
DI-KQ2-SB002	APISSB0832	0.0 - 0.5	6/17/12	**402**	3
DI-KQ2-SB002	APISSB0833	0.5 - 1.0	6/17/12	**420**	3
DI-KQ2-SB003	APISSB0834	0.0 - 0.5	6/17/12	126.8	1.8
DI-KQ2-SB003	APISSB0835	0.5 - 1.0	6/17/12	169	2
DI-KQ2-SB004	APISSB0836	0.0 - 0.5	6/17/12	196	2
DI-KQ2-SB005	APISSB0837	0.0 - 0.5	6/17/12	**546**	4
DI-KQ2-SB005	APISSB0838	0.5 - 1.0	6/17/12	**1,264**	6
DI-KQ2-SB006	APISSB0839	0.0 - 0.5	6/17/12	81.1	1.5
DI-KQ2-SB006	APISSB0840	0.5 - 1.0	6/17/12	92.5	1.6
DI-KQ2-SB007	APISSB0841	0.0 - 0.5	6/17/12	94.6	1.6
DI-KQ2-SB007	APISSB0842	0.5 - 1.0	6/17/12	52.5	1.3
DI-KQ2-SB008	APISSB0843	0.0 - 0.5	6/17/12	**265**	3
DI-KQ2-SB008	APISSB0844	0.5 - 1.0	6/17/12	225	2
DI-KQ2-SB009	APISSB0854	0.0 - 0.5	6/17/12	133.7	1.8
DI-KQ2-SB009	APISSB0855	0.5 - 1.0	6/17/12	94.4	1.6
DI-KQ2-SB010	APISSB0856	0.0 - 0.5	6/17/12	**278**	3
DI-KQ2-SB010	APISSB0857	0.5 - 1.0	6/17/12	182	2
DI-KQ2-SB011	APISSB0858	0.0 - 0.5	6/17/12	**299**	3

Table B-4. Devil's Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
DI-KQ2-SB011	APISSB0859	0.5 - 1.0	6/17/12	**337**	3
DI-KQ2-SB011	APISSB0860	1.0 - 1.5	6/17/12	250	3
DI-KQ2-SB012	APISSB0861	0.0 - 0.5	6/17/12	**261**	3
DI-KQ2-SB013	APISSB0882	0.0 - 0.5	6/18/12	218	2
DI-KQ2-SB014	APISSB0883	0.0 - 0.5	6/18/12	119.5	1.8
DI-KQ2-SB014	APISSB0884	0.5 - 1.0	6/18/12	67.2	1.4
DI-KQ2-SB015	APISSB0885	0.0 - 0.5	6/18/12	35.5	1.2
DI-KQ3-SB001	APISSB0899	0.0 - 0.5	6/18/12	47.9	1.2
DI-KQ3-SB001	APISSB0900	0.5 - 1.0	6/18/12	32	1.1
DI-KQ3-SB002	APISSB0901	0.0 - 0.5	6/18/12	**283**	2
DI-KQ3-SB002	APISSB0902	0.5 - 1.0	6/18/12	**509**	4
DI-KQ3-SB003	APISSB0903	0.0 - 0.5	6/18/12	83.5	1.5
DI-KQ3-SB003	APISSB0904	0.5 - 1.0	6/18/12	89.9	1.5
DI-KQ3-SB004	APISSB0905	0.0 - 0.5	6/18/12	29.7	1
DI-KQ3-SB005	APISSB0906	0.0 - 0.5	6/18/12	**575**	4
DI-KQ3-SB005	APISSB0907	0.5 - 1.0	6/18/12	**282**	3
DI-KQ3-SB006	APISSB0908	0.0 - 0.5	6/18/12	73.7	1.4
DI-KQ3-SB007	APISSB0909	0.0 - 0.5	6/18/12	126.6	1.8
DI-KQ3-SB008	APISSB0910	0.0 - 0.5	6/18/12	57.9	1.3
DI-KQ3-SB008	APISSB0911	0.5 - 1.0	6/18/12	25	1.1
DI-KQ3-SB009	APISSB0912	0.0 - 0.5	6/18/12	206	2
DI-KQ3-SB009	APISSB0913	0.5 - 1.0	6/18/12	69.7	1.4
DI-KQ3-SB010	APISSB0931	0.0 - 0.5	6/21/12	**394**	3
DI-KQ3-SB010	APISSB0932	0.5 - 1.0	6/21/12	**329**	3
DI-KQ3-SB011	APISSB0933	0.0 - 0.5	6/21/12	**1,055**	5
DI-KQ3-SB011	APISSB0934	0.5 - 1.0	6/21/12	**1,138**	6
DI-KQ3-SB012	APISSB0948	0.0 - 0.5	6/21/12	**442**	3
DI-KQ3-SB012	APISSB0949	0.5 - 1.0	6/21/12	**294**	3
DI-KQ3-SB013	APISSB0950	0.0 - 0.5	6/21/12	**1,237**	6
DI-KQ3-SB014	APISSB0981	0.0 - 0.5	6/23/12	**590**	4
DI-KQ3-SB015	APISSB0982	0.0 - 0.5	6/23/12	249	2
DI-KQ3-SB016	APISSB1003	0.0 - 0.5	6/23/12	110.9	1.8
DI-LH1-SB001	APISSB0862	0.0 - 0.5	6/17/12	**3,506**	12
DI-LH1-SB001	APISSB0863	0.5 - 1.0	6/17/12	**3,291**	12
DI-LH1-SB002	APISSB0864	0.0 - 0.5	6/17/12	**3,323**	12
DI-LH1-SB003	APISSB0865	0.0 - 0.5	6/17/12	**4,553**	16
DI-LH1-SB003	APISSB0866	0.5 - 1.0	6/17/12	**4,050**	14
DI-LH1-SB004	APISSB0867	0.0 - 0.5	6/17/12	**2,631**	11
DI-LH1-SB005	APISSB0868	0.0 - 0.5	6/17/12	**3,753**	13
DI-LH1-SB006	APISSB0869	0.0 - 0.5	6/17/12	**2,622**	10
DI-LH1-SB007	APISSB0870	0.0 - 0.5	6/17/12	**3,611**	13

Table B-4. Devil's Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
DI-LH1-SB008	APISSB0871	0.0 - 0.5	6/17/12	**558**	4
DI-LH1-SB009	APISSB0872	0.0 - 0.5	6/17/12	**2,063**	8
DI-LH1-SB010	APISSB0873	0.0 - 0.5	6/17/12	**1,028**	5
DI-LH1-SB010	APISSB0874	0.5 - 1.0	6/17/12	**415**	3
DI-LH1-SB011	APISSB0875	0.0 - 0.5	6/17/12	**1,650**	7
DI-LH1-SB012	APISSB0876	0.0 - 0.5	6/17/12	**3,719**	13
DI-LH1-SB013	APISSB0877	0.0 - 0.5	6/17/12	**2,872**	11
DI-LH1-SB014	APISSB0878	0.0 - 0.5	6/17/12	**1,921**	8
DI-LH1-SB015	APISSB0879	0.0 - 0.5	6/17/12	**2,588**	10
DI-LH1-SB016	APISSB0880	0.0 - 0.5	6/17/12	234	2
DI-LH1-SB017	APISSB0892	0.0 - 0.5	6/18/12	**1,831**	8
DI-LH1-SB018	APISSB0893	0.0 - 0.5	6/18/12	**1,144**	6
DI-LH1-SB019	APISSB0894	0.0 - 0.5	6/18/12	**3,706**	14
DI-LH1-SB020	APISSB0895	0.0 - 0.5	6/18/12	219	2
DI-LH1-SB021	APISSB0896	0.0 - 0.5	6/18/12	**1,775**	7
DI-LH1-SB022	APISSB0897	0.0 - 0.5	6/18/12	**516**	4
DI-LH1-SB023	APISSB0898	0.0 - 0.5	6/18/12	**978**	5
DI-LH1-SB024	APISSB0925	0.0 - 0.5	6/19/12	82	1.4
DI-LH1-SB025	APISSB0926	0.0 - 0.5	6/19/12	**1,414**	6
DI-LH1-SB026	APISSB0927	0.0 - 0.5	6/19/12	**947**	5
DI-LH1-SB027	APISSB0928	0.0 - 0.5	6/19/12	**496**	3
DI-LH1-SB028	APISSB0929	0.0 - 0.5	6/19/12	**484**	3
DI-LH1-SB029	APISSB0930	0.0 - 0.5	6/19/12	**317**	3
DI-LH1-SB030	APISSB0939	0.0 - 0.5	6/21/12	**613**	4
DI-LH1-SB031	APISSB0940	0.0 - 0.5	6/21/12	**660**	4
DI-LH1-SB032	APISSB0941	0.0 - 0.5	6/21/12	**445**	3
DI-LH1-SB033	APISSB0942	0.0 - 0.5	6/21/12	**2,833**	10
DI-LH1-SB034	APISSB0943	0.0 - 0.5	6/21/12	**409**	3
DI-LH1-SB035	APISSB0983	0.0 - 0.5	6/23/12	**723**	4
DI-LH1-SB036	APISSB0984	0.0 - 0.5	6/23/12	**394**	3
DI-LH1-SB037	APISSB0985	0.0 - 0.5	6/23/12	141.8	1.9
DI-LH1-SB038	APISSB0986	0.0 - 0.5	6/23/12	66.8	1.4
DI-LH1-SB039	APISSB0987	0.0 - 0.5	6/23/12	87.5	1.6
DI-LH1-SB039	APISSB0988	0.5 - 1.0	6/23/12	53	1.3
DI-LH1-SB040	APISSB1016	0.0 - 0.5	6/23/12	**790**	5
DI-LH1-SB041	APISSB1017	0.0 - 0.5	6/23/12	**288**	3
DI-LH1-SB042	APISSB1018	0.0 - 0.5	6/23/12	45.3	1.2
DI-LH1-SB043	APISSB1019	0.0 - 0.5	6/23/12	78.2	1.5
DI-LH2-SB001	APISSB1004	0.0 - 0.5	6/23/12	51.9	1.3
DI-LH2-SB002	APISSB1005	0.0 - 0.5	6/23/12	138	1.8
DI-LH2-SB003	APISSB1006	0.0 - 0.5	6/23/12	216	2

Table B-4. Devil's Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
DI-LH2-SB003	APISSB1007	0.5 - 1.0	6/23/12	241	2
DI-LH2-SB004	APISSB1008	0.0 - 0.5	6/23/12	58.8	1.3
DI-LH2-SB005	APISSB1009	0.0 - 0.5	6/23/12	29	1.1
DI-OH1-SB001	APISSB0917	0.0 - 0.5	6/19/12	151.5	1.9
DI-OH1-SB002	APISSB0918	0.0 - 0.5	6/19/12	**402**	3
DI-OH1-SB003	APISSB0919	0.0 - 0.5	6/19/12	176	2
DI-OH1-SB004	APISSB0920	0.0 - 0.5	6/19/12	100.2	1.6
DI-OH1-SB005	APISSB0935	0.0 - 0.5	6/21/12	**261**	2
DI-OH1-SB005	APISSB0936	0.5 - 1.0	6/21/12	**304**	3
DI-OH1-SB006	APISSB0947	0.0 - 0.5	6/21/12	**306**	3
DI-OH1-SB007	APISSB0980	0.0 - 0.5	6/23/12	193	2
DI-OH2-SB001	APISSB0921	0.0 - 0.5	6/19/12	**343**	3
DI-OH2-SB002	APISSB0922	0.0 - 0.5	6/19/12	151.3	1.9
DI-OH2-SB003	APISSB0923	0.0 - 0.5	6/19/12	**275**	2
DI-OH2-SB004	APISSB0924	0.0 - 0.5	6/19/12	208	2
DI-OH2-SB005	APISSB0937	0.0 - 0.5	6/21/12	67.7	1.4
DI-OH2-SB006	APISSB0938	0.0 - 0.5	6/21/12	134.9	1.8
DI-OS1-SB001	APISSB0845	0.0 - 0.5	6/17/12	**5703**	19
DI-OS1-SB002	APISSB0846	0.0 - 0.5	6/17/12	**649**	4
DI-OS1-SB003	APISSB0847	0.0 - 0.5	6/17/12	**2,854**	11
DI-OS1-SB004	APISSB0848	0.0 - 0.5	6/17/12	**883**	5
DI-OS1-SB005	APISSB0849	0.0 - 0.5	6/17/12	**3,095**	11
DI-OS1-SB006	APISSB0850	0.0 - 0.5	6/17/12	**262**	2
DI-OS1-SB007	APISSB0851	0.0 - 0.5	6/17/12	199	2
DI-OS1-SB008	APISSB0852	0.0 - 0.5	6/17/12	60.1	1.4
DI-OS1-SB009	APISSB0887	0.0 - 0.5	6/18/12	**1,557**	7
DI-OS1-SB010	APISSB0888	0.0 - 0.5	6/18/12	**337**	3
DI-OS1-SB011	APISSB0889	0.0 - 0.5	6/18/12	**657**	4
DI-OS1-SB012	APISSB0890	0.0 - 0.5	6/18/12	**278**	3
DI-OS1-SB012	APISSB0891	0.5 - 1.0	6/18/12	26	1
DI-OS1-SB013	APISSB0914	0.0 - 0.5	6/19/12	236	2
DI-OS1-SB014	APISSB0915	0.0 - 0.5	6/19/12	139.3	1.7
DI-OS1-SB015	APISSB0916	0.0 - 0.5	6/19/12	57.9	1.3
DI-OS2-SB001	APISSB0964	0.0 - 0.5	6/21/12	**649**	4
DI-OS2-SB002	APISSB0965	0.0 - 0.5	6/21/12	**680**	4
DI-OS2-SB002	APISSB0966	0.5 - 1.0	6/21/12	**397**	3
DI-OS2-SB003	APISSB0967	0.0 - 0.5	6/21/12	**1,832**	8
DI-OS2-SB004	APISSB0968	0.0 - 0.5	6/21/12	**7,192**	24
DI-OS2-SB005	APISSB0989	0.0 - 0.5	6/23/12	**648**	4
DI-OS2-SB006	APISSB0990	0.0 - 0.5	6/23/12	146.2	1.9
DI-OS2-SB007	APISSB0991	0.0 - 0.5	6/23/12	185	2

Table B-4. Devil's Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
DI-OS2-SB007	APISSB0992	0.5 - 1.0	6/23/12	36.6	1.2
DI-OS2-SB008	APISSB0993	0.0 - 0.5	6/23/12	249	2
DI-OS2-SB009	APISSB1036	0.0 - 0.5	6/24/12	146.5	1.9
DI-SH2-SB001	APISSB1027	0.0 - 0.5	6/24/12	**602**	4
DI-SH2-SB002	APISSB1028	0.0 - 0.5	6/24/12	113.6	1.7
DI-SH2-SB003	APISSB1029	0.0 - 0.5	6/24/12	171	2
DI-SH2-SB004	APISSB1030	0.0 - 0.5	6/24/12	**1,119**	5
DI-SH2-SB005	APISSB1031	0.0 - 0.5	6/24/12	**478**	3
DI-SH2-SB006	APISSB1032	0.0 - 0.5	6/24/12	231	3
DI-SH2-SB007	APISSB1033	0.0 - 0.5	6/24/12	**633**	4
DI-SH2-SB008	APISSB1034	0.0 - 0.5	6/24/12	205	2
DI-SH2-SB009	APISSB1035	0.0 - 0.5	6/24/12	**638**	4
DI-SH2-SB010	APISSB1050	0.0 - 0.5	6/24/12	157.2	2
DI-SH2-SB011	APISSB1051	0.0 - 0.5	6/24/12	219	2
DI-SH4-SB001	APISSB1010	0.0 - 0.5	6/23/12	**1,980**	8
DI-SH4-SB002	APISSB1011	0.0 - 0.5	6/23/12	**2,532**	10
DI-SH4-SB002	APISSB1012	0.5 - 1.0	6/23/12	148.4	1.9
DI-SH4-SB003	APISSB1013	0.0 - 0.5	6/23/12	**6,382**	22
DI-SH4-SB004	APISSB1014	0.0 - 0.5	6/23/12	**1,803**	8
DI-SH4-SB004	APISSB1015	0.5 - 1.0	6/23/12	48.4	1.3
DI-SH4-SB005	APISSB1020	0.0 - 0.5	6/23/12	**2,138**	9
DI-SH4-SB005	APISSB1021	0.5 - 1.0	6/23/12	**981**	5
DI-SH4-SB006	APISSB1022	0.0 - 0.5	6/23/12	198	2
DI-SH4-SB006	APISSB1023	0.5 - 1.0	6/23/12	29.8	1.1
DI-SH4-SB007	APISSB1024	0.0 - 0.5	6/23/12	161.7	2
DI-SH4-SB007	APISSB1025	0.5 - 1.0	6/23/12	32.3	1.1
DI-SH4-SB008	APISSB1026	0.0 - 0.5	6/23/12	**2,122**	9
DI-SH4-SB009	APISSB1048	0.0 - 0.5	6/24/12	**545**	4
DI-SH4-SB010	APISSB1049	0.0 - 0.5	6/24/12	103.3	1.6
DI-SH4-SB011	APISSB1052	0.0 - 0.5	6/24/12	134	1.8
DI-TW1-SB001	APISSB0944	0.0 - 0.5	6/21/12	23.8	1
DI-TW1-SB002	APISSB0945	0.0 - 0.5	6/21/12	42.2	1.2
DI-TW1-SB003	APISSB0946	0.0 - 0.5	6/21/12	24.1	1

Note:
Bolded value exceeds Wisconsin Department of Natural Resources Cleanup Standard of 250 mg/kg.
bgs = below ground surface
XRF = X-Ray Fluorescence

Table B-5. Long Island XRF Results

Station	Sample ID	Depth (ft bgs)	Date Collected	Lead (mg/kg)	+/-
LI-AS1-SB001	APISSB0416	0.0 - 0.5	9/28/11	160	8
LI-AS1-SB001	APISSB0417	0.5 - 1.0	9/28/11	107	7
LI-AS1-SB002	APISSB0418	0.0 - 0.5	9/28/11	99	7
LI-AS1-SB002	APISSB0419	0.5 - 1.0	9/28/11	Non-detect	12
LI-AS1-SB003	APISSB0420	0.0 - 0.5	9/28/11	**261**	10
LI-AS1-SB003	APISSB0421	0.5 - 1.0	9/28/11	**413**	14
LI-AS1-SB004	APISSB0422	0.0 - 0.5	9/28/11	141	8
LI-AS1-SB004	APISSB0423	0.5 - 1.0	9/28/11	20	4
LI-AS1-SB005	APISSB0440	0.0 - 0.5	9/28/11	105	7
LI-AS1-SB005	APISSB0441	0.5 - 1.0	9/28/11	42	5
LI-AS1-SB006	APISSB0442	0.0 - 0.5	9/28/11	**936**	24
LI-AS1-SB006	APISSB0443	0.5 - 1.0	9/28/11	94	7
LI-AS1-SB007	APISSB0457	0.0 - 0.5	9/28/11	156	8
LI-FS1-SB001	APISSB0424	0.0 - 0.5	9/28/11	**2,275**	52
LI-CS1-SB001	APISSB0711	0.0 - 0.5	6/13/12	32.7	1.2
LI-CS1-SB001	APISSB0712	0.5 - 1.0	6/13/12	46.1	1.3
LI-CS1-SB002	APISSB0713	0.0 - 0.5	6/13/12	**282**	3
LI-CS1-SB002	APISSB0714	0.5 - 1.0	6/13/12	170	2
LI-CS1-SB003	APISSB0715	0.0 - 0.5	6/13/12	136	2
LI-CS1-SB003	APISSB0716	0.5 - 1.0	6/13/12	115.2	1.9
LI-CS1-SB004	APISSB0802	0.0 - 0.5	6/15/12	32.2	1.2
LI-FS1-SB001	APISSB0425	0.5 - 1.0	9/28/11	**1,492**	34
LI-FS1-SB002	APISSB0426	0.0 - 0.5	9/28/11	**8,662**	188
LI-FS1-SB002	APISSB0427	0.5 - 1.0	9/28/11	**456**	15
LI-FS1-SB003	APISSB0428	0.0 - 0.5	9/28/11	**825**	21
LI-FS1-SB003	APISSB0429	0.5 - 1.0	9/28/11	118	7
LI-FS1-SB004	APISSB0430	0.0 - 0.5	9/28/11	**615**	17
LI-FS1-SB004	APISSB0431	0.5 - 1.0	9/28/11	102	7
LI-FS1-SB005	APISSB0444	0.0 - 0.5	9/28/11	**368**	14
LI-FS1-SB005	APISSB0445	0.5 - 1.0	9/28/11	14	4
LI-FS1-SB006	APISSB0446	0.0 - 0.5	9/28/11	146	8
LI-FS1-SB006	APISSB0447	0.5 - 1.0	9/28/11	41	5
LI-FS1-SB007	APISSB0448	0.0 - 0.5	9/28/11	**839**	24
LI-FS1-SB007	APISSB0449	0.5 - 1.0	9/28/11	111	8
LI-FS1-SB008	APISSB0450	0.0 - 0.5	9/28/11	**629**	18
LI-FS1-SB008	APISSB0451	0.5 - 1.0	9/28/11	41	5
LI-FS1-SB008	APISSB0452	1.0 - 1.5	9/28/11	Non-detect	11
LI-FS1-SB009	APISSB0453	0.0 - 0.5	9/28/11	196	9
LI-FS1-SB010	APISSB0454	0.0 - 0.5	9/28/11	**330**	12
LI-FS1-SB011	APISSB0455	0.0 - 0.5	9/28/11	**815**	22
LI-FS1-SB012	APISSB0456	0.0 - 0.5	9/28/11	**420**	14
LI-FS1-SB013	APISSB0470	0.0 - 0.5	9/28/11	**253**	11
LI-FS1-SB014	APISSB0471	0.0 - 0.5	9/28/11	**705**	20
LI-FS1-SB015	APISSB0469	0.0 - 0.5	9/28/11	**325**	13
LI-FS1-SB016	APISSB0501	0.0 - 0.5	10/1/11	**262**	11
LI-FT1-SB001	APISSB0408	0.0 - 0.5	9/28/11	65	6

Table B-5. Long Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)			Date Collected	Lead (mg/kg)	+/-
LI-FT1-SB001	APISSB0409	0.5	-	1.0	9/28/11	25	6
LI-FT1-SB002	APISSB0410	0.0	-	0.5	9/28/11	117	8
LI-FT1-SB002	APISSB0411	0.5	-	1.0	9/28/11	26	5
LI-FT1-SB003	APISSB0412	0.0	-	0.5	9/28/11	171	9
LI-FT1-SB003	APISSB0413	0.5	-	1.0	9/28/11	21	5
LI-FT1-SB004	APISSB0414	0.0	-	0.5	9/28/11	72	7
LI-FT1-SB004	APISSB0415	0.5	-	1.0	9/28/11	15	4
LI-FT2-SB001	APISSB0693	0.0	-	0.5	6/13/12	20.6	1.1
LI-FT2-SB001	APISSB0694	0.5	-	1.0	6/13/12	6.6	0.9
LI-FT2-SB002	APISSB0695	0.0	-	0.5	6/13/12	47.2	1.3
LI-FT2-SB002	APISSB0696	0.5	-	1.0	6/13/12	9.2	0.9
LI-FT2-SB003	APISSB0697	0.0	-	0.5	6/13/12	87.3	1.6
LI-FT2-SB003	APISSB0698	0.5	-	1.0	6/13/12	7.2	0.9
LI-FT2-SB004	APISSB0699	0.0	-	0.5	6/13/12	31.4	1.2
LI-FT2-SB004	APISSB0700	0.5	-	1.0	6/13/12	11.3	0.9
LI-FT2-SB005	APISSB0701	0.0	-	0.5	6/13/12	25.4	1.1
LI-FT2-SB005	APISSB0702	0.5	-	1.0	6/13/12	8.1	0.9
LI-FT2-SB006	APISSB0703	0.0	-	0.5	6/13/12	13.6	1
LI-FT2-SB006	APISSB0704	0.5	-	1.0	6/13/12	8.7	0.9
LI-FT2-SB007	APISSB0705	0.0	-	0.5	6/13/12	11	0.9
LI-FT2-SB007	APISSB0706	0.5	-	1.0	6/13/12	8.1	0.9
LI-FT2-SB008	APISSB0707	0.0	-	0.5	6/13/12	12.5	1
LI-FT2-SB008	APISSB0708	0.5	-	1.0	6/13/12	8	0.9
LI-FT2-SB009	APISSB0709	0.0	-	0.5	6/13/12	11.9	1
LI-FT2-SB009	APISSB0710	0.5	-	1.0	6/13/12	6	0.9
LI-KQ1-SB001	APISSB0458	0.0	-	0.5	9/28/11	**414**	14
LI-KQ1-SB001	APISSB0459	0.5	-	1.0	9/28/11	Non-detect	13
LI-KQ1-SB002	APISSB0460	0.0	-	0.5	9/28/11	**679**	19
LI-KQ1-SB002	APISSB0461	0.5	-	1.0	9/28/11	83	7
LI-KQ1-SB003	APISSB0462	0.0	-	0.5	9/28/11	144	8
LI-KQ1-SB003	APISSB0463	0.5	-	1.0	9/28/11	19	5
LI-KQ1-SB004	APISSB0464	0.0	-	0.5	9/28/11	**295**	11
LI-KQ1-SB004	APISSB0465	0.5	-	1.0	9/28/11	Non-detect	15
LI-KQ1-SB005	APISSB0480	0.0	-	0.5	9/28/11	141	8
LI-KQ1-SB005	APISSB0481	0.5	-	1.0	9/28/11	Non-detect	13
LI-KQ1-SB006	APISSB0482	0.0	-	0.5	9/28/11	**1,021**	25
LI-KQ1-SB006	APISSB0483	0.5	-	1.0	9/28/11	245	11
LI-KQ1-SB007	APISSB0484	0.0	-	0.5	9/28/11	**291**	11
LI-KQ1-SB007	APISSB0485	0.5	-	1.0	9/28/11	13	4
LI-KQ1-SB008	APISSB0486	0.0	-	0.5	9/28/11	**478**	15
LI-KQ1-SB008	APISSB0487	0.5	-	1.0	9/28/11	22	5
LI-KQ1-SB009	APISSB0506	0.0	-	0.5	10/1/11	46	6
LI-KQ1-SB010	APISSB0507	0.0	-	0.5	10/1/11	**382**	14
LI-KQ1-SB011	APISSB0508	0.0	-	0.5	10/1/11	242	11
LI-KQ1-SB012	APISSB0509	0.0	-	0.5	10/1/11	56	6
LI-KQ1-SB013	APISSB0541	0.0	-	0.5	10/1/11	199	10
LI-LH1-SB001	APISSB0398	0.0	-	0.5	9/28/11	**3,733**	80
LI-KQ2-SB001	APISSB0717	0.0	-	0.5	6/13/12	**1,629**	8

Table B-5. Long Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)			Date Collected	Lead (mg/kg)	+/-
LI-KQ2-SB001	APISSB0718	0.5	-	1.0	6/13/12	**1,045**	6
LI-KQ2-SB002	APISSB0721	0.0	-	0.5	6/13/12	**1,455**	7
LI-KQ2-SB002	APISSB0722	0.5	-	1.0	6/13/12	**436**	4
LI-KQ2-SB003	APISSB0725	0.0	-	0.5	6/13/12	**266**	3
LI-KQ2-SB003	APISSB0726	0.5	-	1.0	6/13/12	156	2
LI-KQ2-SB004	APISSB0729	0.0	-	0.5	6/13/12	**2,033**	9
LI-KQ2-SB004	APISSB0730	0.5	-	1.0	6/13/12	**1,950**	9
LI-KQ2-SB005	APISSB0733	0.0	-	0.5	6/13/12	**724**	5
LI-KQ2-SB005	APISSB0734	0.5	-	1.0	6/13/12	**419**	3
LI-KQ2-SB007	APISSB0737	0.0	-	0.5	6/13/12	**2,137**	9
LI-KQ2-SB007	APISSB0738	0.5	-	1.0	6/13/12	**1,692**	8
LI-KQ2-SB008	APISSB0741	0.0	-	0.5	6/13/12	**299**	3
LI-KQ2-SB008	APISSB0742	0.5	-	1.0	6/13/12	73.4	1.5
LI-KQ2-SB009	APISSB0743	0.0	-	0.5	6/13/12	**1,636**	8
LI-KQ2-SB009	APISSB0744	0.5	-	1.0	6/13/12	**383**	3
LI-KQ2-SB010	APISSB0745	0.0	-	0.5	6/13/12	**1,998**	8
LI-KQ2-SB010	APISSB0746	0.5	-	1.0	6/13/12	**306**	3
LI-KQ2-SB011	APISSB0747	0.0	-	0.5	6/13/12	**273**	3
LI-KQ2-SB011	APISSB0748	0.5	-	1.0	6/13/12	96.8	1.7
LI-KQ2-SB012	APISSB0719	0.0	-	0.5	6/13/12	**427**	4
LI-KQ2-SB012	APISSB0720	0.5	-	1.0	6/13/12	**813**	5
LI-KQ2-SB013	APISSB0723	0.0	-	0.5	6/13/12	190	2
LI-KQ2-SB013	APISSB0724	0.5	-	1.0	6/13/12	**1,049**	6
LI-KQ2-SB014	APISSB0727	0.0	-	0.5	6/13/12	**1,222**	6
LI-KQ2-SB014	APISSB0728	0.5	-	1.0	6/13/12	**629**	4
LI-KQ2-SB015	APISSB0731	0.0	-	0.5	6/13/12	**4,432**	16
LI-KQ2-SB015	APISSB0732	0.5	-	1.0	6/13/12	**987**	5
LI-KQ2-SB016	APISSB0735	0.0	-	0.5	6/13/12	**1,141**	6
LI-KQ2-SB016	APISSB0736	0.5	-	1.0	6/13/12	**630**	4
LI-KQ2-SB018	APISSB0739	0.0	-	0.5	6/13/12	**587**	4
LI-KQ2-SB018	APISSB0740	0.5	-	1.0	6/13/12	101.5	1.7
LI-KQ2-SB019	APISSB0749	0.0	-	0.5	6/15/12	**1,049**	6
LI-KQ2-SB019	APISSB0750	0.5	-	1.0	6/15/12	149	2
LI-KQ2-SB019	APISSB0751	1.0	-	1.5	6/15/12	84.9	1.5
LI-KQ2-SB020	APISSB0752	0.0	-	0.5	6/15/12	**263**	3
LI-KQ2-SB020	APISSB0753	0.5	-	1.0	6/15/12	206	2
LI-KQ2-SB020	APISSB0754	1.0	-	1.5	6/15/12	**532**	4
LI-KQ2-SB021	APISSB0755	0.0	-	0.5	6/15/12	**1,080**	6
LI-KQ2-SB021	APISSB0756	0.5	-	1.0	6/15/12	**291**	3
LI-KQ2-SB021	APISSB0757	1.0	-	1.5	6/15/12	**556**	4
LI-KQ2-SB022	APISSB0758	0.0	-	0.5	6/15/12	**347**	3
LI-KQ2-SB022	APISSB0759	0.5	-	1.0	6/15/12	**624**	4
LI-KQ2-SB022	APISSB0760	1.0	-	1.5	6/15/12	144	2
LI-KQ2-SB023	APISSB0761	0.0	-	0.5	6/15/12	**479**	4
LI-KQ2-SB023	APISSB0762	0.5	-	1.0	6/15/12	**286**	3
LI-KQ2-SB023	APISSB0763	1.0	-	1.5	6/15/12	139.2	2
LI-KQ2-SB024	APISSB0764	0.0	-	0.5	6/15/12	152	2
LI-KQ2-SB024	APISSB0765	0.5	-	1.0	6/15/12	60.3	1.4

Table B-5. Long Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)			Date Collected	Lead (mg/kg)	+/-
LI-KQ2-SB024	APISSB0766	1.0	-	1.5	6/15/12	35.8	1.2
LI-KQ2-SB025	APISSB0767	0.0	-	0.5	6/15/12	**2,057**	9
LI-KQ2-SB025	APISSB0768	0.5	-	1.0	6/15/12	101.8	1.7
LI-KQ2-SB026	APISSB0769	0.0	-	0.5	6/15/12	173	2
LI-KQ2-SB026	APISSB0770	0.5	-	1.0	6/15/12	97.4	1.8
LI-KQ2-SB027	APISSB0771	0.0	-	0.5	6/15/12	42.2	1.3
LI-KQ2-SB027	APISSB0772	0.5	-	1.0	6/15/12	25.4	1.1
LI-KQ2-SB027	APISSB0773	1.0	-	1.5	6/15/12	37	1.2
LI-KQ2-SB028	APISSB0774	0.0	-	0.5	6/15/12	138.9	1.9
LI-KQ2-SB028	APISSB0775	0.5	-	1.0	6/15/12	7.6	0.9
LI-KQ2-SB028	APISSB0776	1.0	-	1.5	6/15/12	15.8	1
LI-KQ2-SB029	APISSB0777	0.0	-	0.5	6/15/12	**526**	4
LI-KQ2-SB029	APISSB0778	0.5	-	1.0	6/15/12	105	1.8
LI-KQ2-SB029	APISSB0779	1.0	-	1.5	6/15/12	20.9	1.1
LI-KQ2-SB030	APISSB0780	0.0	-	0.5	6/15/12	**514**	4
LI-KQ2-SB030	APISSB0781	0.5	-	1.0	6/15/12	132.3	1.9
LI-KQ2-SB031	APISSB0782	0.0	-	0.5	6/15/12	**464**	4
LI-KQ2-SB031	APISSB0783	0.5	-	1.0	6/15/12	**380**	3
LI-KQ2-SB032	APISSB0784	0.0	-	0.5	6/15/12	180	2
LI-KQ2-SB032	APISSB0785	0.5	-	1.0	6/15/12	38.5	1.2
LI-KQ2-SB033	APISSB0786	0.0	-	0.5	6/15/12	**6,091**	22
LI-KQ2-SB033	APISSB0787	0.5	-	1.0	6/15/12	**1,555**	7
LI-KQ2-SB034	APISSB0788	0.0	-	0.5	6/15/12	**8,644**	30
LI-KQ2-SB034	APISSB0789	0.5	-	1.0	6/15/12	**5,223**	19
LI-KQ2-SB035	APISSB0790	0.0	-	0.5	6/15/12	**803**	5
LI-KQ2-SB035	APISSB0791	0.5	-	1.0	6/15/12	63.9	1.4
LI-KQ2-SB036	APISSB0792	0.0	-	0.5	6/15/12	233	3
LI-KQ2-SB036	APISSB0793	0.5	-	1.0	6/15/12	101.5	1.7
LI-KQ2-SB037	APISSB0794	0.0	-	0.5	6/15/12	77.8	1.6
LI-KQ2-SB037	APISSB0795	0.5	-	1.0	6/15/12	39.4	1.2
LI-KQ2-SB038	APISSB0796	0.0	-	0.5	6/15/12	71	1.5
LI-KQ2-SB038	APISSB0797	0.5	-	1.0	6/15/12	16.8	1
LI-KQ2-SB039	APISSB0798	0.0	-	0.5	6/15/12	167	2
LI-KQ2-SB039	APISSB0799	0.5	-	1.0	6/15/12	10	0.9
LI-KQ2-SB040	APISSB0800	0.0	-	0.5	6/15/12	**257**	3
LI-KQ2-SB040	APISSB0801	0.5	-	1.0	6/15/12	17.4	1
LI-LH1-SB001	APISSB0399	0.5	-	1.0	9/28/11	**636**	18
LI-LH1-SB002	APISSB0400	0.0	-	0.5	9/28/11	**3,271**	65
LI-LH1-SB002	APISSB0401	0.5	-	1.0	9/28/11	**3,359**	79
LI-LH1-SB003	APISSB0402	0.0	-	0.5	9/28/11	**2,198**	50
LI-LH1-SB003	APISSB0403	0.5	-	1.0	9/28/11	**2,573**	53
LI-LH1-SB004	APISSB0404	0.0	-	0.5	9/28/11	**811**	22
LI-LH1-SB004	APISSB0405	0.5	-	1.0	9/28/11	**585**	17
LI-LH1-SB005	APISSB0406	0.0	-	0.5	9/28/11	**3,030**	64
LI-LH1-SB005	APISSB0407	0.5	-	1.0	9/28/11	**1,213**	30
LI-LH1-SB006	APISSB0432	0.0	-	0.5	9/28/11	**345**	13
LI-LH1-SB006	APISSB0433	0.5	-	1.0	9/28/11	111	7
LI-LH1-SB007	APISSB0434	0.0	-	0.5	9/28/11	156	8

Table B-5. Long Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)			Date Collected	Lead (mg/kg)	+/-
LI-LH1-SB007	APISSB0435	0.5	-	1.0	9/28/11	17	4
LI-LH1-SB008	APISSB0436	0.0	-	0.5	9/28/11	**417**	14
LI-LH1-SB008	APISSB0437	0.5	-	1.0	9/28/11	16	4
LI-LH1-SB009	APISSB0438	0.0	-	0.5	9/28/11	236	11
LI-LH1-SB009	APISSB0439	0.5	-	1.0	9/28/11	Non-detect	13
LI-LH1-SB010	APISSB0466	0.0	-	0.5	9/28/11	233	11
LI-LH1-SB011	APISSB0468	0.0	-	0.5	9/28/11	126	8
LI-LH1-SB012	APISSB0467	0.0	-	0.5	9/28/11	**384**	14
LI-LH1-SB013	APISSB0500	0.0	-	0.5	10/1/11	211	10
LI-LH2-SB001	APISSB0510	0.0	-	0.5	10/1/11	Non-detect	12
LI-LH2-SB001	APISSB0511	0.5	-	1.0	10/1/11	Non-detect	12
LI-LH2-SB002	APISSB0512	0.0	-	0.5	10/1/11	Non-detect	12
LI-LH2-SB002	APISSB0513	0.5	-	1.0	10/1/11	Non-detect	11
LI-LH2-SB003	APISSB0514	0.0	-	0.5	10/1/11	Non-detect	11
LI-LH2-SB003	APISSB0515	0.5	-	1.0	10/1/11	15	4
LI-LH2-SB004	APISSB0516	0.0	-	0.5	10/1/11	15	4
LI-LH2-SB004	APISSB0517	0.5	-	1.0	10/1/11	40	5
LI-LH2-SB005	APISSB0518	0.0	-	0.5	10/1/11	Non-detect	12
LI-LH2-SB005	APISSB0519	0.5	-	1.0	10/1/11	Non-detect	11
LI-LH2-SB006	APISSB0520	0.0	-	0.5	10/1/11	16	4
LI-LH2-SB006	APISSB0521	0.5	-	1.0	10/1/11	Non-detect	11
LI-LH2-SB007	APISSB0522	0.0	-	0.5	10/1/11	14	4
LI-LH2-SB007	APISSB0523	0.5	-	1.0	10/1/11	19	4
LI-LH2-SB008	APISSB0524	0.0	-	0.5	10/1/11	Non-detect	12
LI-LH2-SB008	APISSB0525	0.5	-	1.0	10/1/11	Non-detect	11
LI-LH2-SB009	APISSB0526	0.0	-	0.5	10/1/11	Non-detect	11
LI-LH2-SB009	APISSB0527	0.5	-	1.0	10/1/11	32	5
LI-LH2-SB010	APISSB0534	0.0	-	0.5	10/1/11	Non-detect	11
LI-LH2-SB010	APISSB0535	0.5	-	1.0	10/1/11	Non-detect	11
LI-LH2-SB011	APISSB0536	0.0	-	0.5	10/1/11	Non-detect	12
LI-LH2-SB011	APISSB0537	0.5	-	1.0	10/1/11	Non-detect	11
LI-LH3-SB001	APISSB0528	0.0	-	0.5	10/1/11	Non-detect	11
LI-LH3-SB001	APISSB0529	0.5	-	1.0	10/1/11	Non-detect	11
LI-LH3-SB002	APISSB0530	0.0	-	0.5	10/1/11	18	4
LI-LH3-SB002	APISSB0531	0.5	-	1.0	10/1/11	Non-detect	11
LI-LH3-SB003	APISSB0532	0.0	-	0.5	10/1/11	Non-detect	11
LI-LH3-SB003	APISSB0533	0.5	-	1.0	10/1/11	Non-detect	11
LI-OS1-SB001	APISSB0472	0.0	-	0.5	9/28/11	**688**	19
LI-OS1-SB001	APISSB0473	0.5	-	1.0	9/28/11	95	7
LI-OS1-SB002	APISSB0474	0.0	-	0.5	9/28/11	**487**	15
LI-OS1-SB002	APISSB0475	0.5	-	1.0	9/28/11	74	6
LI-OS1-SB003	APISSB0476	0.0	-	0.5	9/28/11	**1,686**	37
LI-OS1-SB003	APISSB0477	0.5	-	1.0	9/28/11	103	7
LI-OS1-SB004	APISSB0478	0.0	-	0.5	9/28/11	**715**	20
LI-OS1-SB004	APISSB0479	0.5	-	1.0	9/28/11	48	5
LI-OS1-SB005	APISSB0502	0.0	-	0.5	10/1/11	**262**	11
LI-OS1-SB006	APISSB0503	0.0	-	0.5	10/1/11	166	9
LI-OS1-SB007	APISSB0504	0.0	-	0.5	10/1/11	**392**	13

Table B-5. Long Island XRF Results (Continued)

Station	Sample ID	Depth (ft bgs)			Date Collected	Lead (mg/kg)	+/-
LI-OS1-SB008	APISSB0505	0.0	-	0.5	10/1/11	**322**	12
LI-OS1-SB009	APISSB0538	0.0	-	0.5	10/1/11	143	8
LI-OS1-SB010	APISSB0539	0.0	-	0.5	10/1/11	125	7
LI-OS1-SB011	APISSB0540	0.0	-	0.5	10/1/11	54	5
LI-SH1-SB001	APISSB0675	0.0	-	0.5	6/13/12	106.4	1.9
LI-SH1-SB001	APISSB0676	0.5	-	1.0	6/13/12	97.2	1.7
LI-SH1-SB002	APISSB0677	0.0	-	0.5	6/13/12	**272**	3
LI-SH1-SB002	APISSB0678	0.5	-	1.0	6/13/12	**572**	4
LI-SH1-SB003	APISSB0679	0.0	-	0.5	6/13/12	**253**	3
LI-SH1-SB003	APISSB0680	0.5	-	1.0	6/13/12	98.5	1.7
LI-SH1-SB004	APISSB0681	0.0	-	0.5	6/13/12	78.7	1.6
LI-SH1-SB004	APISSB0682	0.5	-	1.0	6/13/12	48.4	1.3
LI-SH1-SB005	APISSB0683	0.0	-	0.5	6/13/12	27.7	1.2
LI-SH1-SB005	APISSB0684	0.5	-	1.0	6/13/12	20.7	1.1
LI-SH1-SB006	APISSB0685	0.0	-	0.5	6/13/12	17.5	1
LI-SH1-SB006	APISSB0686	0.5	-	1.0	6/13/12	19.9	1
LI-SH1-SB007	APISSB0687	0.0	-	0.5	6/13/12	135	1.9
LI-SH1-SB007	APISSB0688	0.5	-	1.0	6/13/12	68.1	1.5
LI-SH1-SB008	APISSB0689	0.0	-	0.5	6/13/12	58.2	1.4
LI-SH1-SB008	APISSB0690	0.5	-	1.0	6/13/12	10.1	0.9
LI-SH1-SB009	APISSB0691	0.0	-	0.5	6/13/12	103.7	1.8
LI-SH1-SB009	APISSB0692	0.5	-	1.0	6/13/12	6.9	0.9
LI-SH1-SB010	APISSB0806	0.0	-	0.5	6/15/12	**596**	4
LI-SH1-SB010	APISSB0807	0.5	-	1.0	6/15/12	101.4	1.7
LI-SH1-SB011	APISSB0803	0.0	-	0.5	6/15/12	**288**	3
LI-SH1-SB011	APISSB0804	0.5	-	1.0	6/15/12	223	3
LI-SH1-SB011	APISSB0805	1.0	-	1.5	6/15/12	163	2
LI-SH1-SB012	APISSB0808	0.0	-	0.5	6/15/12	64.6	1.5
LI-SH1-SB012	APISSB0809	0.5	-	1.0	6/15/12	**265**	3

Note:
Bolded value exceeds Wisconsin Department of Natural Resources Cleanup Standard of 250 mg/kg.
bgs = below ground surface
XRF = X-Ray Fluorescence

APPENDIX E

ESTIMATED CAPITAL COST SUMMARIES

APPENDIX E

Cost Estimate for Engineering Evaluation/Cost Analysis[1]

Apostle Islands National Lakeshore

Alternative	Task	Quantity	Unit	Unit Price	Cost	Comments
No Action Alternative						
No Action Alternative	**All Project Sites**					
	Five Year Reviews, NPS Labor	6	Each	$16,720	$100,320	
	Equipment Costs (NPS Boat Use for Site Visits)	6	Each	$2,650	$15,900	
	Publication and Reproduction Costs	6	Each	$800	$4,800	
	SUBTOTAL COST			$20,170	$121,020	
	ESTIMATED PRESENT VALUE COST				**$88,187**	Assumes present value of 30 years at a 1.9% real discount rate pe Appendix C of OMB Circular A-94.
Institutional Controls Alternative						
Institutional Controls Alternative	**Michigan Island**					
	Five Year Reviews, NPS Labor	6	Each	$14,520	$87,120	
	Equipment Costs (NPS Boat Use for Site Visits)	6	Each	$500	$3,000	
	Publication and Reproduction Costs	6	Each	$800	$4,800	
	SUBTOTAL COST			$15,820	$94,920	Assumes present value of 30 years at a 1.9% real discount rate pe
	PRESENT VALUE SUBTOTAL COST				$69,168	Appendix C of OMB Circular A-94.
	Superintendent's Closure	1	Each	$8,200	$8,200	
	Boundary Surveys	1	Each	$4,000	$4,000	
	Fencing	474	Feet	$40.00	$18,960	
	ESTIMATED PRESENT VALUE COST				**$100,328**	
	Outer Island					
	Five Year Reviews, NPS Labor	6	Each	$14,520	$87,120	
	Equipment Costs (NPS Boat Use for Site Visits)	6	Each	$750	$4,500	
	Publication and Reproduction Costs	6	Each	$800	$4,800	
	SUBTOTAL COST			$16,070	$96,420	Assumes present value of 30 years at a 1.9% real discount rate per
	PRESENT VALUE SUBTOTAL COST				$70,261	Appendix C of OMB Circular A-94.
	Superintendent's Closure	1	Each	$8,200	$8,200	
	Boundary Surveys	1	Each	$4,000	$4,000	
	Fencing	314	Feet	$40.00	$12,560	
	ESTIMATED PRESENT VALUE COST				**$95,021**	
	Raspberry Island					
	Five Year Reviews, NPS Labor	6	Each	$14,520	$87,120	
	Equipment Costs (NPS Boat Use for Site Visits)	6	Each	$500	$3,000	
	Publication and Reproduction Costs	6	Each	$800	$4,800	
	SUBTOTAL COST			$15,820	$94,920	Assumes present value of 30 years at a 1.9% real discount rate per
	PRESENT VALUE SUBTOTAL COST				$69,168	Appendix C of OMB Circular A-94.
	Superintendent's Closure	1	Each	$8,200	$8,200	
	Boundary Surveys	1	Each	$4,000	$4,000	
	Fencing	689	Feet	$40.00	$27,560	
	ESTIMATED PRESENT VALUE COST				**$108,928**	
	Devils Island					
	Five Year Reviews, NPS Labor	6	Each	$14,520	$87,120	
	Equipment Costs (NPS Boat Use for Site Visits)	6	Each	$500	$3,000	
	Publication and Reproduction Costs	6	Each	$800	$4,800	
	SUBTOTAL COST			$15,820	$94,920	Assumes present value of 30 years at a 1.9% real discount rate per
	PRESENT VALUE SUBTOTAL COST				$69,168	Appendix C of OMB Circular A-94.
	Superintendent's Closure	1	Each	$8,200	$8,200	
	Boundary Surveys	1	Each	$4,000	$4,000	
	Fencing	1,176	Feet	$40.00	$47,040	
	ESTIMATED PRESENT VALUE COST				**$128,408**	
	Long Island					
	Five Year Reviews, NPS Labor	6	Each	$14,520	$87,120	
	Equipment Costs (NPS Boat Use for Site Visits)	6	Each	$400	$2,400	
	Publication and Reproduction Costs	6	Each	$800	$4,800	
	SUBTOTAL COST			$15,720	$94,320	Assumes present value of 30 years at a 1.9% real discount rate per
	PRESENT VALUE SUBTOTAL COST				$68,731	Appendix C of OMB Circular A-94.
	Superintendent's Closure	1	Each	$8,200	$8,200	
	Boundary Surveys	1	Each	$4,000	$4,000	
	Fencing	970	Feet	$40.00	$38,800	
	ESTIMATED PRESENT VALUE COST				**$119,731**	
	TOTAL ESTIMATED PRESENT VALUE COST				**$552,414**	

APPENDIX E
Cost Estimate for Engineering Evaluation/Cost Analysis[1]
Apostle Islands National Lakeshore

Task	Quantity	Unit	Unit Price	Cost	Comments
Excavation and Off-Site Disposal Alternative					
Michigan Island					
NPS Project Administration	1	Lump Sum	$24,000	$24,000	Estimate pending input from NPS; Assumes 8 hours/week over 20 weeks
Superintendent's Closure	1	Each	$8,200	$8,200	Limiting volunteers to ages 7 and above
NPS Field Oversight	1	Lump Sum	$41,100	$41,100	Estimate pending input from NPS; Assumes 5 weeks oversight
NPS Archaeological Surveys and Archaeologist Oversight	1	Lump Sum	$35,080	$35,080	Estimate pending input from NPS; Assumes 15 field days, 2 staff for initial week
Design, Sec 7, SMP, FSP, Coordination, and Project Admin	1	Lump Sum	$39,066	$39,066	Includes required planning documents and specification development
Walkovers, Contracting Support, and Waste Characterization	1	Lump Sum	$29,159	$29,159	Pre-bid walkover and waste characterization sampling
Field Oversight, Field Screening, and Confirmation Sampling	1	Lump Sum	$70,072	$70,072	Assumes 1-person for full time oversight for 5 weeks, equipment, and sampling
Non-Invasive Utility and Underground Obstruction Locating	1	Lump Sum	$8,650	$8,650	Ground penetrating radar and pipe tracing, no separate mobilizations
Work Crew and Equipment Transport, Per Diem, Winch/Cable	1	Lump Sum	$25,000	$25,000	
Soil Excavation, Reagent, Stabilization, Packaging, Handling	1	Lump Sum	$38,808	$38,808	Assumes on-island stabilization to render soils non-hazardous
Contaminated Soil Loading, Marine Transport, and Unloading	1	Lump Sum	$13,067	$13,067	Assumes 112 in-place cubic yards
Contaminated Soil Land Transport and Landfill Disposal	1	Lump Sum	$13,566	$13,566	Assumes non-hazardous disposal, 1.5 tons per in-place cubic yard
Backfill Sand and Topsoil/Sphagnum Moss Marine Transport	1	Lump Sum	$21,000	$21,000	Includes loading and unloading
Backfill Supply, Handling, and Placement	1	Lump Sum	$13,067	$13,067	
NPS Revegetation	1	Lump Sum	$58,225	$58,225	Estimate pending input from NPS; Assumes 15 field days, 3 personnel per trip
Removal Action Report/Case Closure Requests	1	Lump Sum	$22,225	$22,225	
ESTIMATED COST				**$460,284**	
Outer Island					
NPS Project Administration	1	Lump Sum	$24,000	$24,000	Estimate pending input from NPS; Assumes 8 hours/week over 20 weeks
Superintendent's Closure	1	Each	$8,200	$8,200	Limiting volunteers to ages 7 and above
NPS Field Oversight	1	Lump Sum	$24,660	$24,660	Estimate pending input from NPS; Assumes 3 weeks oversight
NPS Archaeological Surveys and Archaeologist Oversight	1	Lump Sum	$35,080	$35,080	Estimate pending input from NPS; Assumes 15 field days, 2 staff for initial week
Design, Sec 7, SMP, FSP, Coordination, and Project Admin.	1	Lump Sum	$39,066	$39,066	Includes required planning documents and specification development
Walkovers, Contracting Support, and Waste Characterization	1	Lump Sum	$29,159	$29,159	Pre-bid walkover and waste characterization sampling
Field Oversight, Field Screening, and Confirmation Sampling	1	Lump Sum	$46,353	$46,353	Assumes 1-person for full time oversight for 18 weeks, equipment, and sampling
Non-Invasive Utility and Underground Obstruction Locating	1	Lump Sum	$8,650	$8,650	Ground penetrating radar and pipe tracing, no separate mobilizations
Work Crew and Equipment Transport, Per Diem, Winch/Cable	1	Lump Sum	$30,000	$30,000	
Soil Excavation, Reagent, Stabilization, Packaging, Handling	1	Lump Sum	$12,402	$12,402	Assumes on-island stabilization to render soils non-hazardous
Contaminated Soil Loading, Marine Transport, and Unloading	1	Lump Sum	$4,243	$4,243	Assumes 33 in-place cubic yards
Contaminated Soil Land Transport and Landfill Disposal	1	Lump Sum	$3,997	$3,997	Assumes non-hazardous disposal, 1.5 tons per in-place cubic yard
Backfill Sand and Topsoil/Sphagnum Moss Marine Transport	1	Lump Sum	$6,482	$6,482	Includes loading and unloading
Backfill Supply, Handling, and Placement	1	Lump Sum	$3,771	$3,771	
NPS Revegetation	1	Lump Sum	$22,075	$22,075	Estimate pending input from NPS; Assumes 5 field days, 3 personnel per trip
Removal Action Report/Case Closure Requests	1	Lump Sum	$22,225	$22,225	
ESTIMATED COST				**$320,364**	
Raspberry Island					
NPS Project Administration	1	Lump Sum	$24,000	$24,000	Estimate pending input from NPS; Assumes 8 hours/week over 20 weeks
Superintendent's Closure	1	Each	$8,200	$8,200	Limiting volunteers to ages 7 and above
NPS Field Oversight	1	Lump Sum	$24,660	$24,660	Estimate pending input from NPS; Assumes 3 weeks oversight
NPS Archaeological Surveys and Archaeologist Oversight	1	Lump Sum	$35,080	$35,080	Estimate pending input from NPS; Assumes 15 field days, 2 staff for initial week
Design, Sec 7, SMP, FSP, Coordination, and Project Admin.	1	Lump Sum	$39,066	$39,066	Includes required planning documents and specification development
Walkovers, Contracting Support, and Waste Characterization	1	Lump Sum	$29,159	$29,159	Pre-bid walkover and waste characterization sampling
Field Oversight, Field Screening, and Confirmation Sampling	1	Lump Sum	$46,402	$46,402	Assumes 1-person for full time oversight for 18 weeks, equipment, and sampling
Non-Invasive Utility and Underground Obstruction Locating	1	Lump Sum	$8,650	$8,650	Ground penetrating radar and pipe tracing, no separate mobilizations
Work Crew and Equipment Transport, Per Diem, Winch/Cable	1	Lump Sum	$27,500	$27,500	
Soil Excavation, Reagent, Stabilization, Packaging, Handling	1	Lump Sum	$24,786	$24,786	Assumes on-island stabilization to render soils non-hazardous
Contaminated Soil Loading, Marine Transport, and Unloading	1	Lump Sum	$8,769	$8,769	Assumes 76 in-place cubic yards
Contaminated Soil Land Transport and Landfill Disposal	1	Lump Sum	$9,206	$9,206	Assumes non-hazardous disposal, 1.5 tons per in-place cubic yard
Backfill Sand and Topsoil/Sphagnum Moss Marine Transport	1	Lump Sum	$16,077	$16,077	Includes loading and unloading
Backfill Supply, Handling, and Placement	1	Lump Sum	$8,769	$8,769	
NPS Revegetation	1	Lump Sum	$22,075	$22,075	Estimate pending input from NPS; Assumes 5 field days, 3 personnel per trip
Removal Action Report/Case Closure Requests	1	Lump Sum	$22,225	$22,225	
ESTIMATED COST				**$354,624**	
Devils Island					
NPS Project Administration	1	Lump Sum	$24,000	$24,000	Estimate pending input from NPS; Assumes 8 hours/week over 20 weeks
Superintendent's Closure	1	Each	$8,200	$8,200	Limiting volunteers to ages 7 and above
NPS Field Oversight	1	Lump Sum	$32,880	$32,880	Estimate pending input from NPS; Assumes 4 weeks oversight
NPS Archaeological Surveys and Archaeologist Oversight	1	Lump Sum	$35,080	$35,080	Estimate pending input from NPS; Assumes 15 field days, 2 staff for initial week
Design, Sec 7, SMP, FSP, Coordination, and Project Admin.	1	Lump Sum	$39,066	$39,066	Includes required planning documents and specification development
Walkovers, Contracting Support, and Waste Characterization	1	Lump Sum	$29,159	$29,159	Pre-bid walkover and waste characterization sampling
Field Oversight, Field Screening, and Confirmation Sampling	1	Lump Sum	$60,528	$60,528	Assumes 1-person for full time oversight for 18 weeks, equipment, and sampling
Non-Invasive Utility and Underground Obstruction Locating	1	Lump Sum	$8,650	$8,650	Ground penetrating radar and pipe tracing, no separate mobilizations
Work Crew and Equipment Transport, Per Diem, Equipment	1	Lump Sum	$25,000	$25,000	
Soil Excavation, Reagent, Stabilization, Packaging, Handling	1	Lump Sum	$152,748	$152,748	Assumes on-island stabilization to render soils non-hazardous
Contaminated Soil Loading, Marine Transport, and Unloading	1	Lump Sum	$32,608	$32,608	Assumes 323 in-place cubic yards
Contaminated Soil Land Transport and Landfill Disposal	1	Lump Sum	$39,123	$39,123	Assumes non-hazardous disposal, 1.5 tons per in-place cubic yard
Backfill Sand and Topsoil/Sphagnum Moss Marine Transport	1	Lump Sum	$53,833	$53,833	Includes loading and unloading
Backfill Supply, Handling, and Placement	1	Lump Sum	$12,305	$12,305	
NPS Revegetation	1	Lump Sum	$58,225	$58,225	Estimate pending input from NPS; Assumes 15 field days, 3 personnel per trip
Removal Action Report/Case Closure Requests	1	Lump Sum	$22,225	$22,225	
ESTIMATED COST				**$633,630**	
Long Island					
NPS Project Administration	1	Lump Sum	$24,000	$24,000	Estimate pending input from NPS; Assumes 8 hours/week over 20 weeks
Superintendent's Closure	1	Each	$8,200	$8,200	Limiting volunteers to ages 7 and above
NPS Field Oversight	1	Lump Sum	$24,660	$24,660	Estimate pending input from NPS; Assumes 3 weeks oversight
NPS Archaeological Surveys and Archaeologist Oversight	1	Lump Sum	$35,080	$35,080	Estimate pending input from NPS; Assumes 15 field days, 2 staff for initial week
Design, Sec 7, SMP, FSP, Coordination, and Project Admin.	1	Lump Sum	$39,066	$39,066	Includes required planning documents and specification development
Walkovers, Contracting Support, and Waste Characterization	1	Lump Sum	$29,159	$29,159	Pre-bid walkover and waste characterization sampling
Field Oversight, Field Screening, and Confirmation Sampling	1	Lump Sum	$39,020	$39,020	Assumes 1-person for full time oversight for 18 weeks, equipment, and sampling
Non-Invasive Utility and Underground Obstruction Locating	1	Lump Sum	$8,650	$8,650	Ground penetrating radar and pipe tracing, no separate mobilizations
Work Crew and Equipment Transport, Per Diem, Equipment	1	Lump Sum	$23,000	$23,000	
Soil Excavation, Reagent, Stabilization, Packaging, Handling	1	Lump Sum	$155,466	$155,466	Assumes on-island stabilization to render soils non-hazardous
Contaminated Soil Loading, Marine Transport, and Unloading	1	Lump Sum	$25,769	$25,769	Assumes 318 in-place cubic yards
Contaminated Soil Land Transport and Landfill Disposal	1	Lump Sum	$38,518	$38,518	Assumes non-hazardous disposal, 1.5 tons per in-place cubic yard
Backfill Sand and Topsoil/Sphagnum Moss Marine Transport	1	Lump Sum	$19,738	$19,738	Includes loading and unloading
Backfill Supply, Handling, and Placement	1	Lump Sum	$16,997	$16,997	
NPS Revegetation	1	Lump Sum	$58,225	$58,225	Estimate pending input from NPS; Assumes 15 field days, 3 personnel per trip
Removal Action Report/Case Closure Requests	1	Lump Sum	$22,225	$22,225	
ESTIMATED COST				**$567,772**	
TOTAL ESTIMATED COST				**$2,336,674**	

Excavation and Off-Site Disposal Alternative

Notes:
1 = Cost estimate subject to change based on further assessment, waste characterization, regulatory interpretation, preliminary and final design considerations, volume/unit pricing estimate refinement, and encountered field conditions.
Cost estimates are assumed to be +30%/-20%.
NPS = National Park Service
OMB = Office Management and Budget