REMEDIAL ACTION CONTRACT 2 FOR REMEDIAL, ENFORCEMENT OVERSIGHT, AND NON-TIME CRITICAL REMOVAL ACTIVITIES IN REGION 5

REMEDIAL INVESTIGATION REPORT
FINAL

US SMELTER AND LEAD REFINERY (USS LEAD)
SUPERFUND SITE
LAKE COUNTY, INDIANA

Prepared for
United States Environmental Protection Agency
Region 5
77 West Jackson Boulevard
Chicago, IL 60604

Work Assignment No:	No. 154-RICO-053J
Contract No:	EP-S5-06-02
Date Submitted:	June 2012
Prepared by:	SulTRAC
SulTRAC Project Manager:	Rik Lantz
Telephone No:	(312) 443-0571
EPA Work Assignment Manager:	Michael Berkoff
Telephone No:	(312) 353-8983

TABLE OF CONTENTS

Section **Page**

TABLE OF CONTENTS (CONTINUED)

Section **Page**

TABLE OF CONTENTS (CONTINUED)

Section **Page**

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF TABLES

APPENDICES

ACRONYMS AND ABBREVIATIONS

µg/kg	Microgram per kilogram
µg/L	Microgram per liter
ALM	Adult Lead Model
AOC	Administrative Order of Consent **or** Area of concern
ARCO	Atlantic Richfield Company
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	Below ground surface
BTV	Background threshold value
CAMU	Corrective action management unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
cm/sec	Centimeters per second
COC	Chain of custody
COI	Constituent of interest
COPC	Chemical of potential concern
CSM	Conceptual site model
CTE	Central Tendency Exposure
DAI	DAI Environmental, Inc.
DCT	Default Closure Tables
DVR	Data Validation Report
EMPA	Electron microprobe (speciation) analysis
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
EQM	Environmental Quality Management
ERRS	Emergency Rapid Response Services
ESAT	Environmental Services Assistance Team
FIELDS	Field Environmental Decision Support
f_{oc}	Fraction of organic carbon (unitless)
FS	Feasibility Study
FSP	Field Sampling Plan
g/cm^3	Gram per cubic centimeter
Handbook	EPA Superfund Lead-Contaminated Residential Sites Handbook
HHRA	Human Health Risk Assessment
HHRAP	Human Health Risk Assessment Protocol
HI	Howard Industries **or** Hazard index
HRS	Hazard Ranking System

ACRONYMS AND ABBREVIATIONS (CONTINUED)

ID	Identification number
IDEM	Indiana Department of Environmental Management
IDW	Investigation-derived waste
IEUBK	Integrated Exposure Uptake Biokinetic Model
IHBRR	Indiana Harbor Belt Railroad
ISBH	Indiana State Board of Health
ISCST3	Industrial Source Complex-Short Term 3
ISGS	Illinois State Geological Survey
K_d	Distribution coefficient (mL/g)
K_H	Henry's Law Constant
K_{ow}	Octanol-water coefficient (mL/g)
LAW	Law Engineering & Environmental Services
MassDEP	Massachusetts Department of Environmental Protection
mg/kg	Milligram per kilogram
mg/kg-day	Milligram(s) per kilogram [of body weight] per day
mg/L	Milligram per liter
MRFI	Modified RCRA Facility Investigation
MSA	Metropolitan statistical area
msl	Mean sea level
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	National Parks Service
NRCS	Natural Resources Conservation Service
NTCHS	National Technical Committee for Hydric Soils
NTCRA	Non Time-Critical Removal Action
OERR	Office of Emergency and Remedial Response
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PEF	Particulate emission factor
PRG	Preliminary remediation goal
PRP	Potential responsible party
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
RAC 2	Remedial Action Contract No. EP-S5-06-02
RAGS	Risk Assessment Guidance for Superfund
RAL	Remedial Action Level

ACRONYMS AND ABBREVIATIONS (CONTINUED)

RCI	Resource Consultants, Inc.
RCRA	Resource Conservation and Recovery Act
RI	Remedial investigation
RI/FS	Remedial investigation/feasibility study
RISC	Risk Integrated System of Closure
RL	Reporting limit
RME	Reasonable Maximum Exposure
RPD	Relative Percent Difference
RSL	Regional Screening Levels
SAP	Sampling and Analysis Plan
SDG	Sample delivery group
SSL	Site Screening Level
START	Superfund Technical Emergency and Rapid Response Team
STN	STN Environmental JV
SVOC	Semi-volatile organic compound
TACO	Tiered Approach to Corrective Action Objectives
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TCRA	Time-Critical Removal Action
TechLaw	TechLaw, Inc.
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USS Lead Site	U.S. Smelter and Lead Refinery Superfund Site
UTL	Upper Tolerance Limit
VOC	Volatile organic compound
WA 54	Work Assignment No. 054-RICO-053J
WA 154	Work Assignment No. 154-RICO-053J
WAM	Work Assignment Manager
Weston	Weston Solutions, Inc.
WRS	Wilcoxon Rank Sum
XRF	X-ray fluorescence

1.0 INTRODUCTION

This remedial investigation (RI) report presents and analyzes the data collected during a two-phased RI conducted at the U.S. Smelter and Lead Refinery (USS Lead) Superfund Site located in Lake County, Indiana, for U.S. Environmental Protection Agency (EPA) Region 5 under Work Assignment (WA) Nos. 054-RICO-053J (WA 54) and 154-RICO-053J (WA 154), Remedial Action Contract No. EP-S5-06-02 (RAC 2). The purpose of WA 54 and WA 154 is to conduct a remedial investigation/feasibility study (RI/FS) at the USS Lead Site to enable EPA to select a remedy that eliminates, reduces, or controls risks to human health and the environment.

The USS Lead Superfund Site consists of the former industrial facility located at 5300 Kennedy Avenue (hereafter referred to as OU2) and the residential area north of OU2 (hereafter referred to as OU1). OU1 is bounded by East Chicago Avenue on the north, East 151st Street/149th Place on the south, the Indiana Harbor Canal on the west, and Parrish Avenue on the east (Figure 1-1). This RI report documents work conducted in OU1 during December 2009 and August 2010, constituting the initial phase of the RI for the USS Lead Site, and summarizes previous work done by others. Contamination at OU2 will be addressed as part of a separate investigation.

Specific goals of this RI are as follows:

- Investigate the lateral and vertical extent of lead-contaminated soils at residences, schools, parks, vacant lots, and other locations where children may come into contact with contaminated soil within the USS Lead Site
- Investigate whether other contaminants may be associated with lead-contaminated soils at the USS Lead Site
- Evaluate whether the lead-contaminated soil at the USS Lead Site requires disposal as characteristic hazardous waste
- Evaluate risks associated with contaminated soils
- Provide a good basis for estimating the number of homes within OU1 that will require remediation

The wetlands surrounding the former USS Lead Facility are part of OU2 and were not investigated during this phase of the RI because the wetlands are considered part of the former facility, which will be addressed under a separate WA. Furthermore, groundwater at the USS Lead Site will be considered as part of the OU2 study and has not been evaluated as part of this RI. Groundwater data collected as part of previous investigations indicate that lead was either below reporting limits or was detected at concentrations below the Indiana Department of Environmental Management (IDEM) Risk Integrated System of Closure (RISC) Tier 1 standards for groundwater (Geochemical Solutions 2004). The detection limit referenced in the Modified RCRA Facility Investigation (MRFI) report dated March 2004 was 2.9 micrograms per liter (µg/L) (Geochemical Solutions 2004); the IDEM RISC standard for lead in groundwater is 15 µg/L. It is reasonable to conclude that, if there are no significant impacts to groundwater in OU2, where the concentrations of lead in soil range up to 20,000 milligrams per kilogram (mg/kg), there will be no significant impacts to groundwater in OU1, where soil-lead concentrations are not as high (see Section 5.0 below).

1.1 PURPOSE OF REPORT

The objective of the RI was to investigate and characterize the nature and extent of contamination and the risk that may be posed to human health and the environment by lead and any other contaminants of concern in soil at the USS Lead Site. The analyte list developed for the investigation was based on previous EPA and IDEM investigations, as well as the Superfund Lead-Contaminated Residential Sites Handbook (EPA 2003c).

1.2 REPORT ORGANIZATION

This report consists of the nine sections summarized below. Tables A-1 through A-9 in Appendix A present the full analytical data set.

- Section 1.0, Introduction: This section includes an introduction to the site, discusses the purpose of the investigation, and describes the site history and previous investigations.
- Section 2.0, Regulatory Framework: This section describes the regulatory framework for residential lead sites.
- Section 3.0, Remedial Investigation Field Activities: This section discusses the field activities carried out during Phase I and Phase II of the project.
- Section 4.0, Physical Characteristics: This section presents the physical characteristics of the site including general setting, surface features, weather, soils, geology, hydrogeology, demography and land use, and ecology.
- Section 5.0, Nature and Extent of Contamination: This section provides a description of the nature and extent of contamination.
- Section 6.0, Contaminant Fate and Transport: This section presents expected contaminant fate and transport based on physical and chemical properties, chemical persistence, and migration routes.
- Section 7.0, Human Health Risk Assessment: This section presents the results of the human health risk assessment.
- Section 8.0, Summary and Conclusions: This section provides the summary and conclusions of this RI report.
- Section 9.0, References: This section lists the references used to prepare this report.

1.3 SITE BACKGROUND

The site description, site history, previous investigations, and potential source areas are discussed below.

1.3.1 Site Description

The USS Lead Site is located approximately 18 miles southeast of Chicago, Illinois, in East Chicago, Indiana (Figure 1-1). East Chicago is surrounded by one of the most heavily industrialized areas in the U.S., including steel mills, oil refineries, heavy manufacturing, chemical processing plants, and heavy rail. OU1 is primarily low-income residential with commercial and light industrial areas nearby. East Chicago's population in July 2009 was 29,900, of which 51.6% were Hispanic, 40.3% were African-American, and 7.2% were White, non-Hispanic (City-Data 2011). The East Chicago median household income is $28,289, versus the Indiana median household income of $45,424 (City-Data 2011). The March 2011 unemployment rate for East Chicago was 12.7%, compared to Indiana's March 2011 unemployment rate of 8.8% (City-Data 2011). The average annual precipitation in East Chicago between 1961 and 1990 was 36.82 inches (FedStats 2009). A five-year wind-rose plot for the years 1987 to 1991 at a site in Hammond, Indiana (Figure 1-2) indicates that prevailing winds are from the southwest and north at less than 20 mph (EPA 2006). EPA considers East Chicago an environmental justice community, which means it is a community that historically is an under-represented minority and low-income area burdened with significant environmental challenges (EPA 2011b).

United States Geological Survey (USGS) historical aerial photographs from 1939, 1951, 1959, and 2005 show OU2 and OU1 over time (Figure 1-3). Review of these aerial photographs indicates that the majority of the residential neighborhoods within the USS Lead Site, west of Huish Avenue, were built before 1939. Approximately half of the homes east of Huish Avenue were built before 1939. Between 1939 and 1951, approximately 75 to 80 percent of the homes were built and, by 1959, most of the homes east of Huish Avenue were built. Figure 1-3 shows the progression of development within OU1. These photographs also show that the Anaconda Copper Company occupied the area where the Gosch Elementary School and the public housing residential complex immediately south of the school are currently located (the southwest portion of OU1). The Gosch Elementary School and the East Chicago Public Housing complex were built on the former Anaconda Copper Company site after 1959.

The East Chicago area in the vicinity of OU2 has historically supported a variety of industries. In addition to the USS Lead smelting operation, some other industrial operations may have also managed lead and other metals. For example, immediately east of OU2, across Kennedy Avenue, is the former DuPont site (currently leased and operated by W.R. Grace & Co., Grace Davison). One of the processes that historically took place at the DuPont site was the manufacturing of the pesticide lead arsenate (Figure 1-4). Northwest of the USS Lead Site, west of Gladiola Street and north of 151st Street, two smelter operations reportedly managed lead and other metals (Geochemical Solutions 2004). A 1930 Sanborn Fire Insurance Map identifies the operations as Anaconda Lead Products and International Lead Refining Company (referred to in this report as the "former Anaconda facility") (Geochemical Solutions 2004). According to the Sanborn map (Figure 1-5), Anaconda Lead Products was a manufacturer of white lead and zinc oxide, and the International Lead Refining Company was a metal-refining facility. These facilities consisted of a pulverizing mill, white-lead storage areas, a chemical laboratory, a machine shop, a zinc-oxide experimental unit building and plant, a silver refinery, a lead refinery, a baghouse, and other miscellaneous buildings and processing areas. Locations of these possible source facilities are presented in Figure 1-4.

1.3.2 Site History

A graphical representation of the timeline of events at the USS Lead Site is presented as Figure 1-6. USS Lead is a former lead smelter located at 5300 Kennedy Avenue, East Chicago, Indiana. The facility was constructed in the early 1900s by the Delamar Copper Refinery Company to produce copper. In 1920, the property was purchased by U.S. Smelting, Refining, and Mining, and later by USS Lead. At that time, USS Lead operated a primary lead smelter at the facility. An electrolytic process called the "Betts process" was used for refining lead into high-purity lead at the Site. In the Betts process, 400-lb anodes of primary lead bullion were placed in tanks containing cathodes, anodes, and a solution of lead fluosilicate and free hydrofluosilicic acid. During electrolysis, impurities in the primary lead bullion accumulated on the anode and lead was deposited on the cathode. The cathode was then removed, remelted, and treated with compressed air to oxidize and float any remaining impurities, and the purified lead was cast into lead "pigs." The Betts process volatilized metals, including arsenic, during production (RCI 1990).

Between 1972 and 1973, the facility was converted to a secondary lead smelter, which recovered lead from scrap metal and automotive batteries. A 100-ton furnace produced 1-ton lead blocks and smaller 12-lb pigs. The lead blocks and pigs were subsequently remelted and refined to soft lead, antimony lead, and calcium lead. Metal alloys used in the refining process included silver, copper, tin, antimony, and arsenic. All operations at the site were discontinued in 1985. Two primary waste materials were generated as a result of the smelting operations: (1) blast-furnace slag and (2) lead-containing dust emitted from the blast furnace stack. Blast-furnace slag was stockpiled south of the plant building and spread over an adjoining 21 acres of wetlands once per year. The blast-furnace baghouse collected approximately 300 tons of baghouse flue dust per month during maximum operating conditions. Some of the baghouse dust was reintroduced into the furnace for additional lead recovery; however, not all could be recycled without a significant reduction in furnace efficiency. By the late 1970s, approximately 8,000 tons of baghouse dust were stored onsite (RCI 1990).

In 1975 and 1985, OU2 received a National Pollutant Discharge Elimination System (NPDES) permit to discharge furnace cooling water and storm water runoff to the Grand Calumet River. According to IDEM, such discharges exceeded permit levels for several compounds (EPA 2009b). In the 1980s, several state and federal enforcement actions were taken against the company. In September 1985, the Indiana State Board of Health (ISBH) found the USS Lead facility in violation of State law because lead particles were found downwind (to the north and northeast) of the facility (EPA 2009b). All industrial operations at the USS Lead Site ceased in 1985 (EPA 2009b).

On November 18, 1993, EPA and USS Lead entered into an Administrative Order of Consent (AOC) pursuant to Section 3008(h) of the Resource Conservation and Recovery Act (RCRA). The AOC required USS Lead to implement interim measures, including site stabilization and construction of a corrective action management unit (CAMU), and to conduct an MRFI (Geochemical Solutions 2001a). The CAMU covers approximately 10 acres and is surrounded by a subsurface slurry wall. Excavation and construction of the CAMU was conducted in two phases and completed between August and September 2002 (Geochemical Solutions 2004). The baghouse dust and bags were removed from the site pursuant to the IDEM Partial Interim Agreed Order in Cause No. N-296 and were sent offsite for secondary lead recovery. Slag generated from the blast-furnace operations was placed in piles on the southern portion of the property. The cleanup of slag was described in the Interim Stabilization Measures Work Plan prepared by ENTACT and was completed during the third quarter 2002 (Geochemical Solutions 2004).

As part of a RCRA Corrective Action in 2003 and 2006, EPA conducted soil sampling in OU1. In the 2003 EPA RCRA investigation, eighty-three residential properties within the USS Lead Site were sampled and analyzed for lead using a Niton X-ray fluorescence (XRF) instrument in late July and early August 2003. Soils from 43 locations (52 percent) exceeded the 400 mg/kg residential soil screening criterion for lead. In 2006, EPA's Field Environmental Decision Support (FIELDS) team supplemented the work done in 2003, by collecting additional data from 14 properties sampled in 2003 in order to (1) assess whether the uppermost soils (0 to 1-inch below ground surface [bgs]) had elevated lead concentrations relative to deeper soils (1 to 6 inches bgs), (2) compare composite samples to individual samples to assess whether composite samples accurately represented the concentrations in residential yards and parks, and (3) compare lead concentrations in the fine and coarse fractions of sieved samples to evaluate whether lead was preferentially distributed in the fine grain sizes.

On January 22, 2008, EPA approved a time-critical removal action for private residential properties within OU1 due to elevated levels of lead in surface soils identified during investigations conducted from 2002 through 2007 (Weston 2009). EPA identified 15 private properties that contained soil with lead concentrations exceeding the "regulatory removal action level" of 1,200 mg/kg in the top 6 inches of soil (Weston 2009). EPA was able to obtain access agreements to only 13 of the 15 properties. The properties were remediated between June 9 and September 22, 2008, by Weston Solutions, Inc. (Weston) and Environmental Quality Management (EQM) under a Time Critical Removal Action (TCRA). The properties were excavated to a depth of 1 to 2.5 feet bgs. Weston used an XRF instrument to field screen and confirm that excavation was completed to a depth where lead concentrations were below 400 mg/kg. All the properties were backfilled with clean fill and re-sodded by September 25, 2008. A total of 1,838 tons of soil was transported offsite to a landfill facility as special waste (Weston 2009).

The USS Lead Site was evaluated under the Hazard Ranking System (HRS) in September 2008 and was found to have an observed release of lead in the air migration pathway as well as the surface water migration pathway (EPA 2008a). The USS Lead Site was listed as a Superfund site on the National Priorities List (NPL) on April 8, 2009.

1.3.3 Previous Investigations/Activities

Many investigations have been conducted at the USS Lead Site. The following documents summarize the investigations that have been conducted from 1985 to the present. These investigations are discussed below in chronological order. A summary of previous investigations and the specific areas they covered is presented on Figure 1-7.

1985 Inspection Report of Hammond Lead and USS Lead Refining Soil Survey:
The "Inspection Report of Hammond Lead and USS Lead Refining Soil Survey," dated October 15, 1985, was completed by the Environmental Services Division of the Central District Office of EPA, at the request of the Air Management Division of the Central District Office (EPA 1985) (Figure 1-4). The survey concluded that the lead levels in the vicinity of the USS Lead Site were generally higher than those found in the vicinity of Hammond Lead (EPA 1985). The soil survey was performed to assess the impact of the deposition of airborne particulates in the area from the nearby potential industrial lead sources. The facilities listed in the report included Hammond Lead, USS Lead, Federated Metals, and the Amoco Oil Refinery – LTV Steel (EPA 1985). The survey was conducted by EPA; the Indiana Board of Health;

Lake County Air Monitoring; the City of East Chicago, Indiana; and DuPont of East Chicago, Indiana. All samples taken during this soil survey were collected offsite from the facilities in question, in adjacent residential areas. Hammond Lead Products (Hammond) is located south of the Grand Calumet River (south of OU1) at 165th Street and Summer Street in Hammond, Indiana (Figure 1-4), and has been producing lead chemicals since 1930 (Hammond 2005). Federated Metals is a former metal smelting and refining facility located at Indianapolis Boulevard and New York Avenue in Hammond, Indiana, about 3 miles northwest of the USS Lead residential area. Federated Metals encompasses approximately 36 acres and is undergoing remediation through a RCRA corrective action. Amoco Oil Refinery – LTV Steel is located at 129th Street and Indianapolis Boulevard in Hammond, Indiana, about 2 miles northwest of the USS Lead residential area. The former Federated Metals facility and Amoco Oil Refinery are both located crosswind of OU1 (Figure 1-4). The survey presented only sampling procedures and analytical results; it did not provide any conclusions or recommendations.

2001 Site-Wide Sampling and Analysis Report:
Geochemical Solutions prepared the “Site Wide Sampling and Analysis Report,” dated July 24, 2001, in response to a Partial Interim Agreed Order in Cause adopted by IDEM in April 1990 for OU2. At OU2, soil containing elevated concentrations of lead had been removed to the CAMU and the report found that the excavation resulted in soil metals concentrations less than site action levels. This report provided the data for the soil (surface, subsurface, and confirmatory) and surface water remaining at the site after the RCRA corrective action, in order to verify that the site met the Indiana RISC Tier 1 Industrial Closure Levels remediation goals. The analytical results indicated that the remedial activities reduced the contaminants of concern to below the site action levels. The wetland area at the southern portion of the site had soil concentrations above RISC Tier 1 Industrial Closure Levels, but the metals in this area were established as non-mobile, based on the groundwater results for this sampling event. Contaminated soils in the wetland area were not excavated (Geochemical Solutions 2001a).

2001 USS Lead MRFI Addendum Off-Site Sampling and Analysis Report:
Geochemical Solutions prepared the “USS Lead MRFI Addendum Off-Site Sampling and Analysis Report,” dated October 15, 2001, to summarize the activities conducted to investigate the nature and extent of off-site windborne contamination originating from the USS Lead Site (Geochemical Solutions 2001b). The report concluded that the surface-soil lead concentrations decreased with increasing distance from the site, and the highest concentrations of lead were detected east of the site along Kennedy Avenue. There also was evidence of fill material from an “unknown source” in the triangle area (south of OU1 along Huish Drive), the Howard Industries Property, and along Kennedy Avenue due to the increasing

lead concentrations with depth and observation of "slag" material during sampling and excavation activities. A total of 47 surface soil samples (0 to 6-inch depth interval) and 22 depth profile samples (6-inch depth intervals beneath the surface soil samples) were screened with an XRF instrument.

2002 Air Dispersion Modeling and Historical Aerial Photography Review:
TechLaw, Inc. (TechLaw) received technical direction from EPA Region 5 in 2001 to conduct an air dispersion modeling and review of historical aerial photographs in support of the MRFI activities at OU2 and issued a report entitled, "Air Dispersion Modeling and Historical Aerial Photography Review" for the USS Lead Site on April 5, 2002. The report stated that the modeled deposition pattern shows that emissions from the former facility could have contributed to lead in soils to the east, north (residential area), and south (Calumet River) of the facility (TechLaw 2002).The air-dispersion modeling was conducted using EPA's Industrial Source Complex-Short Term 3 (ISCST3) model (TechLaw 2002). The ISCST3 model results were compared to analytical soil data collected from the vicinity of the USS Lead Site (TechLaw 2002), as well as the results of the Law Engineering & Environmental Services (Law) "Draft Independent Assessment of the Impacts of Historical Lead Air Emissions in East Chicago, Indiana," dated November 2000 (Law 2000). Both the TechLaw and Law models considered the main stack and fugitive emissions from the blast furnace charging operations at USS Lead as sources. However, TechLaw also included impacts from three baghouse dust piles, and Law included contributions from Hammond Lead. The maximum impacts and impacts at other locations from the TechLaw modeling were lower than those reported by Law. The air-dispersion modeling conducted by TechLaw correlates with elevated lead concentrations east of the facility and west of Kennedy Avenue (TechLaw 2002).

The report included a review of historical aerial photography, which relied primarily on the aerial photography presented in "Site Analysis, U.S. Smelter and Lead Refinery, Inc., East Chicago, Indiana" (EPA 1992). The review was conducted to evaluate the following: (1) historical site practices and patterns, such as the location of on-site lead sources, and (2) how historical land-use practices may have affected the distribution of lead contamination from OU2 in soils offsite. The review indicated that off-site areas immediately north of OU2, in the industrial area east of Huish Avenue, and on the DuPont property east of OU2, were periodically disturbed. The disturbances may have resulted in re-suspension of air-deposited material, redistribution of contaminants in the soil column, and removal of some contaminated soil from the area (TechLaw 2002).

2003 Report on X-Ray Fluorescence Field Study of Selected Properties in Vicinity of Former USS Lead Refinery Facility, East Chicago, Indiana:

EPA Region 5 issued a report entitled, "Report on X-Ray Fluorescence Field Study of Selected Properties in Vicinity of Former USS Lead Refinery Facility, East Chicago, Indiana," in November 2003 as part of the RCRA Corrective Action work. The report found that over 50 percent of sampled soils exceeded the 400 mg/kg residential soil screening criterion for lead. The report summarized the XRF field data collected by EPA and IDEM to further characterize soils in OU1 north of OU2. Eighty-three residential properties were sampled and analyzed for lead using a Niton XRF instrument in late July and early August 2003. In addition to lead, several other metals were analyzed using XRF; however, only zinc, iron, and zirconium results were reported because the other metals did not meet the >10-sigma criterion necessary for valid results. Soils from 43 locations (52 percent) exceeded the 400-mg/kg residential soil screening criterion for lead. Soils from 29 of the 83 properties were also submitted to the Central Regional Laboratory for chemical analysis. Only the XRF results were presented in the 2003 report.

2004 Off-Site Soil Excavation, Howard Industries (HI Triangle Area):

Based on the off-site sampling results as described in the "MRFI Report Addendum-Off Site Sampling" (Geochemical Solutions 2001b), two off-site areas were identified as areas with elevated lead concentrations in surface soils due to the industrial operations conducted at the USS Lead Facility (OU2). One area was a triangular region located adjacent to the northeast corner of OU2, bounded by East 151st Street to the north, a railroad access road to the east, and the Indiana Harbor Belt Railroad (IHBRR) tracks to the south. The other area was located to the east of OU2, between Kennedy Avenue and the IHBRR tracks. Because the northeast area encompasses two different parcels, the excavation was subdivided further into two areas: a triangular parcel owned by IHBRR (the IHBRR triangle area), immediately adjacent to OU1, and a triangular area owned by Howard Industries (the HI triangle area) (DAI 2004a).

In September 2002, DAI Environmental, Inc. (DAI) collected pre-excavation samples within the HI triangle area to delineate the extent of lead-contaminated surface soils. Excavation of the HI triangle area was conducted on October 24 and 25, 2002, and the excavation depths ranged from 3 inches to 1.5 feet bgs. At the sample locations in the HI triangle area, native dune sand was encountered between 6 and 10 inches bgs. Approximately 1,190 cubic yards of lead-contaminated soil were removed from the HI triangle area and placed in the CAMU on OU1 (DAI 2004a). Post-excavation samples were collected and, although some samples were above the IDEM residential closure limit for lead (400 mg/kg), they were below the IDEM industrial closure limit (1,300 mg/kg). Any fill material encountered was not excavated because it was not related to windborne deposition. The excavation area was backfilled with clay, ¾-inch stone, followed by gravel, then compacted to grade to form a parking lot (DAI 2004a).

2004 Off-Site Soil Excavation, Indiana Harbor Belt Railroad (IHBRR Triangle Area):
As described above, the IHBRR triangle area was one portion of the northeast off-site area in which surface soils contained elevated concentrations of lead. In September 2002, DAI collected pre-excavation samples to delineate the extent of lead-contaminated surface soils within the IHBRR triangle area. Excavation of the IHBRR triangle area was conducted from October 14 through November 3, 2002, and the excavation depths ranged from 6 inches to 2 feet bgs. At the sample locations in the HI triangle area, native dune sand was encountered between 6 inches and 2 feet bgs. In areas where “fill material [was] thin or absent, lead concentrations [were] observed to decrease rapidly with depth, commonly dropping to background concentrations [23.79 mg/kg] below six (6) inches” (DAI 2004b). Approximately 5,776 cubic yards of lead-contaminated soil were removed from the IHBRR triangle area and placed in the CAMU on OU2 (DAI 2004b). Post-excavation samples were collected; six samples were above the IDEM residential closure limit for lead (400 mg/kg) and one sample was above the IDEM industrial closure limit (1,300 mg/kg). The post-excavation soil sample above the IDEM industrial closure limit for lead was located above the Phillips Petroleum pipeline; therefore, the excavation depth was limited to 8 inches. The six samples with lead concentrations above the IDEM residential closure limit were not further excavated due to the presence of fill materials. The excavation area was backfilled with sand and clay, and common grasses were planted for erosion control (DAI 2004b).

2004 Off-Site Soil Excavation Kennedy Avenue (Eastern Off-Site Area):
As described above, the third area of excavation was to the east of OU2 (Eastern Off-Site Area). In September 2002, DAI collected pre-excavation samples to delineate the extent of lead-contaminated surface soils within the Eastern Off-Site Area. Excavation of the Eastern Off-Site Area was conducted from October 3 through 9, 2002, and the excavation depths ranged from 6 inches to over 3 feet bgs. Approximately 2,379 cubic yards of lead-contaminated soil were removed from the Eastern Off-Site Area and placed in the CAMU on OU2 (DAI 2004c). Post-excavation samples were collected and 18 samples exceeded the IDEM residential closure limit for lead and five samples exceeded the IDEM industrial closure limit for lead. These samples were located in areas limited by the presence of fill materials and physical obstructions, such as the Kennedy Avenue right-of-way. The excavation area was backfilled with sand and clay and common grasses were planted for erosion control (DAI 2004c).

2004 On-Site Soil Excavation (Wetlands Area):

Elevated lead concentrations in the wetlands within OU2 were originally discovered during site-wide sampling activities conducted by Law Engineering in 1999 (DAI 2004d). Subsequent sampling in the wetland area confirmed that elevated lead concentrations were concentrated in the upper portion of the soil and root mass (in the upper 12 inches) of the wetlands. To address the elevated lead levels in wetland area soils, the wetland was excavated in 2002 and approximately 9,680 cubic yards of soil were removed (DAI 2004d).

In preparation for the excavation, DAI collected pre-excavation soil samples from August 28 through September 13, 2002, from two discrete intervals: 6-12 inches bgs and 12-18 inches bgs. The 0-6-inch interval was not sampled because it consisted almost entirely of root mass with very little soil (DAI 2004d). Clean sand was placed in the wetland area to create north-south trending peninsulas where the excavator and sampling personnel could travel. Ten parallel peninsulas of sand were extended out into the wetlands to complete the excavation activities. Excavation of the wetland area was conducted from August 19 through September 18, 2002, and the excavation depths ranged from 1 to 3 feet bgs. Approximately 9,680 cubic yards of lead-contaminated soil were removed from the wetland area and placed in the CAMU on OU2 (DAI 2004d). Two hundred twenty-one (221) post-excavation samples were collected; 11 samples exceeded the IDEM industrial closure limit (1,300 mg/kg) for lead. The report states that “a full excavation of the entire wetland exhibiting lead concentrations in excess of 1,300 mg/kg was deemed impractical and would have resulted in a near complete devastation of the wetland environment.” The 11 locations that exceeded the IDEM industrial closure limit were located in areas where mechanical/physical constraints limited excavation, and additional excavation was impossible or threatened destruction of the wetland (DAI 2004d). Upon completion of the excavation, the upper portion of each sand peninsula was removed but the basal portion of each peninsula was left in place at the request of IDEM to create low ridges that that could potentially serve serve as desirable nesting habitat for certain water fowl (DAI 2004d).

2004 Draft Final USS Lead, Modified RCRA Facility Investigation (MRFI) Report:

Geochemical Solutions prepared the “Draft Final USS Lead Modified RCRA Facility Investigation (MRFI) Report,” dated March 1, 2004, for USS Lead. The purpose of the Draft Final MRFI Report was to present the conceptual site model, to describe the current conditions at the site by summarizing past remediation and sampling efforts, and to summarize soil/sediment, fill, surface water, and groundwater data collected to date. The Draft Final MRFI Report stated that most on-site soils that were identified as contaminated had been removed and consolidated in the on-site CAMU. Wetland sediment/soil sampling indicated that contaminated soils were present in the wetlands. However, some of the contaminated soils could not be removed from the wetlands due to physical constraints and were left in place. All other contaminated soils that had been identified were removed from the facility and consolidated in the on-site CAMU. The report stated that "lead migration to groundwater is not likely" at the USS Lead Site and that the lead in soil at the USS Lead Site "does not dissolve or become mobile in groundwater as indicated by the quarterly groundwater sampling." The report concluded that contamination from the USS Lead facility decreased with increasing distance from the site. The report also noted that increasing lead concentrations with depth at several locations suggest that lead-containing slag had been used as fill. Lastly, the report concluded that "groundwater migration flows [do] not appear to represent a significant mechanism for contamination migration" (Geochemical Solutions 2004).

2004 Draft Characterization of Lead and Other Metals in Soil in the Vicinity of the USS Lead Site, East Chicago, Indiana:

TechLaw conducted a study to characterize lead and other metals in the soils within OU1 and OU2 which was presented in the report, "Draft Characterization of Lead and Other Metals in Soil in the Vicinity of the USS Lead Site, East Chicago, Indiana" (TechLaw 2004a). The report concluded that samples from OU2 had lead isotope signatures that differed from the DuPont site samples. TechLaw obtained split samples collected from the above-mentioned July and August 2003 sampling events conducted by the EPA and IDEM, and from the MRFI activities conducted by Geochemical Solutions. Twenty of the 83 OU1 area samples collected by EPA and IDEM were selected for lead isotope and target metal analysis by American Analytical & Technical Services, and electron microprobe (speciation) analysis (EMPA) by the Laboratory for Environmental & Geologic Studies (TechLaw 2004a). TechLaw collected 15 split samples from OU1 on July 9, 2003, during the MRFI activities, but only submitted eight soil samples for analysis. The study also included six samples TechLaw collected in August 2002 in the vicinity of the USS Lead Site (TechLaw 2004a). Details regarding the types of analyses and analytical procedures are documented in the report.

The TechLaw report concluded that the lead isotope data from the 2003 samples collected at the OU2 facility are more similar to common lead than the lead isotope data from samples collected offsite. Additionally, the report concludes that the lead isotope signature of the OU1 area data is more similar to the OU2 lead isotope signature than it is to the DuPont lead isotope signature. However, TechLaw could not definitively prove that the lead in the off-site samples came from OU2 (TechLaw 2004a). In addition, "no clear Dupont signature was seen in the off-site samples" (TechLaw 2004a). EMPA data suggested that a significant amount of lead within the study area may be complexed with iron and manganese hydroxides. Due to their small particle sizes and relatively large surface areas, TechLaw concludes that there is a possibility that airborne particulates from off-site areas contributed a significant amount of the lead that is observed in the soil at the USS Lead Site (TechLaw 2004a).

2006 EPA FIELDS Investigation:

In 2006, EPA's FIELDS team supplemented the work done under the RCRA program in 2003 by collecting additional data from the same locations studied in 2003. The 2006 FIELDS study refined the field methods that were used in 2003 by (1) conducting analyses to investigate whether the surface most soils (0 to 1 inch bgs) had elevated lead concentrations relative to deeper soils (1 to 6 inches bgs), (2) comparing composite samples to individual samples to assess whether composite samples accurately represented the concentrations in residential yards and parks, and (3) sieving samples and comparing lead concentrations in the fine and coarse fractions to evaluate whether lead was preferentially distributed in the fine grain sizes. The 2006 FIELDS investigation was not documented as a report. Instead, the information discussed in this section is derived from a FIELDS team presentation entitled "USS Lead Soil Contamination Site: Do Lead Concentrations Differ at Depth?" dated March 5, 2007.

Lead concentrations in samples from 27 residential yards were used to investigate whether lead concentrations differed significantly with depth, specifically whether lead concentrations found in the surface interval were different from the amount of lead found at depth. FIELDS showed that there was no difference between lead concentrations in samples collected from the 0- to 1-inch interval and those collected from the 1- to 6-inch interval. Lead concentrations in the samples collected from the 6- to 12-inch interval were significantly less than those in both the 0- to 1-inch and the 1- to 6-inch intervals. Samples from seven random residential yards were statistically analyzed to see if composite samples and individual samples showed significant differences. FIELDS concluded that, on average, the XRF lead concentrations of the composite samples were 9.1 percent higher than the individual samples. Twelve random samples were analyzed with the XRF before and after the samples were sieved. These results were statistically analyzed to investigate whether lead was preferentially distributed in the fine grain sizes. On average, the XRF lead concentrations of sieved samples were 9.2 percent higher than the XRF lead concentrations of un-sieved samples.

2007 STN Draft Site Assessment Letter Report, USS Lead Site (Background Study):

In September 2007, EPA and STN Environmental JV (STN) collected composite soil samples from Pulaski Park and St. Joseph Cemetery in Hammond, Indiana, to evaluate background lead concentrations in areas that were considered unaffected by the USS Lead Site (STN 2007). Soil samples were analyzed with an XRF instrument prior to being submitted to the analytical laboratory. Based on the Contract Laboratory Program (CLP) laboratory analytical results and the XRF readings for lead, the total lead in surface and subsurface background soil samples ranged from 21.7 mg/kg to 98.6 mg/kg. STN did not derive a background concentration for lead, but noted that all concentrations in areas unaffected by the USS Lead Site were below 100 mg/kg and did not pose a threat of exposure to human health and the environment (STN 2007).

2008 Hazard Ranking Summary Documentation Record:

The HRS evaluating the surface water and air pathways for possible contamination spreading from OU1 to the surrounding areas at the USS Lead Site was completed in September 2008. The HRS notes that the air pathway documents “an observed release of lead at USS Lead” and is supported by evidence of lead both on and off of the OU1 property.

Two identified lead sources at OU2 were (1) a slag waste pile and (2) wastewater discharges. The slag waste pile contained lead concentrations ranging from 12,000 to 53,000 mg/kg and, since the pile was never capped, it is a source of possible airborne releases of contaminants prior to its removal in 2002. The former baghouse at the USS Lead facility likely contributed to lead emissions at a rate of 16.07 tons of lead per year. The HRS report scored the air migration pathway at the maximum possible score of 100, which far exceeds the minimum score of 28.5 to determine that a site is eligible to be listed on the NPL. The second source is the wastewater discharge from OU2 to the Grand Calumet River. Groundwater and surface water are beyond the scope of this RI; therefore, these sources are not discussed in detail here. The HRS report also notes that a soil exposure pathway exists both on and off the OU2 portion of the USS Lead Site, and the report referenced EPA’s 1985 “Inspection Report of Hammond Lead and USS Lead Refining Soil Survey”; however, the report did not score the pathway (EPA 1985, 2008a).

2011 Time Critical Removal Action:

EPA completed a TCRA of 16 properties with lead in soil concentrations exceeding 400 mg/kg from October through December 2011. The TCRA consisted of removing lead-contaminated soil from 5 East Chicago public housing addresses and 11 residential properties (2 of which were not remediated in the prior 2008 TCRA due to access issues). The TCRA was conducted between October 24 and December 9, 2011. Approximately 1,913 tons of low-level lead-contaminated soil were excavated during the TCRA and the material was sent to an off-site location for disposal. Each property was backfilled to the existing grade and seeded after the soil removal was completed (EPA 2011c, 2011d, 2011e).

1.3.4 Potential Source Areas

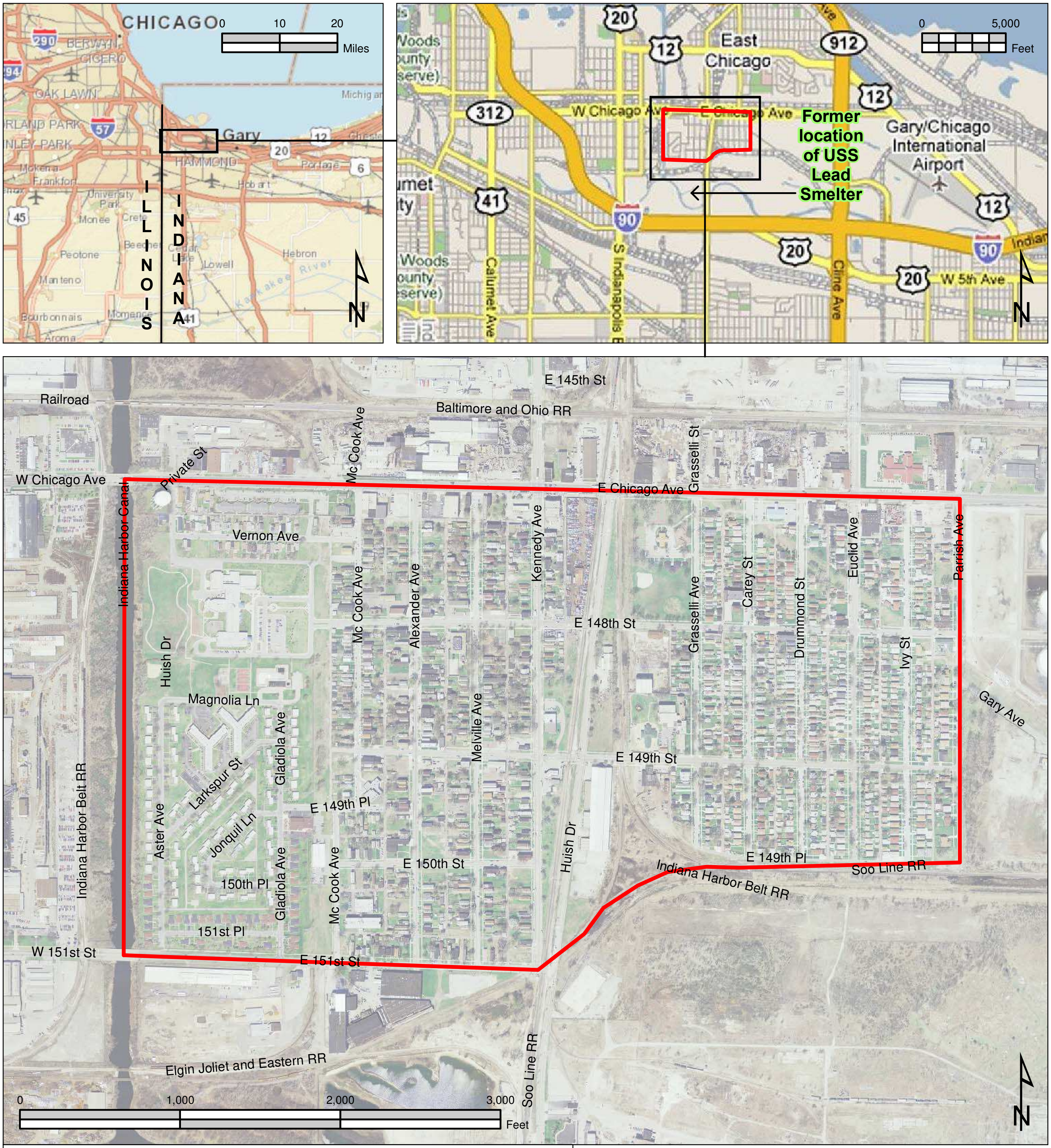
EPA has investigated and continues to investigate potential sources of contamination at the USS Lead Site. On the basis of its preliminary investigations, EPA has sent General Notice of Liability letters to

USS Lead, ARCO, and DuPont. ARCO is a successor-in-interest to the Anaconda Copper Company, which operated a facility on the western boundary of the study area along the Indiana Harbor Canal. DuPont owns property immediately south of OU1 and east of OU2 (Figure 1-4).

1.3.5 Summary

OU2 has undergone cleanup through the RCRA program. USS Lead has addressed the majority of on-site contamination at OU2 with a CAMU and with several excavations outside the facility, but has not addressed OU1. Multiple investigations were conducted concurrently in OU1 to investigate the source and extent of lead-contaminated soils. Studies were conducted in OU1 to investigate the concentrations of lead in soils, model aerial deposition, and characterize the lead with isotopic analysis to identify a potential responsible party (PRP). EPA approved the removal of lead-contaminated soils from several residential properties through a TCRA due to the elevated lead concentrations in the surface soils greater than the regulatory removal action level of 1,200 mg/kg. Thirteen properties were remediated during the TCRA in the summer of 2008. EPA's RCRA program requested that OU1 be managed under the Superfund program. The USS Lead Site was entered on the NPL in April 2009, and the Superfund program initiated this RI in 2009. An additional 16 properties where surface soils were contaminated with lead above 1,200 mg/kg were remediated during a second TCRA during the fall of 2011, based on sampling conducted during this RI.

FIGURES



□ OU-1 boundary

Imagery sources (clockwise from upper left):
ESRI Resource Center
Google Maps
ISDP (Indiana Spatial Data Portal)

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

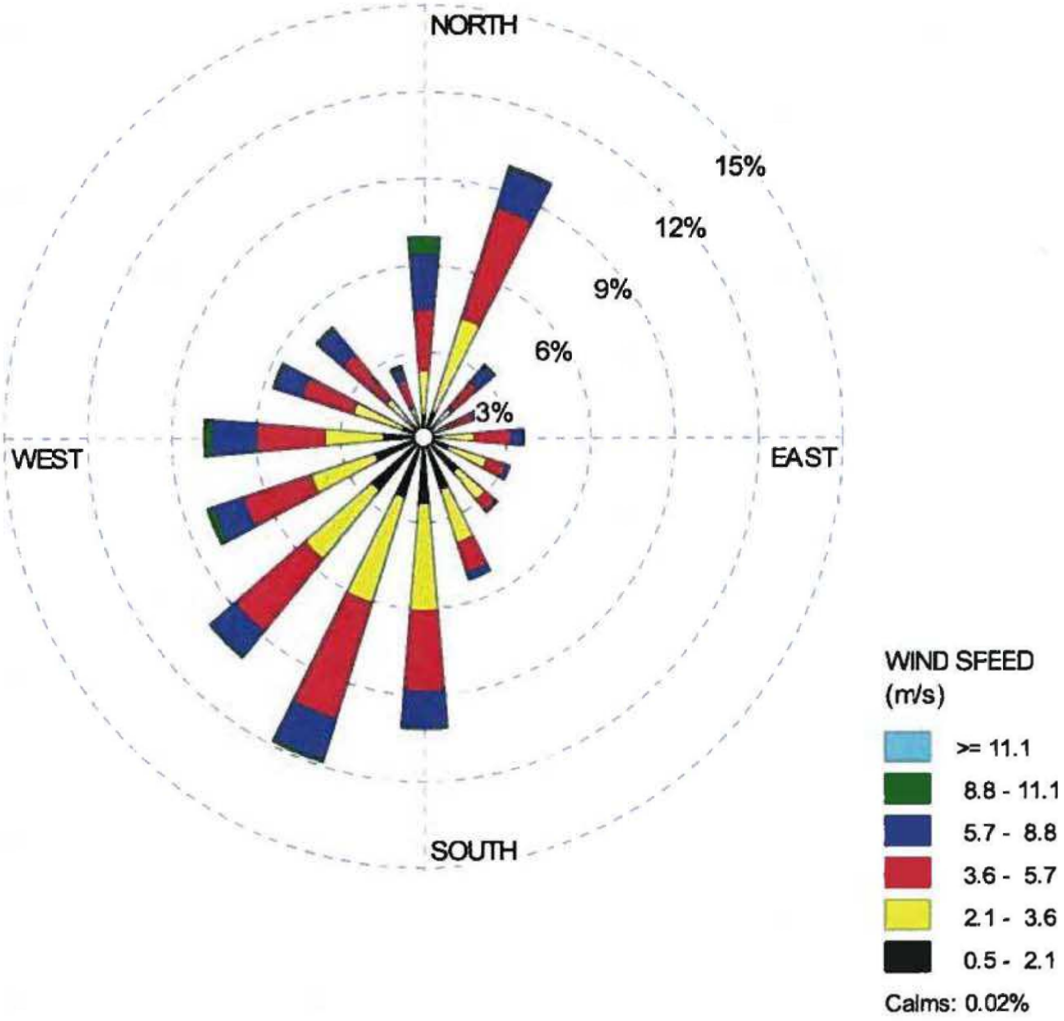
FIGURE 1-1

USS LEAD RESIDENTIAL AREA SITE LOCATION MAP

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC

Figure 2: Wind Rose Showing Prevailing Wind Directions in Hammond, Indiana, 1987 – 1991



Source: USEPA 2006. Supplemental Risk Assessment of Potential Air Emissions from the Confined Disposal Facility for the Indiana Harbor and Shipping Canal Sediment Dredging and Disposal Project.

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

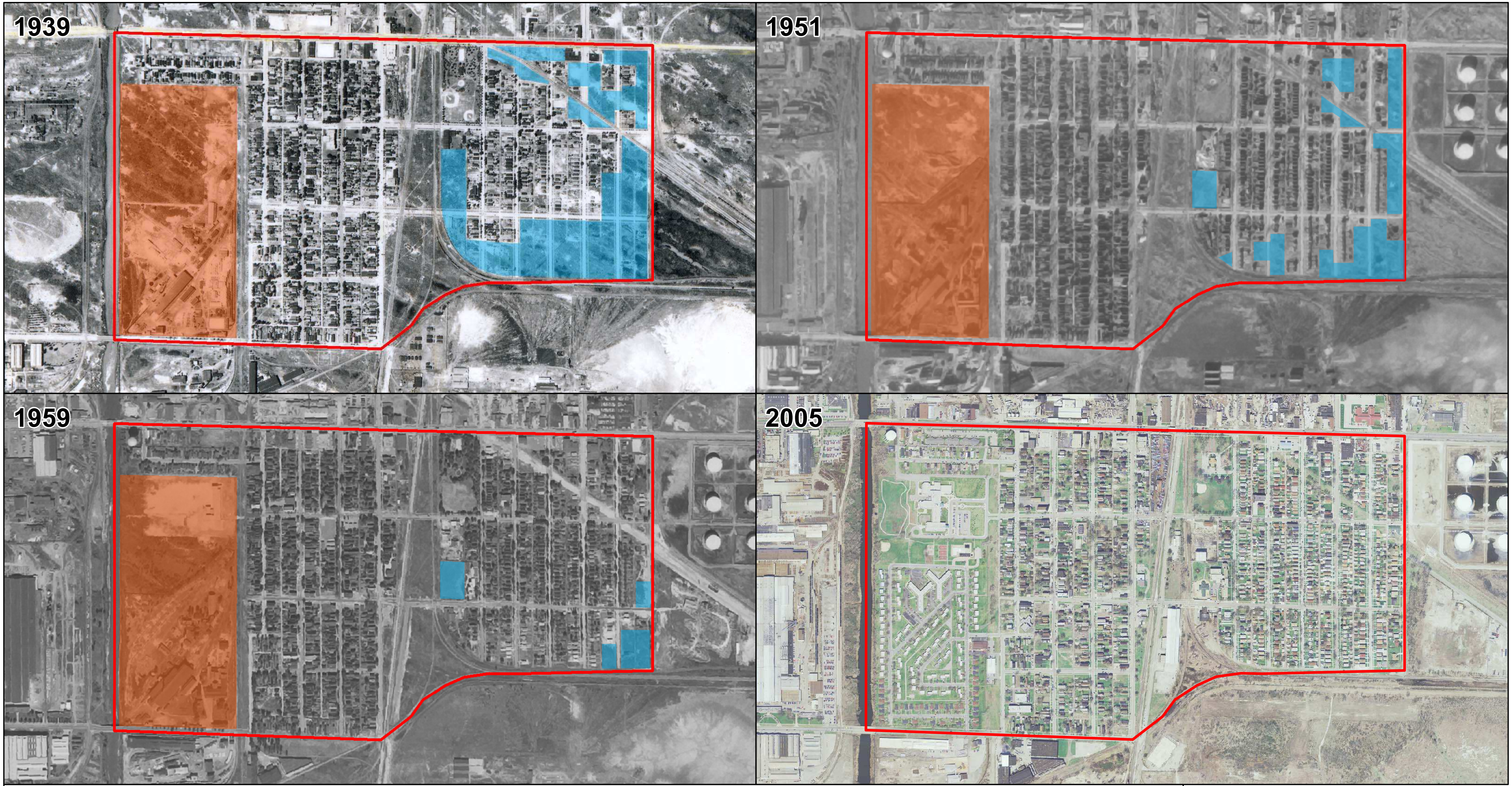
REMEDIAL INVESTIGATION REPORT

FIGURE 1-2

WIND ROSE SHOWING PREVAILING WIND IN HAMMOND 1987-1991

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



🟦 Undeveloped area

🟧 Former Anaconda plant

🟥 OU-1 boundary

Imagery sources (clockwise from upper left):
Indiana State Archives,
USGS EarthExplorer,
ISDP (Indiana Spatial Data Portal),
USGS EarthExplorer

Note: Graphic scale is approximate for the 1939, 1951 & 1959 imagery

0 1,000 2,000 3,000 4,000 5,000 feet 1 inch = 900 feet

N

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

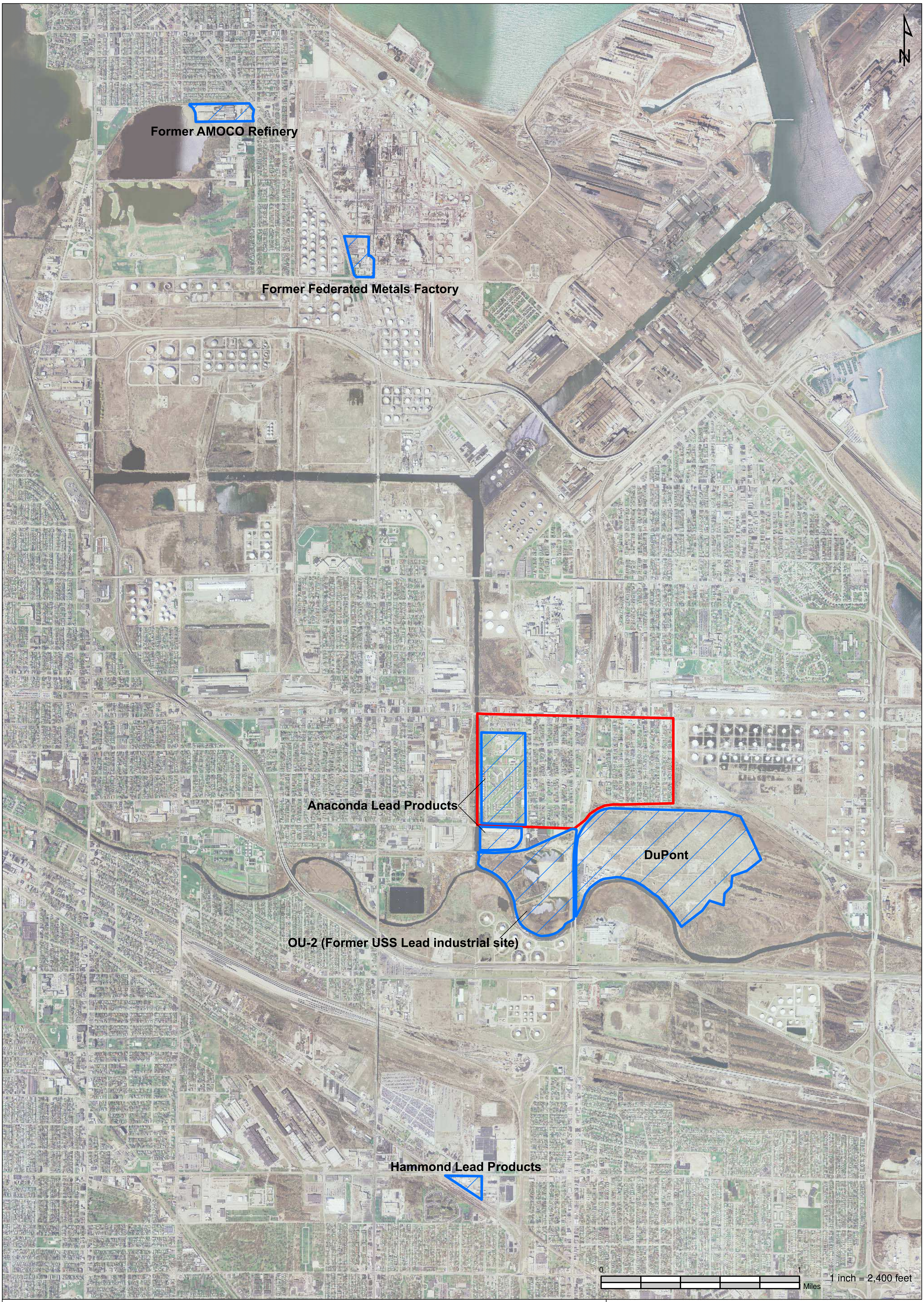
REMEDIAL INVESTIGATION REPORT

FIGURE 1-3

HISTORICAL IMAGERY

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



🟥 OU-1 boundary

▨ Industrial sites

Imagery sources (clockwise from upper left):
ISDP (Indiana Spatial Data Portal)

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

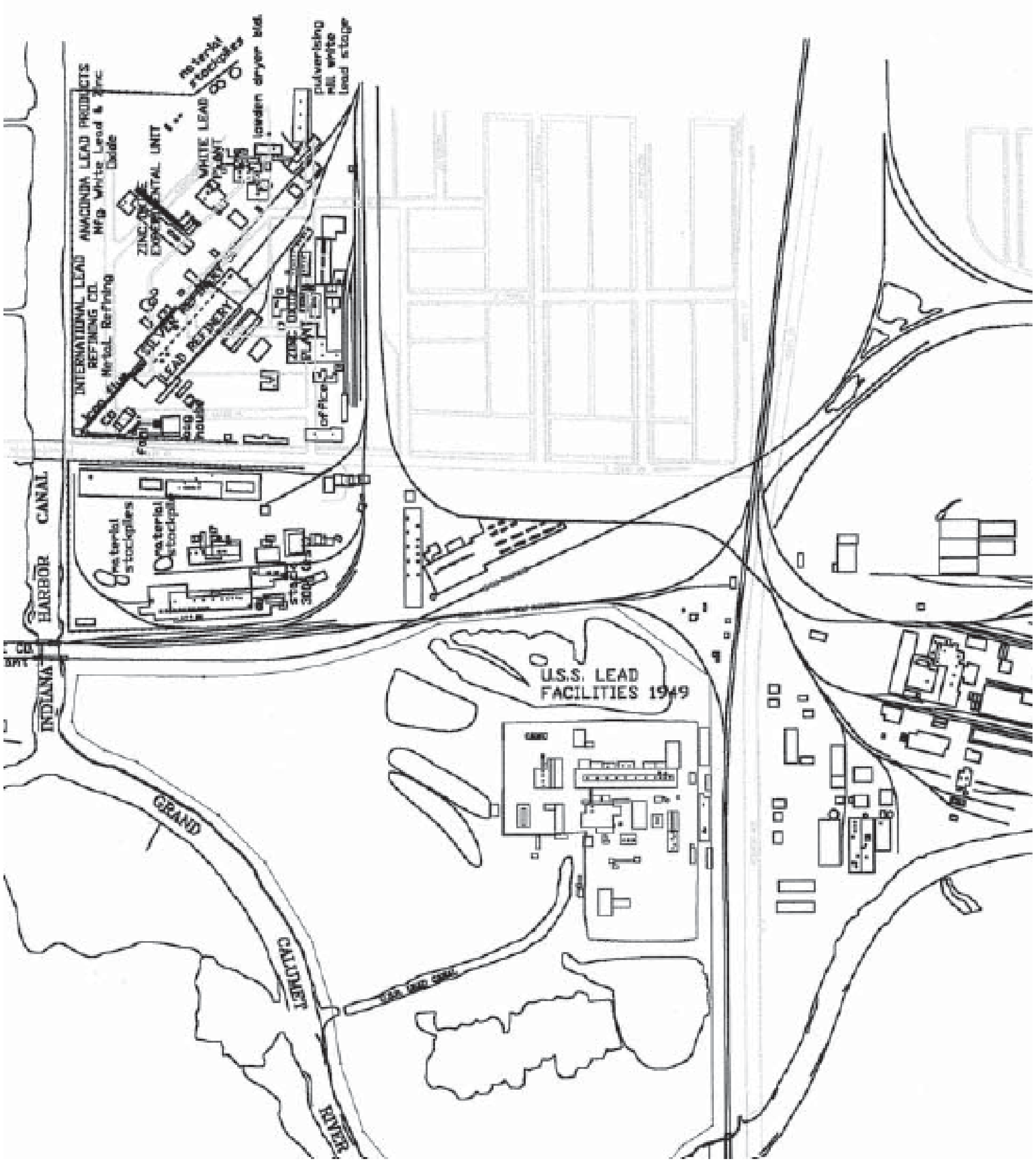
REMEDIAL INVESTIGATION REPORT

FIGURE 1-4

HISTORICAL OVERVIEW OF STUDY AREA

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



Source: Detail from Figure A, “Draft Characterization of Lead and Other Metals in Soil in the Vicinity of the USS Lead Site, East Chicago, Indiana.” TechLaw 2004.

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

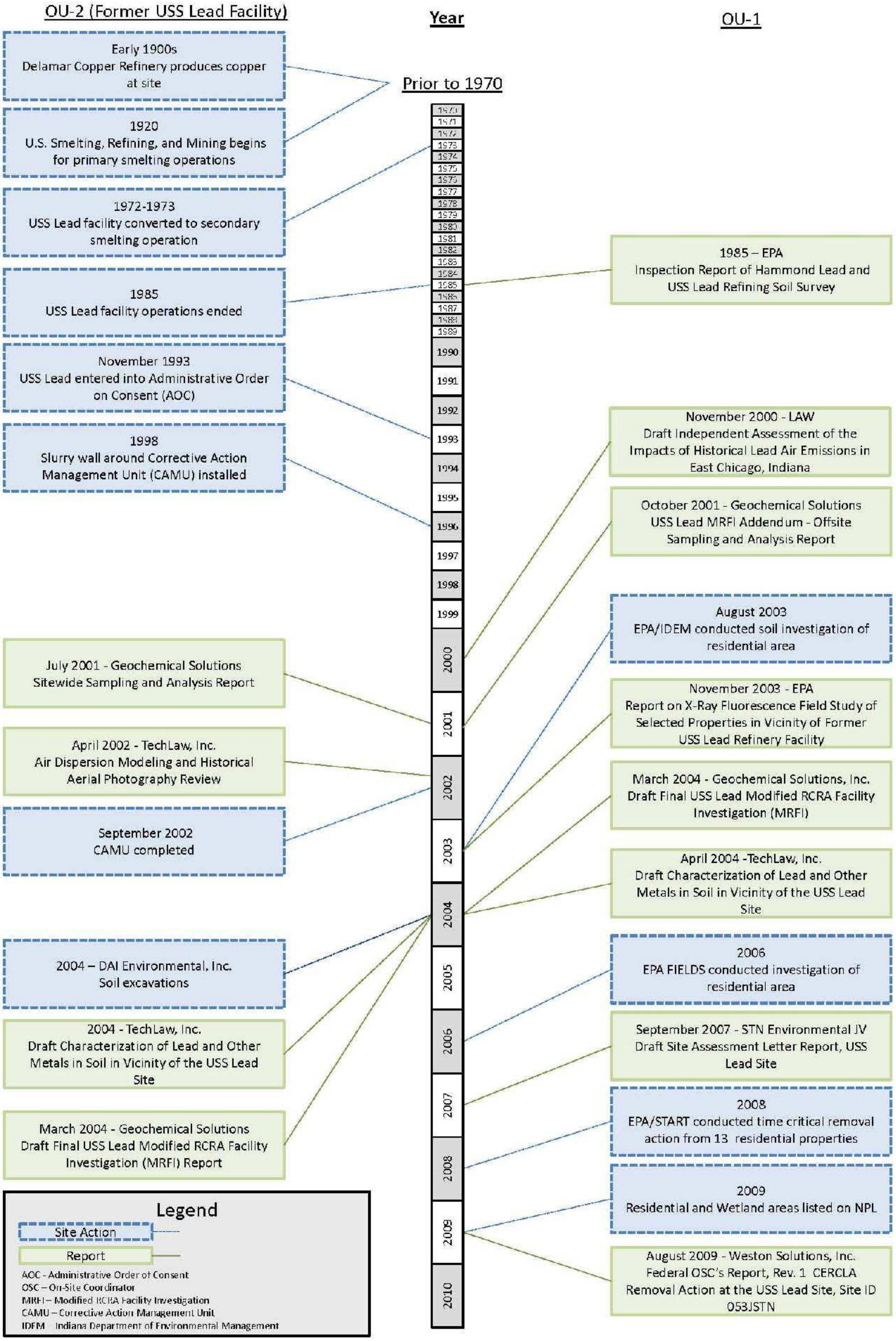
REMEDIAL INVESTIGATION REPORT

FIGURE 1-5

ANACONDA LEAD PRODUCTS SANBORN FIRE INSURANCE MAP (1930)

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

SulTRAC



OU-2 (Former USS Lead Facility)

Early 1900s
Delamar Copper Refinery produces copper at site

1920
U.S. Smelting, Refining, and Mining begins for primary smelting operations

1972-1973
USS Lead facility converted to secondary smelting operation

1985
USS Lead facility operations ended

November 1993
USS Lead entered into Administrative Order on Consent (AOC)

1998
Slurry wall around Corrective Action Management Unit (CAMU) installed

July 2001 - Geochemical Solutions
Sitewide Sampling and Analysis Report

April 2002 - TechLaw, Inc.
Air Dispersion Modeling and Historical Aerial Photography Review

September 2002
CAMU completed

2004 – DAI Environmental, Inc.
Soil excavations

2004 - TechLaw, Inc.
Draft Characterization of Lead and Other Metals in Soil in Vicinity of the USS Lead Site

March 2004 - Geochemical Solutions
Draft Final USS Lead Modified RCRA Facility Investigation (MRFI) Report

Year

OU-1

1985 – EPA
Inspection Report of Hammond Lead and USS Lead Refining Soil Survey

November 2000 - LAW
Draft Independent Assessment of the Impacts of Historical Lead Air Emissions in East Chicago, Indiana

October 2001 - Geochemical Solutions
USS Lead MRFI Addendum - Offsite Sampling and Analysis Report

August 2003
EPA/IDEM conducted soil investigation of residential area

November 2003 - EPA
Report on X-Ray Fluorescence Field Study of Selected Properties in Vicinity of Former USS Lead Refinery Facility

March 2004 - Geochemical Solutions, Inc.
Draft Final USS Lead Modified RCRA Facility Investigation (MRFI)

April 2004 -TechLaw, Inc.
Draft Characterization of Lead and Other Metals in Soil in Vicinity of the USS Lead Site

2006
EPA FIELDS conducted investigation of residential area

September 2007 - STN Environmental JV
Draft Site Assessment Letter Report, USS Lead Site

2008
EPA/START conducted time critical removal action from 13 residential properties

2009
Residential and Wetland areas listed on NPL

August 2009 - Weston Solutions, Inc.
Federal OSC's Report, Rev. 1 CERCLA Removal Action at the USS Lead Site, Site ID 053JSTN

Legend

Site Action
Report
AOC - Administrative Order of Consent
OSC – On-Site Coordinator
MRFI – Modified RCRA Facility Investigation
CAMU – Corrective Action Management Unit
IDEM – Indiana Department of Environmental Management

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

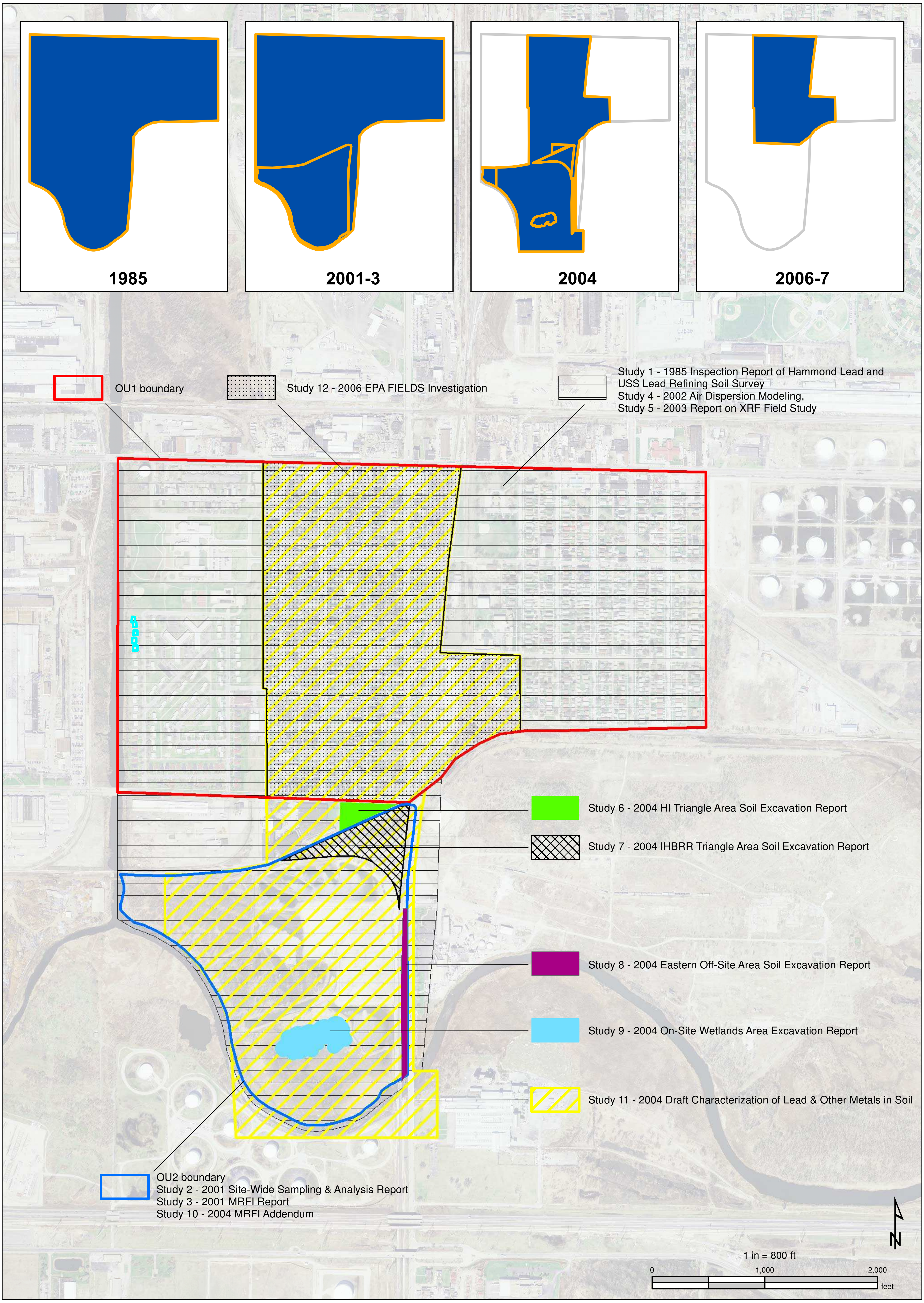
REMEDIAL INVESTIGATION REPORT

FIGURE 1-6

SITE HISTORICAL TIMELINE

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

FIGURE 1-7
HISTORICAL INVESTIGATION STUDY AREAS

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC

2.0 REGULATORY FRAMEWORK

Historical operations in the vicinity of the USS Lead Site have led to numerous investigations of lead in soil. Fugitive emissions from historical operations have resulted in soil contamination in residential property, which in turn can cause high blood lead levels in children (EPA 2003c). Lead site characterization and remediation are distinctive, due to the reliance on blood-lead concentrations to quantify lead exposure and toxicity. This section presents the regulatory guidance documents and standards that were evaluated to address contamination by lead and other analytes detected during the RI.

2.1 REGULATORY GUIDANCE DOCUMENTS AND STANDARDS

Both federal and state agencies have developed standards to protect human health and the environment from the effects of exposure to contaminants, and guidance documents to aid in decision-making. The following are the primary documents that establish regulatory criteria for the screening of RI results at the site:

- EPA Superfund Lead-Contaminated Residential Sites Handbook (EPA 2003c)
- EPA Regional Screening Levels (RSL) (EPA 2010c)
- IDEM Technical Resource Guidance Document, RISC (IDEM 2009)

The regulatory criteria discussed below are used to determine the site screening levels (SSL) for this RI. Contaminants that exceed the SSLs are evaluated further in Sections 5 (nature and extent of contamination) and 7 (HHRA) of this RI. Each document and its applicability to the USS Lead Site is described in the sections below.

2.1.1 Superfund Lead-Contaminated Residential Sites Handbook

The Superfund Lead-Contaminated Residential Sites Handbook (the Handbook) is a reference guide that is used to “promote a nationally consistent decision-making process for assessing and managing risks associated with lead-contaminated residential sites across the country” (EPA 2003c). The Handbook recommends using soil lead concentration thresholds of 400 mg/kg and 1,200 mg/kg to prioritize cleanups. The Handbook considers only the impact(s) of lead at residential sites; it does not consider other compounds that may pose risk. The Handbook states, “As recognized in the TSCA §403 Rule, lead contamination at levels equal to or exceeding the 400 mg/kg and 1,200 mg/kg standards may pose serious health risks based upon a site-specific evaluation and may warrant timely response actions. However, the soil-lead hazard levels under the TSCA §403 Rule should not be used to modify approaches to addressing brownfields, NPL sites, state Superfund sites, federal [Comprehensive Environmental Response, Compensation, and Liability Act] CERCLA removal actions and CERCLA non-NPL facilities" (EPA 2003c). Therefore, the Handbook provides a useful context in which to consider lead contamination at the USS Lead Site, but does not provide strictly applicable cleanup standards for the site.

As stated in the Handbook, the 400 and 1,200 mg/kg standards "should not be confused with clean-up numbers." However, the Handbook uses these standards to establish a three-tiered approach in determining early actions to mitigate identified site risks. The three tiers are (EPA 2003c):

- Tier 1 represents properties with soil-lead concentrations above 1,200 mg/kg
  - TCRAs can be used to address risks at Tier 1 properties;
- Tier 2 represents properties with soil-lead concentrations between 400 mg/kg and 1,200 mg/kg
  - Non Time-Critical Removal Actions (NTCRA) can be used to address risks at Tier 2 properties;
- Tier 3 represents properties with soil-lead concentrations below 400 mg/kg
  - NTCRAs, long-term remedial actions, or no remedial action at all, may be used to address risks at Tier 3 properties.

Additionally, as detailed in Section 3.1 below, the Handbook also provides sampling methodologies to follow for residential lead site assessments.

2.1.2 EPA Regional Screening Levels

EPA developed RSLs in an effort to improve consistency and incorporate updated guidance across EPA regions. The RSLs were developed with input from EPA Regions III, VI, and IX, regions that have historically established their own risk-based concentration standards (EPA 2010c). The RSL tables contain residential and industrial RSLs for selected contaminants in environmental media (soil and groundwater) and information regarding chemical properties, toxicity, and carcinogenic effects. The RSL for lead in residential soils is 400 mg/kg; the RSL for lead in industrial soils is 800 mg/kg (EPA 2010c). OU1 of the USS Lead Site is primarily composed of residential properties; therefore, the EPA residential RSLs were included in the SSLs to be conservative.

2.1.3 IDEM RISC Technical Resource Guidance Document

IDEM's RISC Technical Resource Guidance Document (the RISC Technical Guide) was written for use by environmental professionals seeking closure of sites under an IDEM remedial program. The RISC

Technical Guide states: "The intent of the document is to provide (1) a default approach to site closure and (2) a framework for nondefault options if the default approach is not used" (IDEM 2009). Much like the RSLs, the Default Closure Tables (DCT) contained in the RISC Technical Guide present residential and industrial criteria for direct soil contact. The DCT Residential Closure Level (Soil – Direct) for lead is 400 mg/kg, and the Industrial Closure Level (Soil – Direct) for lead is 1,300 mg/kg (IDEM 2009). Cleanup values for USS Lead RI results are included in the DCT for direct soil contact. As noted above, OU1 of the USS Lead Site is primarily composed of residential properties; therefore, the DCT Residential Closure Levels (Soil – Direct) were considered the appropriate IDEM RISC standard for screening purposes.

2.2 SCREENING CRITERIA

Conservative screening tools were used to identify SSLs, concentrations of lead and other chemicals that might pose a risk to human health or the environment. Because lead and other elements occur naturally and/or anthropogenically, SulTRAC developed site-specific background threshold values (BTV) for metals and polycyclic aromatic hydrocarbons (PAH) in soil as part of the Risk Assessment. The field sampling approach used to collect background samples is summarized in Section 3.2.1, and the statistical procedures used to derive site-specific BTVs are summarized in Section 5.1 and Appendix B of the Risk Assessment (see Appendix E of this RI Report). SulTRAC developed site SSLs from screening criteria in the Superfund Lead-Contaminated Residential Sites Handbook, EPA residential RSLs, IDEM RISC residential DCTs, and site-specific BTVs. As discussed in Section 5.0 below, the SSLs that were used to evaluate the RI analytical results used the lowest of the following: the Handbook, the EPA residential RSL, or the IDEM RISC residential DCT. If the site-specific BTV was greater than the lowest of the above-listed values, then the site-specific BTV was selected as the SSL.

In addition, SulTRAC used EPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model and the Adult Lead Model (ALM) to estimate soil concentrations that correspond to acceptable blood-lead concentrations for residents and non-residents, respectively (EPA 2003a; 2009c, d). Section 7.2.2 and Appendix C of the HHRA (Appendix E to this RI report) present the methodology based on the IEUBK and ALM models used to calculate acceptable receptor-specific soil-lead concentrations (referred to as preliminary remediation goals [PRG]). The lead PRGs were compared to the lead exposure point concentrations (EPC) (average lead concentrations) to evaluate whether adverse effects could result from exposure to lead in soil. For residential child receptors, the average lead concentration in soil at each property was compared to the EPA residential soil RSL of 400 mg/kg. The 400 mg/kg RSL was calculated using EPA's IEUBK model and default exposure assumptions. SulTRAC concluded that insufficient site-specific information (for example, localized concentrations of lead in air, water, and foodstuffs) was available to warrant calculation of a site-specific residential soil PRG. Therefore, residential properties with average lead concentrations in soil greater than 400 mg/kg were identified as presenting potential lead risks to residential receptors.

A summary of the soil SSLs is presented in Tables 5-1 through 5-4 for metals, PAHs, volatile organic compounds (VOCs), and pesticides/polychlorinated biphenyls (PCB), respectively. Note that the Risk Assessment evaluated detected concentrations independently of the nature-and-extent evaluation and used a Risk-Assessment-specific set of screening levels. The Risk Assessment screening levels are summarized in Section 7.1.3.1 and are designed for the protection of human health for different types of land use, specifically: EPA residential RSLs for residential, recreational, and school properties; EPA industrial RSLs for industrial and commercial properties; and site-specific BTVs.

3.0 REMEDIAL INVESTIGATION FIELD ACTIVITIES

SulTRAC conducted two phases of field investigations at OU1. Phase I field activities conducted in December 2009 included extensive XRF screening of soils at residential properties distributed in a widely spaced grid pattern across all of OU1. Phase II field activities conducted in August 2010 included filling in spatial data gaps due to the inability to acquire access during the Phase I investigation, sampling additional properties associated with sensitive populations, establishing background concentrations, characterizing the soil for future disposal purposes, and confirmation soil sampling for the City of East Chicago Department of Redevelopment.

This section discusses the Phase I field investigation activities (Section 3.1), Phase II field activities (Section 3.2), and data quality (Section 3.3).

3.1 PHASE I INVESTIGATION ACTIVITIES

As discussed with EPA and outlined in the work plan (SulTRAC 2009a), the first phase of the RI included extensive XRF screening of soils at residential properties distributed in a widely spaced grid pattern across all of OU1. Further, the Phase I investigation collected additional samples from the same properties to resolve potential issues identified in the Handbook (EPA 2003c), such as airborne contamination concentrating along drip lines of roofs, correlation of lead with organic or other contaminants, and size fractionation of lead contamination.

EPA's Work Assignment Manager (WAM) provided a package of 132 residential access agreements from March and April 2006. Additional residential access agreements were obtained during Phase I of the investigation through a fact-sheet mailing, public information sessions, and contacting residents door to door. To provide uniform density of sampling in the entirety of OU1, SulTRAC selected several properties for sampling where access had been obtained on each residential block. Prior to sampling, utility locators visited each selected property to mark the locations of utilities.

SulTRAC originally intended to sample three properties per block during the Phase I investigation. Because of time constraints and difficulty in obtaining property access, approximately two properties per block were sampled instead. This pattern allowed SulTRAC to maintain even spatial coverage, subject to access agreements and utility clearance. Field sampling took place from December 7 to December 23, 2009. In that time, 74 properties—including one school, two parks, and one recreation center—were sampled using a combination of hand augers and spades (Figure 3-1).

On March 26, 2010, SulTRAC sampled soils at a property on Vernon Avenue at the request of EPA because the City of East Chicago was planning to redevelop two properties on Vernon Avenue (SulTRAC had previously sampled one of the properties in December 2009). Because the soil has now been removed from one of the properties, the data collected from this parcel during the December 2009 field event are not included in this RI report. As of the date of this RI report, the soils at the other Vernon Avenue property remain and the data associated with this property are included in this RI report. In summary, a total of 75 properties were sampled; however, this RI report presents data for the 74 properties whose soils remain onsite. Details regarding the confirmation soil sampling and excavation oversight activities on Vernon Avenue are presented in Section 3.2.4.

At each property, depth-discrete composite samples were collected from each yard, including five-point composite samples from 0-6 inches, 6-12 inches, 12-18 inches, and 18-24 inches bgs, in an X-shaped pattern, with one sample from each endpoint of the X and one sample from the center. Aliquots of soil from each 6-inch interval from the five points were composited into a zip-lock type bag, labeled, and homogenized. The only exception to this sample procedure was at the recreation center, where a five-point composite sample was not collected; only a play-area grab sample was collected. During the course of sampling, the lithology of soils encountered in each boring was recorded. Each discrete sampling location of each five-point sample was photographed with the address, sample ID, and aliquot number in view, and a hand-drawn map of the property was created to illustrate the layout of the sample locations. Samples were collected with a combination of hand augers and spades.

In addition to composite samples from each yard, discrete grab samples were collected from four 6-inch depth intervals near the center of any play area, garden, or flower bed encountered in a yard. If possible, four-point composite drip line samples were collected to a depth of 6 inches bgs using a spade around the building at each property. In the case of homes with gutters, SulTRAC sampled at each downspout discharge. In many cases, the drip line area adjacent to buildings was paved with cement, and no drip line sample was collected. Decontamination was conducted after each five-point composite sample and any downspout, garden, or play area samples were collected at each property. Decontamination consisted of a standard scrub with Alconox, a rinse in tap water, and a final rinse with distilled water. The decontamination water was decanted in the yard where the samples were collected to minimize investigation-derived waste (IDW). Soil sample borings or test pits were filled with potting soil and the grass restored after the sample collection.

At the end of each day, the soil samples were taken to the field trailer and analyzed using a hand-held Niton XRF analyzer (Thermo Scientific Niton XLT 898D). The soil samples were homogenized both at the time of sample collection and again prior to the XRF screening. The composite soil samples collected in plastic one-gallon zip-lock bags were shaken within the bag until the soil visually appeared homogeneous, or for approximately one to two minutes. The air was released from the plastic bags prior to conducting the XRF screening. If a soil sample appeared overly saturated, the sample bag was left open to dry out the sample to minimize XRF interference with water. Twenty percent of the screened soil samples were submitted to the CLP laboratory for confirmation analysis for total metals. The soil samples chosen for laboratory analysis were packed in 8-ounce glass sample jars, placed in a cooler with ice, and sent to ALS Laboratory Group in Salt Lake City, Utah, for total metals analysis. All sampling procedures and QC samples were in accordance with the approved Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) (SulTRAC 2009b, 2009c). All XRF-screened soil samples that were not submitted to the CLP laboratory for analysis were returned to the property they were collected from. The soil was either evenly spread across the property or placed under shrubs or within flower gardens.

SulTRAC collected a total of 722 composite and grab samples for field lead analysis via XRF (method SW-846-6200). The Thermo Scientific Niton XLT 898D analyzer was used to screen all soil samples. The calibration for the XRF instrument was checked against the standard supplied with the instrument, prior to each screening session, and recorded in the logbook. Once the calibration was checked against the standard, the XRF instrument was set to read standard soil bulk material. Each soil sample was screened with the XRF instrument for a minimum of 60 seconds; then the lead results, in parts per million, were recorded in the logbook and in an Excel spreadsheet. If the XRF instrument identified other metals above the XRF detection limits, the other metals were recorded in the logbook. Generally, each soil sample was screened one time for lead. Random soil samples were screened three to four times to check the variability of the XRF instrument and to verify that the samples were homogenized. These results were recorded in the logbook. When there were significant differences in the screened results, the bag was homogenized again and screened several times to check whether the differences were due to the soil sample not being fully homogenized.

Twenty percent of the 722 XRF-screened soil samples were submitted to the CLP laboratory, ALS Laboratory Group in Salt Lake City, Utah, for total metals analysis (method ILM05.4 ICP-AES). The Handbook (EPA 2003c) suggests that 20 percent laboratory confirmation samples will provide sufficient data to perform a regression analysis and thereby generate a correction factor for the field XRF data. The correction factor is used to modify field-obtained XRF results to obtain more representative contaminant concentrations. EPA's FIELDS group performed a regression analysis and diagnostics on the CLP laboratory results versus the XRF screened field results, and then used the regression to develop a correction factor for application to all of the XRF screened field results. The regression analysis and correlation are discussed further in Section 5.2 of this RI report.

In selecting the 20 percent of samples to be submitted to the laboratory, the XRF screened results were split into three different categories: low (0 to 300 mg/kg), medium (300 to 600 mg/kg), and high (greater than 600 mg/kg) based on XRF screening concentrations. Soil samples were selected to represent each of these categories evenly and to span the entire range of sample results obtained from the XRF screening to provide the best reasonably achievable correlation. Because of the method used to select samples for CLP metals analysis, most but not all of the properties sampled have both XRF and CLP metals results for one or more samples. Of the 722 soil samples collected, 145 field samples and 15 field duplicate samples were submitted to the CLP laboratory for total metals analysis.

SulTRAC collected a variety of other samples to address other potential issues identified in the Handbook (EPA 2003c), as described below.

- **Sieved samples:** SulTRAC submitted one sample from approximately 8% of the properties sampled (six samples) to a CLP laboratory for sieve analysis to investigate whether contamination was associated with the finer grain-size fraction. The CLP laboratory sieved the six soil samples using a number 60 (250-micron) sieve, then analyzed each sample subset for total metals using method ILM 05.4 ICP-AES. Results of the sieve analyses are discussed further in Section 5.4.4 of this RI report.

- **Samples analyzed for a full suite of contaminants:** One soil sample from approximately 10% of the properties sampled (eight samples) was analyzed for a full suite of contaminants, including VOCs, semi-volatile organic compounds (SVOC), PCBs, and pesticides. The samples were analyzed using method SOM01.2 for the organic analytes. The properties and depths where samples were analyzed for a full suite of contaminants were randomly selected. Where possible, the samples for full-scan and sieve analysis samples were collected from the same properties and depths. However, no VOC samples were collected from the uppermost 6 inches; instead, all VOC samples were collected from subsurface soils (deeper than 6 inches bgs). VOC samples were not composited due to the tendency of VOCs to volatilize. The FSP specified that a single VOC sample would be collected from the interval that was most contaminated based on field observations (SulTRAC 2009b); however, no contamination was evident. Therefore, VOC samples were chosen randomly. Analytical results are discussed further in Section 5.0 of this RI report.

- **Equipment rinsate samples:** During the three-week sampling event, a rinsate sample was collected from each sampling team per week. A total of six rinsate samples were submitted to the CLP laboratory for total metals analysis.

Variances from the original FSP were typically minor and concerned the use of spades and hand augers in lieu of slide hammers. The slide hammers proved ineffective in vacant lots because of the prevalence of fill debris like brick and cement. In areas with too much debris for even the hand auger, a spade was employed to create a small excavation and the sample was collected from the side of the excavation, beginning at the bottom. At several properties, the five-point composite was reduced to a three-point composite either because the yard was too small or the debris was so pervasive that the boring could not be advanced deeper than a few inches. In many cases, a drip-line sample could not be collected because the home was surrounded by cement or the downspout emptied into a drain near the side of the home. Field notes recorded during the investigation can be found in Appendix B.

3.2 PHASE II INVESTIGATION ACTIVITIES

During the Phase II investigation, soil samples were collected from a total of 22 properties. The 22 properties included three public parks and 13 residences in OU1; two public parks and one cemetery in Hammond, Indiana, to collect background soil samples; and three previously sampled properties in OU1 to characterize soils for disposal. SulTRAC collected a total of 186 composite and grab samples from the 22 properties. Soil samples were collected in OU1 to further identify the properties that may require remedial action by filling in spatial data gaps and collecting additional soil samples from locations with sensitive populations (i.e., schools and public parks where children play). Additionally, the City of East Chicago Department of Redevelopment excavated two residential properties in OU1 where SulTRAC collected confirmation soil samples and provided limited excavation oversight. The OU1 soil sampling activities are presented below in Section 3.2.1, and the background soil sampling and soil disposal sampling activities are presented in Section 3.2.2 and Section 3.2.3, respectively. The confirmation soil sampling activities are presented in Section 3.2.4. The field notes were recorded for each soil sample location in a field notebook and are presented in Appendix B.

3.2.1 Phase II OU1 Investigation

Phase II field sampling took place from August 10 to 18, 2010. During that time, 16 properties—including 13 residences and 3 parks—were sampled using hand augers (Figure 3-1).

The residential properties and parks within OU1 were sampled as described in Phase I Investigation Activities (Section 3.1), with the major exception that all samples were submitted to the CLP laboratories for total metals and PAH analyses. As described in the FSP Addendum, XRF analysis was not conducted on any samples collected during the Phase II sampling activities (SulTRAC 2010a). As during the Phase I investigation, a five-point composite sample was collected at discrete 6-inch intervals to a depth of 2 feet in the front and back yards at each residential property or from each of 4 quadrants at the public parks. The sampling procedures, documentation, and QC sampling were conducted as described above in Section 3.1 and in accordance with the approved Amended FSP (SulTRAC 2010a) and Amended QAPP (SulTRAC 2010b). A few deviations from the above-described sampling procedures are as follows:

- one residential property/school (the Carmelite Home for Girls) was sampled in quadrants due to the large size of the property;
- two-point composite samples instead of five-point composite samples were collected from two properties because the yard was too small;
- drip line samples could not be collected from a majority of the properties because the residence was surrounded by cement or the downspout emptied into a drain near the side of the home. In a few cases, grab (not composite) samples were collected from the downspout because the downspouts were located on separate buildings at the same address; and
- one public park, Kennedy Park, was not split into the traditional 4 equal-sized quadrants due to its unusual narrow, triangular configuration. The park was split into 4 sections from south to north, and four- or five-point composite samples were collected from each section.

The composite soil samples were collected in plastic one-gallon zip-lock bags, which were shaken for approximately one to two minutes until the soil visually appeared homogeneous. The composited soil samples were then packed in 8-ounce clear glass jars, placed in a cooler with ice, and shipped to the CLP laboratories. The samples analyzed for total metals were sent to Liberty Analytical Corporation in Cary, North Carolina, or A4 Scientific in The Woodlands, Texas. The samples analyzed for PAHs were sent to KAP Technologies, Inc. in The Woodlands, Texas, or ALS Laboratory Group in Salt Lake City, Utah. Soil sample borings or test pits were filled with excess sample soil and/or potting soil and the grass restored after the sample collection.

One rinsate sample and one field blank sample were submitted to the CLP laboratory for total metals and PAH analyses.

3.2.2 Background Soil Investigation

SulTRAC conducted a site-specific background soil investigation in the vicinity of the USS Lead Site to investigate background soil concentrations of target analyte list (TAL) metals and SVOCs. Locations were chosen based on EPA's assessment of private and public properties that are presumed not to have been disturbed or affected by aerial deposition of contaminants from the operations at OU2. The locations are also assumed to be unaffected by any urban fill or backfill material from OU2. In 2007, STN collected soil samples at two properties for its background investigation: (1) Pulaski Park located in Hammond, Indiana, and (2) Saint Joseph/Saint John Cemetery located at 1547 - 167th Street in

Hammond, Indiana (Figure 3-2). The soil samples collected were analyzed only for total lead and, therefore, SulTRAC returned to these two locations as well as to a third location, Harrison Park in Hammond, Indiana (Figure 3-2), to collect soil samples for analyses of TAL metals and SVOCs. SulTRAC discovered that the cemetery was actually divided into three different cemeteries: (1) Elmwood Cemetery; (2) Saint Joseph/Saint John Cemetery; and (3) Saint Michael Cemetery. The City of Hammond purchased and created Pulaski Park in 1929 and Harrison Park in 1898. The cemeteries were established in 1921.

On August 9, 2010, SulTRAC collected soil samples from the two public parks and the group of cemeteries as described above. Within each park/cemetery, two grab soil samples (one from the 0- to 6-inch depth interval and one from the 6- to 12-inch depth interval) were collected, which is consistent with the 2007 STN background sampling. At the two parks, soil samples were collected from three discrete locations for a total of six soil samples per park. At each of the three cemeteries, soil samples were collected from one discrete location for a total of two samples per cemetery.

The soil samples were collected with a hand auger and placed in disposable plastic re-sealable bags to homogenize the sample before placing the soil in sample containers. Sample time, location ID, and depths were recorded in the field logbook. A photograph was taken at each discrete location with a white board indicating the location ID, park name, and date. A location ID, different from the sample ID, was used to easily identify the sample location. The following designations were used as the location IDs:

- PP = Pulaski Park
- HP = Harrison Park
- CEM = Cemetery

The hand auger was cleaned between each sample location with an Alconox/water mixture and rinsed with distilled water as specified in the FSP (SulTRAC 2009b). The soil samples were packaged and shipped under standard chain-of-custody (COC) procedures, as described in the project Sampling and Analysis Plan (SAP), to CLP laboratories for TAL metals and SVOC analyses.

SulTRAC used the following unique sample identification numbers (ID) to distinguish the background samples from the USS Lead Site samples:

- BKG = Background sample
- 3-digit number = sequential sample number unique for each property

- A/B/C = discrete location within the property
- 0-6/6-12 = depth of sample, in inches bgs

Therefore, sample ID "BKG079-A-0-6" would indicate that a background sample was collected from the "79th" property (in this case Pulaski Park) from discrete location "A" from the 0- to 6-inch bgs depth interval. The table below lists the background sample ID, the location ID, property address, and the name of the property. The analytical results and statistical study conducted on the background soil sample results are presented in Section 5.1 of this RI report.

Table 3-1: Background Sample IDs

Sample ID	Location ID	Property Address of Sample	Name of Property
BKG079-A-0-6	PP01	137th Street and South Grover Avenue, Hammond, IN	Pulaski Park
BKG079-A-6-12			
BKG079-B-0-6	PP02		
BKG079-B-6-12			
BKG079-C-0-6	PP03		
BKG079-C-6-12			
BKG080-A-0-6	HP01	Hohman Avenue and Waltham Street, Hammond, IN	Harrison Park
BKG080-A-6-12			
BKG080-B-0-6	HP02		
BKG080-B-6-12			
BKG080-C-0-6	HP03		
BKG080-C-6-12			
BKG081-A-0-6	CEM01	1547 167th Street, Hammond, IN	Saint Joseph/Saint John Cemetery
BKG081-A-6-12			
BKG081-B-0-6	CEM02		Saint Michael Cemetery
BKG081-B-6-12			
BKG081-C-0-6	CEM03		Elmwood Cemetery
BKG081-C-6-12			

Notes:

BKG	Background
CEM	Cemetery
HP	Harrison Park
ID	Identification number
PP	Pulaski Park

3.2.3 Soil Disposal Characteristics

SulTRAC collected three soil samples from a range of lead concentrations for Toxicity Characteristic Leaching Procedure (TCLP) testing. The purpose of this preliminary waste characterization of impacted soil was to assess whether the soils could be disposed of as non-hazardous waste, as was done during the

TCRA conducted in 2008. The three soil samples were collected from three different properties, based on the sample results collected from the Phase I field investigation. A discrete grab soil sample was collected from each of the following properties based on the total lead concentration:

- Aster Avenue from a front yard at the 6- to 12-inch depth interval (highest total lead concentration of Phase I properties: 9,406 mg/kg)
- Gladiola Avenue from a back yard at the 6- to 12-inch depth interval (total lead concentration of 3,774 mg/kg)
- McCook Avenue from a front yard at the 0- to 6-inch depth interval (total lead concentration of 1,019 mg/kg)

The soil samples were placed in 8-ounce glass containers supplied by the subcontracted laboratory, STAT Laboratories in Chicago, Illinois, placed in a cooler on ice, and delivered to the laboratory for TCLP lead and total lead analysis. Standard COC procedures were observed. Results of the TCLP lead analysis are presented in Section 5.3.1.1 of this RI report.

3.2.4 Confirmation Soil Sampling

Soils at 407 Vernon Avenue and 5018 Alexander Avenue were excavated by the City of East Chicago Department of Redevelopment in August 2010. Sampling during the December 2009 Phase I investigation revealed elevated lead concentrations at both properties. When SulTRAC arrived at the properties on September 27, 2010, they had been excavated to a depth of approximately 2 feet bgs. Based on visual observation, fill material was present at 407 Vernon Avenue at depths below 2 feet in the western center of the property. SulTRAC collected five-point composite samples from the front and back portions of each property at the bottom of the excavations. The soil samples were collected as described above, except that samples were collected only from the bottom of the excavations. Therefore, two samples from each property were submitted to a CLP laboratory for TAL metals and PAH analyses.

The confirmation soil samples revealed that lead concentrations above 400 mg/kg were present at the base of the 2-foot excavation at 407 Vernon Avenue. On October 12, 2010, the City of East Chicago Department of Redevelopment further excavated the front half of the property to a depth of 4 feet and the back of the property to 3 feet. A concrete slab at the front of the property prevented excavation beyond a depth of 4 feet. SulTRAC inspected the area of additional excavation once the excavation was complete and conducted XRF screening of soils on the property. SulTRAC collected 20 XRF measurements from the base of the excavation. No XRF readings from the base of the final excavation exceeded 400 mg/kg.

Details of the excavation oversight activities were documented in a letter report to the EPA (SulTRAC 2010c).

3.3 DATA QUALITY

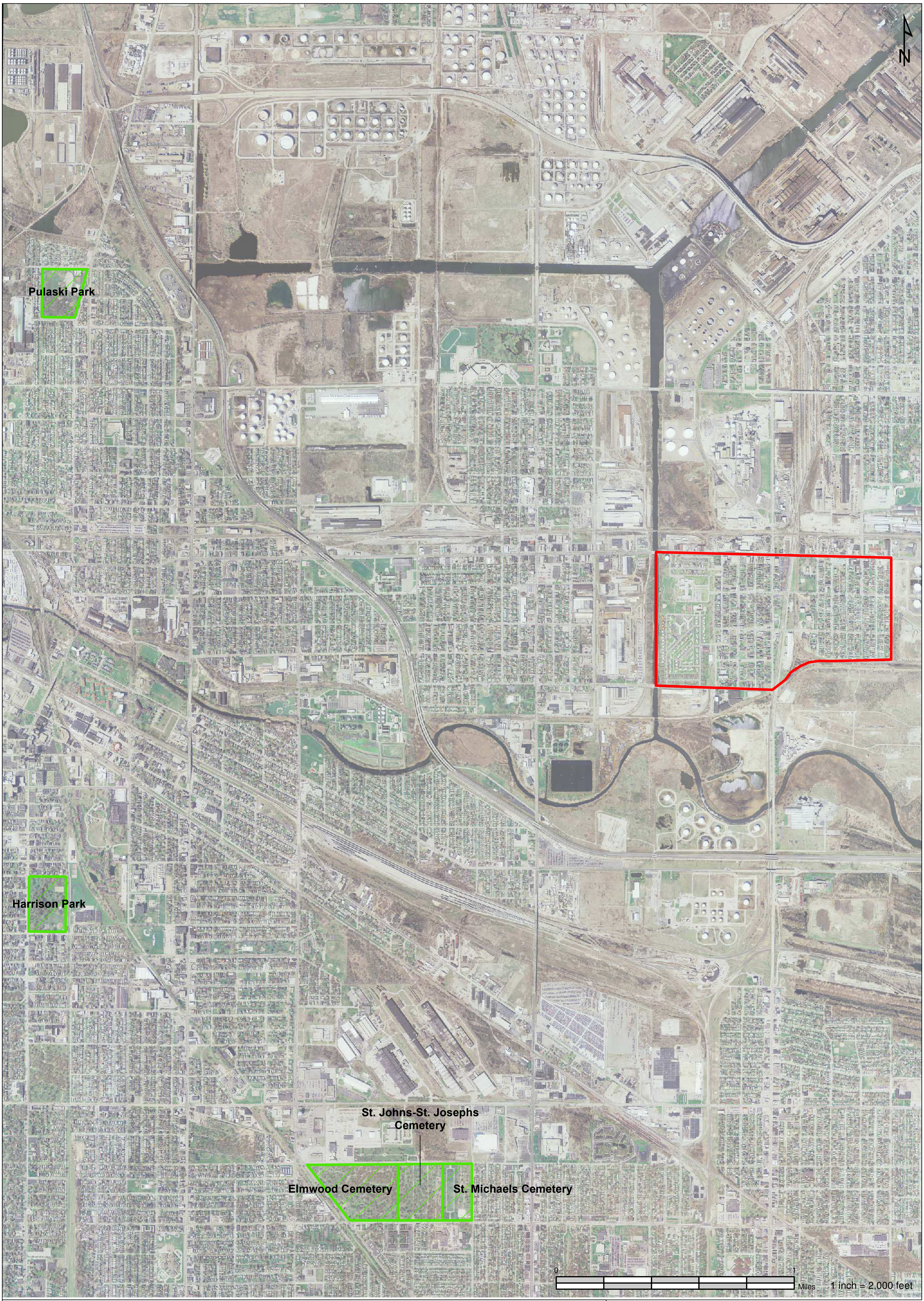
Upon receipt of the analytical results from the CLP laboratory, SulTRAC's senior chemist conducted data validation and prepared a Data Validation Report (DVR) for the Phase I soil sample results. The DVR was prepared in accordance with the EPA-approved work plan (SulTRAC 2009a). Data validation was conducted in accordance with the *EPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review, EPA-540-R-08-01* (June 2008); *EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, OSWER 9240.1-45, EPA 540-R-04-004* (October 2004); and SulTRAC's *Remedial Investigation/Feasibility Study Quality Assurance Project Plan, USS Lead Superfund Site, East Chicago, Lake County, Indiana* (October 2009). No major issues were identified that warrant corrective action; minor issues are discussed in the DVR in Appendix C.

From the Phase II sampling results, SulTRAC validated two sample delivery groups (SDG); all others were validated by EPA's Environmental Services Assistance Team (ESAT). SulTRAC's senior chemist performed a project-level validation on the SDGs validated by ESAT as well as making project-level decisions to use re-extracted/diluted results versus the original sample result. SulTRAC's two validated SDGs and ESAT's validation are presented in Appendix C. No major issues were identified that warrant corrective action; minor issues are discussed in the DVRs and ESAT's data-validation summaries.

FIGURES

Figure 3-1 OU1 Properties Sampled

REDACTED



🟥 OU-1 boundary

▨ Background sample areas

Imagery sources (clockwise from upper left):
ISDP (Indiana Spatial Data Portal)

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

FIGURE 3-2

BACKGROUND SAMPLING

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC

4.0 PHYSICAL CHARACTERISTICS

This section presents the physical characteristics of the USS Lead Site and its surrounding areas. The General Site Setting (Section 4.1), Surface Features (Section 4.2), Climate (Section 4.3), Soils (Section 4.4), Geology (Section 4.5), Hydrogeology (Section 4.6), Demography and Land Use (Section 4.7), and Ecology (Section 4.8) are discussed below.

4.1 GENERAL SITE SETTING

The USS Lead Site is located in East Chicago, Indiana. East Chicago is located on Lake Michigan and lies approximately 18 miles southeast of Chicago, Illinois. The City of East Chicago, Indiana, has a total area of 15.6 square miles (mi^2) of which 12 mi^2 are land and 3.7 mi^2 are water (East Chicago 2011). The OU1 Area of the USS Lead Site is the focus of this RI, and it is located in the southern portion of the city of East Chicago. OU1 encompasses approximately 322 acres and is bounded by East Chicago Avenue on the north, East 151st Street on the south, the Indiana Harbor Canal on the west, and Parrish Avenue on the east (see Figure 1-1). OU1 is a mixed residential and commercial/industrial area north of the former USS Lead industrial facility (OU2). The mixed-use area includes (1) numerous residences, including single and multi-family units, some of which are public housing in the southwest corner of the area, (2) various generally small commercial/industrial operations, (3) various municipal and community offices and operations, (4) two schools (the Carrie Gosch Elementary School and the Carmelite School for Girls), (5) four parks, and (6) numerous places of worship (see Figure 3-1). Residences, schools, and public parks constitute the large majority of properties and acreage within OU1.

The East Chicago area has historically supported a variety of industries. In addition to the USS Lead smelting operation, some other industrial operations may have also managed lead and other metals. For example, immediately east of OU2, across Kennedy Avenue, is the former DuPont site, which historically manufactured the pesticide lead arsenate. Northwest of OU2, west of Gladiola Street and north of 151st Street, two smelter operations managed lead and other metals (Geochemical Solutions 2004). These were the former Anaconda Lead Products and International Lead Refining Company, located on the current East Chicago Housing Authority Complex in the southwest corner of OU1. Anaconda Lead Products was a manufacturer of white lead and zinc oxide; the International Lead Refining Company was a metal-refining facility.

4.2 SURFACE FEATURES

The Grand Calumet River runs along the southern boundary of East Chicago, south of OU1. The Indiana Harbor Canal connects Lake Michigan with the Grand Calumet River, which forms the western border of OU1. OU1 is flat-lying and has little elevation change across the area, with an average elevation of 592 feet above mean sea level (msl) (East Chicago 2011).

4.3 CLIMATE

The City of East Chicago is located in northwestern Indiana, which is considered to have a humid continental climate with cool winters and warm, humid summers. The mean monthly temperatures in East Chicago vary between approximately 26°F in January and 71°F in July (East Chicago 2011). Mean annual rainfall is approximately 36.3 inches (NWS 2010). Annual total snowfall is approximately 45 inches. Lake-effect snow accounts for approximately half of the snowfall in this region, due to the effects of the moisture and relative warmth of Lake Michigan (East Chicago 2011). As noted in Section 1.3.1, Site Description, a five-year wind rose plot (see Figure 1-2) for the years 1987 to 1991 at a site in Hammond, Indiana, indicates that prevailing winds are from the southwest and north at less than 20 mph (EPA 2006). East Chicago also is prone to tornado activity, as activity is 118% greater than the overall U.S. average (City-Data 2011).

4.4 SOILS

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) identifies two different soil types within OU1: Urban Land (**Ur**) and Oakville-Adrian Complex, 0 to 6 percent slopes (**OkB**) (see Figure 4-1) (USDA 2010). Essentially, the entire residential area is classified as **Ur**, while two small areas, approximately 7 to 8% of the site acreage, are classified as **OkB**.

The **Ur** classification includes residential, industrial, commercial, and institutional land; construction and public administrative sites; railroads and railroad yards; cemeteries; airports; golf courses; sanitary landfills; sewage-treatment plants; and small parks and other facilities within urban or built-up areas. **Ur** has a non-irrigated capability classification 8. A Class 8 rating indicates the greatest limitations and narrowest choices for practical use (USDA 2010). Class 8 soils have limitations that preclude commercial agriculture and which restrict their use to recreational purposes, wildlife habitat, watershed, or aesthetic purposes.

During site investigations, SulTRAC identified five main soil varieties within the NRCS-designated **Ur** soil classification (see Table 4-1). The five soil types were organic topsoil, fill, fill with construction debris, fill with slag, and native sand. All but the native sand were found from the surface to depths of 24 inches bgs, depending on the location. Native sand, when found *in situ*, was typically located 18 to 24 inches bgs. The following table summarizes the listed five main soil varieties within the **Ur** classification as described by SulTRAC field personnel.

Table 4-1: Soil Types Observed at OU1

SulTRAC Abbreviation	Brief Description	Detailed Description/Notes
Ot	Organic Topsoil	Loose black to greyish-brown silty sand, usually restricted to upper sample
F	Fill	Grayish-brown to brown to gray fine, loose, unsorted sand
Fc	Fill with Construction Debris	Grayish-brown to brown to gray fine, loose, unsorted sand with construction debris such as brick fragments, metal nails, and assorted glass pieces
Fs	Fill with Slag	Grayish-brown to brown to gray fine, loose, unsorted sand with pieces of slag
Ns	Native Sand	Yellowish-brown to brown to gray fine, loose, unsorted sand. Native soil to the region typically covered with fill (F, Fc, Fs)

OkB is a complex made up of the Oakville soil type (60%) and the Adrian soil type (40%), which are so closely intermingled that both soil types cannot be differentiated on the NRCS soil maps. The Oakville soil type is a well-drained fine sand from ground surface down to approximately 60 inches bgs. The sand is likely derived from past aeolian processes which resulted in dune deposits. The Adrian soil type is a very poorly drained, usually saturated, muck and sand combination. The typical Adrian soil profile from 0 to 34 inches bgs is muck, and from 34 to 80 inches bgs is sand. This soil type is glacial in origin and likely formed in depressions on till, outwash, or lake plains.

OkB includes "partially hydric" soils, which are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils with at least one component of the map unit rated as hydric. Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation. **OkB** has a non-irrigated capability classification of 4. Class 4 soils have very severe limitations that reduce the choice of plants or require very careful management, or both. Only a few soil samples were collected in **OkB** areas during this investigation; soils in these areas were not significantly different from **Ur** soils.

4.5 GEOLOGY

The regional geology of northwest Indiana largely consists of unconsolidated Pleistocene glacial deposits which unconformably overlie Pennsylvanian Bedrock (ISGS 1975, Gray et al., 1987). The Quaternary-aged sediments from youngest to oldest include the Equality, Wadsworth, and Lemont Formations (see Figure 4-2).

The Equality Formation underlies the top few feet of soils described in Section 4.4. The Equality Formation, also known as the Calumet Aquifer, is primarily a sand unit with some silts, clays, and gravel interbeds or lenses. The Equality Formation is estimated to extend to approximately 25 feet bgs (585 to 560 feet above msl) in the vicinity of OU2 (RCI 1990).

The Wadsworth Formation underlies the Equality Formation in the Indiana Harbor Canal Region. The Wadsworth Formation, also referred to as the Wadsworth Till, is a clay/till unit which contains less than 15% sand and often less than 10% sand in its silt and clay matrix (Hansel 1985). The Wadsworth Till also acts as an aquitard to restrict downward migration of groundwater from the overlying Equality Formation (Calumet Aquifer). Regionally, the Wadsworth Formation is greater than 160 feet thick and is interpreted to have been deposited by end moraines that encircled the southern margin of Lake Michigan during the last glaciation. In the vicinity of the USS Lead Site, the Wadsworth Till is approximately 120 feet thick (560 to 440 feet above msl) (Watson, et al. 1989).

The Lemont Formation underlies the Wadsworth Formation. Locally, the Lemont Formation is mainly a glacial till facies that is typically gray to brown/tan in color and calcareous, with grain sizes ranging from silty clay to sandy loam to gravel. The predominant clast lithologies of the Lemont Formation include Paleozoic shales and carbonates. The Lemont Formation has been interpreted as subglacial and ice-marginal facies of several off-lapping, glaciogenic sequences (ISGS 1975).

Soil borings have not been advanced to any great depth in OU1, as the maximum depths of most of the soil borings reached 2 feet bgs. Boring logs and monitoring-well installation logs from previous site investigations conducted between OU1 and the Grand Calumet River provide geological information down to 40 feet bgs. Lithologic logs for 14 monitoring wells installed in this area show the typical geological profile for this site. Fill and sand from approximately 1 to 2 feet bgs overlie a fine sand unit to a depth of 29 feet bgs. This fine sand unit is described as 80 to 90% fine-grained quartz with 10 to 20% other fines (silts/clay). Within this sand unit are thin (0.5- to 2-inch thick) peat lenses which are associated with thin zones of marine fossils (“micro-shells”) and black streaking of the peat and/or sand matrix. At approximately 29 feet bgs, coarser sand or gravel layers are present which overlie a very firm gray calcareous clay unit, the top of which is at approximately 30 feet bgs. Of the 14 documented boring logs, 9 soil borings reached depths of 30 feet bgs or more (Geochemical Solutions 2004). This site-specific geological profile coincides with the regional profile outlined in the paragraph above. The sand and gravel layers are part of the Calumet Aquifer with the very firm gray clay marking the top of the Wadsworth Formation, a lacustrine clay and till stratigraphic unit. No boring logs were found to have advanced to either the Lemont Formation or bedrock in the immediate vicinity of the USS Lead Site.

4.6 HYDROGEOLOGY

Currently, groundwater is not being investigated as part of OU1 and will be included as part of OU2 at a later date. Therefore, all groundwater measurements, gradients, flow directions, etc., that are presented in this RI report are from previous site investigations in the immediate vicinity of OU2.

The Calumet Aquifer is not a local water-supply source. All municipalities in this region obtain water from Lake Michigan. The Calumet Aquifer is the uppermost aquifer and is generally saturated within the first 10 feet bgs. In 1989, groundwater elevations varied between approximately 585 feet above msl just south of OU1 to 582 feet above msl near the Grand Calumet River. These measurements are based on observations of standing water and regional groundwater measurements performed by the USGS in 1989 (Watson, et al. 1989). More recently, in 2004, groundwater elevations varied between 583 feet above msl just south of OU1 and 580 feet above msl near the Grand Calumet River (Geochemical Solutions 2004) (see Figure 4-3). Regionally, groundwater flows towards Lake Michigan, but in the vicinity of OU2, groundwater flows in a south/southwest direction towards the Grand Calumet River. Although undocumented, groundwater likely flows toward the Indiana Harbor Canal, so flow is likely to the west in the westernmost part of OU1.

Data collected from wells near the Indiana Harbor Canal and Grand Calumet River indicate that groundwater fluctuations in this area are complex. A 1989 USGS study identified local groundwater mounds and sinks and concluded that significant groundwater discharges to local ditches, wetlands, and sewer lines were likely in this area (Watson, et al. 1989).

The USGS study reports the following:

> Throughout the rest of the Grand Calumet River/Indiana Harbor Canal, the stream usually gained water from the aquifer. Normal and natural hydrologic factors caused flow patterns to reverse for varying periods of time. Bank storage affected the

> stream/aquifer interaction; and locally variable recharge, such as that produced by summer thunderstorms, also may have affected these interactions. Storms on Lake Michigan caused estuary-like effects on the Indiana Harbor Canal that could be detected as far as 4 miles upstream from the lake. These estuary-like effects caused the stage in the Indiana Harbor Canal to rise. When the stage in the Indiana Harbor Canal rose rapidly because of the estuary-like effects, the flow gradient was reversed, and the Indiana Harbor Canal lost water to the Calumet aquifer.

More recent groundwater measurements were acquired by reviewing 25 monitoring well and boring logs from the area south of OU1 and the Indiana Harbor Belt Railroad grade and north and east of the Grand Calumet River meander (see Figure 4-3). In this locality, the water table ranges from 3 to 14 feet bgs. Data from the first quarter of groundwater sampling in 2004 by Geochemical Solutions show groundwater elevations ranging between 579.50 and 583.55 feet above msl, with a southwest flow (Geochemical Solutions 2004). Generally, the groundwater contours in this area parallel the Grand Calumet River, with a groundwater sink in the southwest part of the CAMU at OU2 due to the inward hydraulic groundwater gradient established at the CAMU. Outside the CAMU, groundwater flows towards the Grand Calumet River, perpendicular to the potentiometric contour lines.

Hydraulic conductivities were measured in select wells associated with OU2 by ENTACT, Inc. and DAI Environmental during past site investigations. In 1996, a mean average hydraulic conductivity of 0.021 centimeters per second (cm/sec) was measured from slug tests at MW-2, MW-4, and MW-5 by ENTACT, Inc. (Geochemical Solutions 2004). In 2003, DAI Environmental measured individual conductivities from pumping tests at MW-5, MW-13, and MW-23 of 0.018 cm/sec, 0.009 cm/sec, and 0.021 cm/sec, respectively (Geochemical Solutions 2004). These conductivities decreased with increasing proximity to the Grand Calumet River.

The hydraulic gradient at OU2 is variable depending on location; however, the flow direction is generally to the southwest. Horizontal hydraulic gradients were calculated using first quarter 2004 groundwater elevation data (see Figure 4-3) (Geochemical Solutions). MW-5 and MW-8 are approximately 0.0034 foot/foot; those calculated using MW-3 and MW-13 are approximately 0.0031 foot/foot. It is likely that the horizontal gradient in OU1 would be somewhat lower than that immediately adjacent to the Grand Calumet River.

The vertical hydraulic gradient at OU2 was calculated using first quarter groundwater elevation data from 2004 in two site well pairs, MW-1/MW-14 and MW-9/MW-10. The results indicate a downward gradient of 0.0044 foot/foot just south of OU1 (MW-1/MW-14, just a few feet south of the Indiana Harbor Belt Railroad grade). The other monitoring well pair (MW-9/MW-10) had a downward gradient of

0.0029 foot/foot and was located nearly 600 feet east of Kennedy Avenue and 1,200 feet north of the Grand Calumet River. There are several other monitoring well pairs at the facility (see Figure 4-3); however, the well pairs are situated in the vicinity of either an artificial inward gradient created by the CAMU or at the shoreline of a surface-water body. Therefore, these vertical gradients are not necessarily indicative of site conditions in OU1.

4.7 DEMOGRAPHY AND LAND USE

East Chicago's population in July 2009 was 29,900, of which 51.6% were Hispanic, 35.2% were African American, and 12.1% were White, non-Hispanic (City-Data 2011). The East Chicago median household income was $27,900, versus the Indiana median household income of $45,424 (City-Data 2011). The annual unemployment rate as of April 2010 for East Chicago was 13.3%, compared to the Indiana 2009 annual unemployment rate of 9.9% (City-Data 2011). The density of East Chicago was approximately 2,496 people per square mile, and the average household size in East Chicago was 2.8 people (City-Data 2011). Based on the average household size and the number of homes in OU1, the approximate density within OU1 in East Chicago is 7,000 people per square mile. Based on an inspection of historical aerial photographs, the primary land use in East Chicago is industrial. Residential land use accounts for approximately 20% of the city's land. OU1 is one of the most densely populated areas in East Chicago.

EPA considers East Chicago an environmental justice community, which means it is a community that historically is an under-represented minority and low-income area burdened with significant environmental challenges (EPA 2011b).

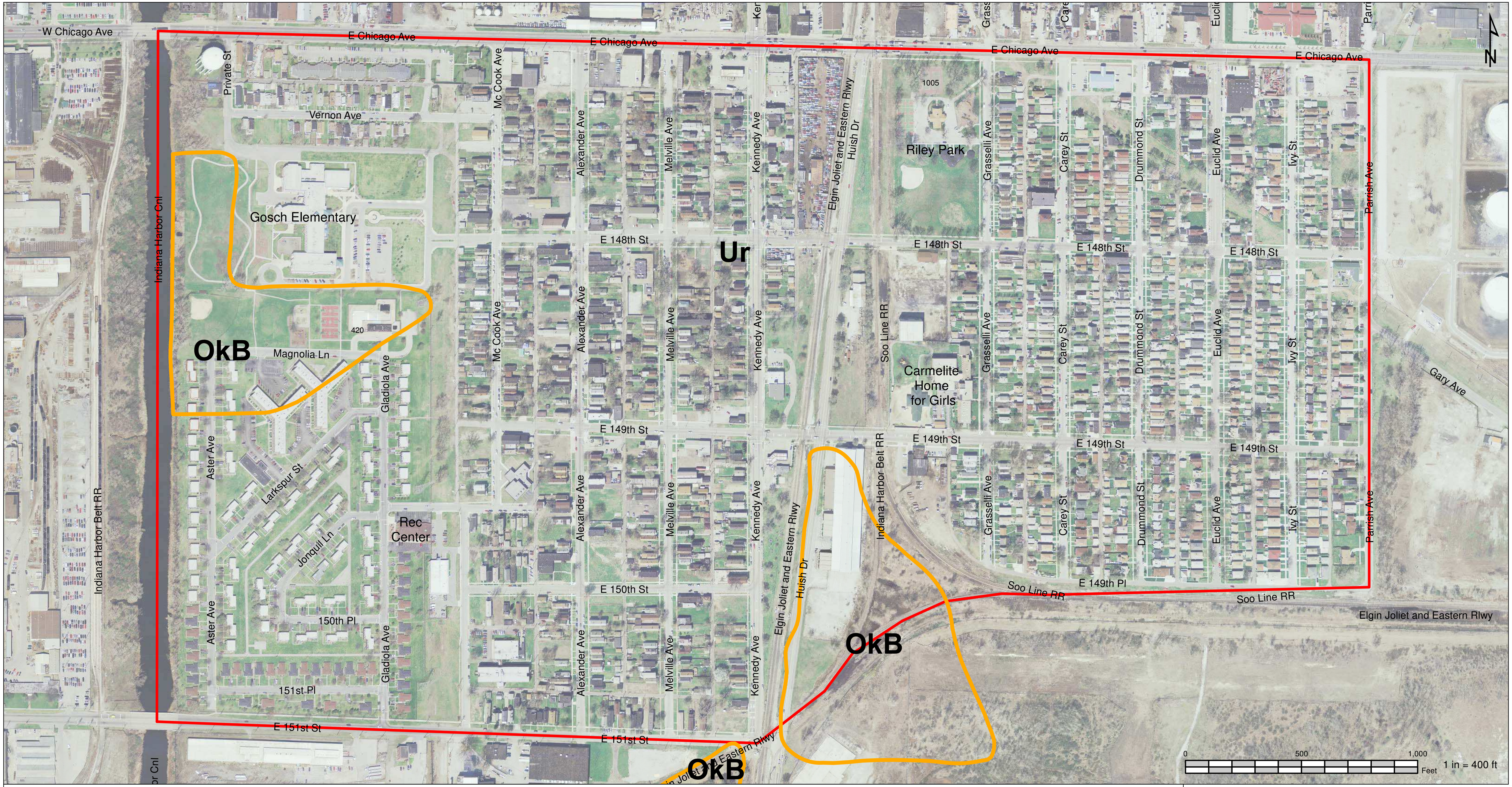
4.8 ECOLOGY

No ecological habitats have been identified within OU1. A wetland area is located within OU2. The wetland includes the following ecological wetland habitat areas: marsh/riparian, upland, dune and swale, savanna, and scrub shrub (TechLaw 2004a).

The wetland areas at the USS Lead Site border the Grand Calumet River and the Indiana Harbor Canal. The Grand Calumet River is an impaired waterway and is contaminated with conventional pollutants, heavy metals, and organic compounds. The contamination in the river has resulted in contaminated sediments, degradation of fish populations, and other biota impacts (EPA 2011a). The wetland area is a habitat known to be used by State-designated endangered and threatened species, including the marsh wren (*cistothorus palustris*), a state-designated endangered bird; Bebbs sedge (*carex bebbi*), a state threatened plant; blandings turtles (*emydoidea blandingii*), a state endangered turtle; and franklin ground squirrel (*spermophilus franklinii*), a state designated endangered animal (EPA 2008a).

The Indiana Dunes National Lakeshore Area lies 10 miles east of OU1. The Indiana Dunes National Lakeshore Area contains 15 miles of Lake Michigan shoreline and 15,000 acres of dunes, oak savannas, swamps, bogs, marshes, prairies, rivers, and forest habitats (NPS 2006).

FIGURES



🟧 Soil area

🟥 OU-1 boundary

Soil types:
OkB—Oakville-Adrian complex, 0 to 6 percent slopes
Ur – Urban Land

Source:
Modified from: USDA. 2010. “Natural Resources Conservation Service Web Soil Survey.”
Accessed on January 26, 2011.
On-line Address: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Imagery sources:
ISDP (Indiana Spatial Data Portal)

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

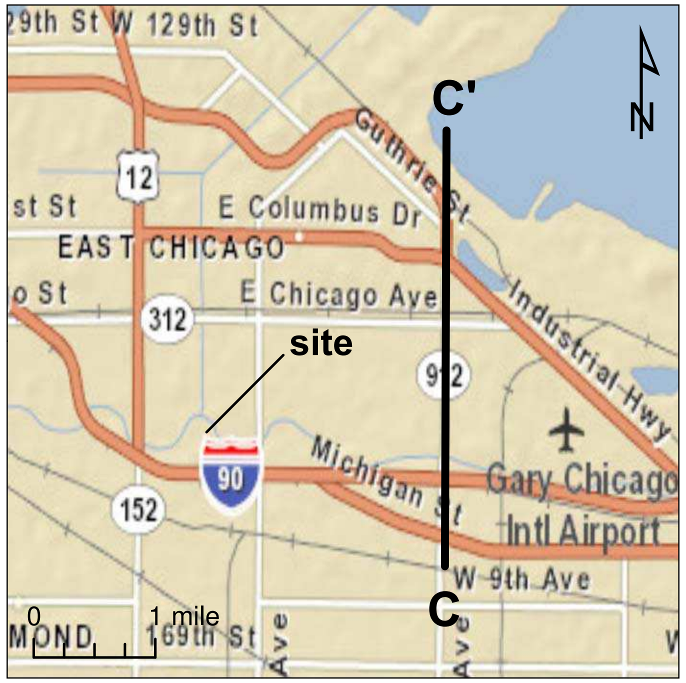
REMEDIAL INVESTIGATION REPORT

FIGURE 4-1

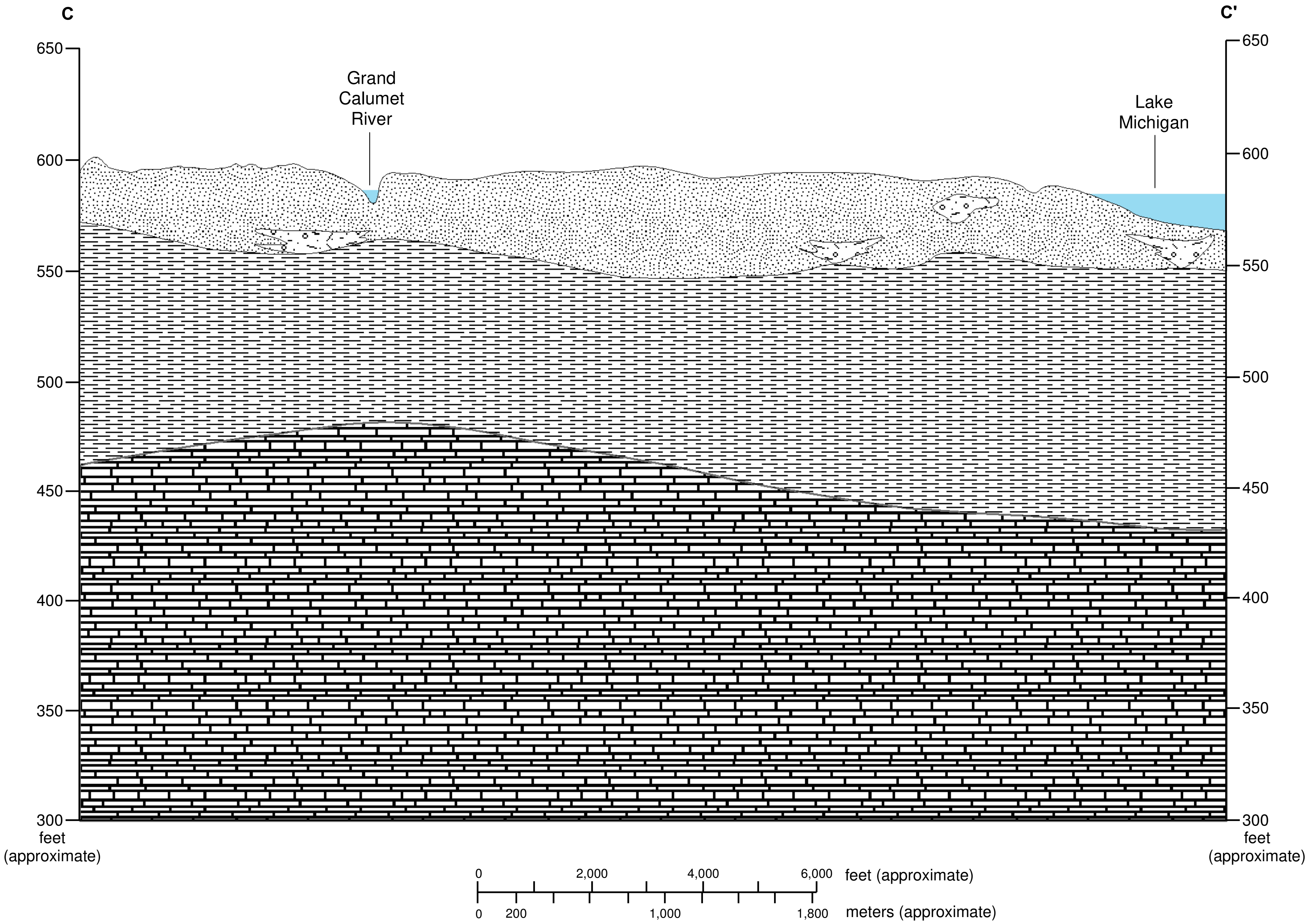
SITE SOILS

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



Line of section



- ▨ Silt, sand and gravel (Calumet aquifer)
- ▨ Sand and gravel (Calumet aquifer)
- ▤ Till
- ▦ Bedrock

Source:
Modified from USGS Open File Report 88-492, 1989
and Report 94-4110, 1995

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

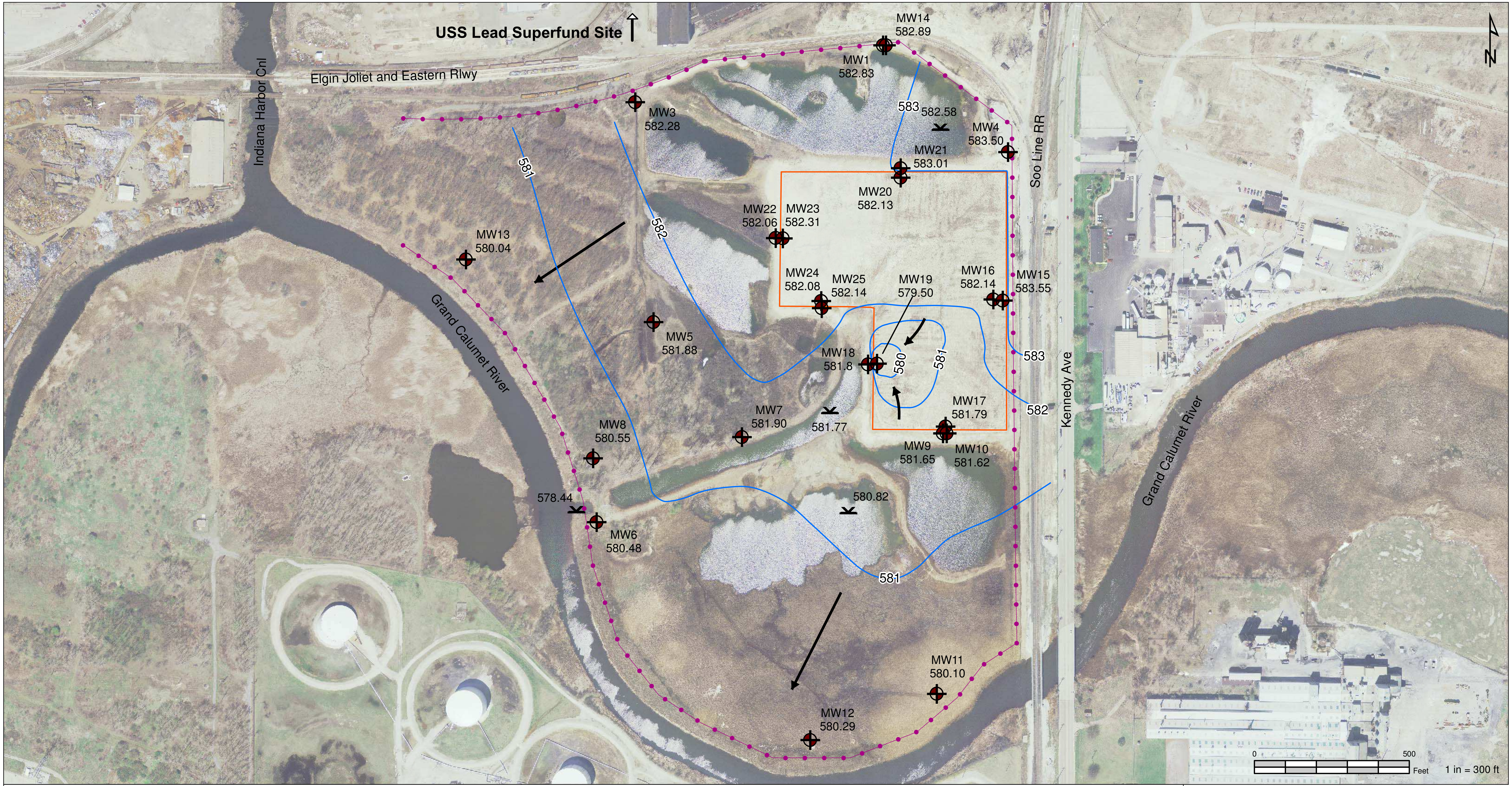
REMEDIAL INVESTIGATION REPORT

FIGURE 4-2

GENERALIZED REGIONAL GEOLOGIC CROSS-SECTION

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



580.55 Groundwater elevation (First Quarter 2000)

580.10 Surface water elevation (First Quarter 2004)

Groundwater contour

Groundwater flow

Fence

CAMU slurry wall (OU-2)

Source:
Modified from: Geochemical Solutions. 2004.
"Draft Final USS Lead Modified RCRA Facility Investigation (MRFI) Report." March 1.

Imagery source:
ISDP (Indiana Spatial Data Portal)

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

FIGURE 4-3

MONITORING WELL LOCATIONS AND GROUNDWATER FLOW IN THE VICINITY OF USS LEAD SITE

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC

5.0 NATURE AND EXTENT OF CONTAMINATION

This section summarizes the nature and extent of constituents of interest (COI) identified at OU1 of the USS Lead Site. SulTRAC collected surface and subsurface soil samples in 2009 and 2010 from a total of 88 properties to investigate the nature and extent of contamination in and around OU1 of the USS Lead Site. As required by the Handbook and as referenced in Section 3.1 above, the soil samples were analyzed for lead and various combinations of other metals, cyanide, VOCs, SVOCs, PCBs, and pesticides (EPA 2003a). No groundwater samples were collected as part of this RI. Since no groundwater, surface water, or sediment samples were collected, the entire discussion of the nature and extent of contamination in this RI report is limited to soils. Groundwater at the USS Lead Site will be considered as part of the OU2 study and has not been evaluated as part of this RI.

This section discusses the results of the soil investigation on OU1 and includes an examination of the laboratory analytical results. The examination focuses on the site COIs, lead, arsenic, and PAHs. The primary COI at the Site is lead; however, since arsenic and PAHs were also detected in soil, they are included in all analytical discussions about the nature and extent of contamination. The investigation methods and proposed remedy for lead are based on the guidance provided in the Handbook; hence, lead does not require as much discussion as arsenic and PAHs. Despite the additional text in this RI report discussing arsenic and PAHs at the Site, lead is the primary COI and is the COI driving the remedy.

This section of the RI report is organized as follows: First, the SSLs that were used to identify contaminated areas are presented (Section 5.1). Next, the universe of analytical results that are included in the discussion is defined (Section 5.2). Then, the nature and extent of contamination are discussed on an individual contaminant basis (Section 5.3). Following this discussion, the distribution of contaminants across OU1 is discussed (Section 5.4). Finally, the overall conclusions about the nature and extent of contamination are summarized (Section 5.5).

5.1 SITE SCREENING LEVELS

SSLs were developed for the chemicals detected at the site and are presented in Tables 5-1 through 5-4. Although SVOCs (including PAHs), pesticides, and PCBs are discussed in this RI report, there is no reasonable expectation that consistent releases of these compounds into the OU1 area are associated with a metals smelting facility (USS Lead). Rather, as discussed further in Section 8, detections of these compounds are associated with other anthropogenic sources typical of a metropolitan industrial area, and the results discussed herein are intended for completeness of this RI report only.

The first step in characterizing the nature-and-extent evaluation was to select conservative SSLs. Conservative screening tools were used to identify chemicals that might pose a risk to human health or the environment. As discussed in Section 2.0 (Regulatory Guidance) of the Handbook, EPA residential RSLs, IDEM RISC residential DCTs, and BTVs were used to develop SSLs for this RI. The SSLs used to evaluate the RI analytical results were the lower of the EPA residential RSLs, the IDEM RISC residential DCTs, or the Handbook lead values. Because many metals occur naturally or ubiquitously in urban areas, a BTV was calculated for selected metals and PAHs. To account for the possible natural occurrence of lead and other elements, if the BTV was higher than the value selected above, the BTV was used. The BTV was used as the SSL for arsenic and several PAHs, because background concentrations exceeded risk-based screening levels. A summary of the soil SSLs is presented in Tables 5-1 through 5-4 for metals, PAHs, VOCs, and PCBs/pesticides, respectively.

As summarized above in Section 3.2.2, background soil samples were collected in August 2010 from two public parks and three cemeteries in Lake County, Indiana (see Figure 3-2). Within each park/cemetery, grab soil samples were collected from two depths (0-6 inches bgs and 6-12 inches bgs). At the two parks, soil samples were collected from three discrete locations for a total of six soil samples per park. At each of the three cemeteries, soil samples were collected from one discrete location for a total of two samples per cemetery. The grab samples were sent to EPA's CLP laboratories for analysis for TAL metals and SVOCs. The statistical procedures used to derive the BTVs are described in Appendix B to the Risk Assessment (see Appendix E to this RI Report).

To evaluate whether background concentrations should be pooled across depths or evaluated separately for each depth for individual chemicals, a series of qualitative evaluations and tests performed. The qualitative evaluation concluded that the background sample results were the same regardless of depth. Next, the combined data were reviewed and analyzed using multiple tests and evaluations to identify and remove outlier concentrations from the data set. Outliers were removed from the raw data and excluded from calculations performed on the trimmed or final background data sets. Based on the trimmed background data set, estimates were derived for an upper threshold or plausible upper bound (sometimes referred to as a "concentration limit," although BTV is the term used by EPA [EPA 2010b]) for the background distribution for individual chemicals. The statistical procedures used to derive the BTVs are presented in the “Proposed Approach for Developing Background Data Sets and Conducting Background Screening of Site Results” (see Appendix B to the Risk Assessment [Appendix E to this RI Report]).

The BTVs used to establish SSLs for metals and PAHs are presented in Tables 5-1 and 5-2, respectively. The calculated BTVs are less than the RSLs and IDEM RISC DCT values for all metals except arsenic, and for all PAHs, except for benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene. BTVs were not calculated for VOCs, PCBs, or pesticides.

5.2 DATA CONSIDERED IN THIS REMEDIAL INVESTIGATION

SulTRAC collected samples from 88 properties between December 2009 and August 2010. Figures 5-1 through 5-3 present the locations of the soil samples collected and analyzed during the RI for metals, organic compounds, and from drip zones, respectively. Appendix A presents analytical data for soils collected during this RI. Soil samples collected during three separate field efforts were considered in this RI. These three events were:

- Historical sampling of 66 samples from 56 properties, conducted by EPA and analyzed by XRF in 2003
- Phase I RI sampling of 74 properties, consisting of 189 residential yards, quadrants, and drip zones, conducted by SulTRAC, with all samples analyzed by XRF and 20 percent of samples analyzed by CLP in 2009.(two properties sampled during the 2009 sampling event were excavated by the City of East Chicago and the results from those properties are not considered here)
- Phase II RI data-gap sampling of 17 properties within OU1, consisting of 46 residential yards, quadrants, and drip zones (including three properties from 2009 that were revisited) sampled by SulTRAC and analyzed by CLP in 2010

When both CLP and XRF samples were collected and analyzed for the same location, the maximum sample result was selected and presented in the data discussion, tables, and figures in this RI report. Based on the Handbook, samples were collected from front and back yards, drip zones, and quadrants for large properties such as schools and parks. Drip zones often provide evidence of lead-based paint or aerial deposition of contaminants running off roofs. Because drip zone samples were composite samples collected from along the perimeter of a residence, it was not possible to assign drip zone samples to a front or back yard, and they were considered separately as an independent “yard” that spanned the entire property. Therefore, a “yard” was defined as one of the following sample types: front yard (F), back yard (B), drip zone (D), or quadrant (QA, QB, QC, QD). Accordingly, a typical property might have three "yards": a front, back, and a drip zone. Discrete samples from flower gardens, vegetable gardens, and play areas were combined into their respective yards for the purposes of this discussion.

Eighty-eight unique properties were sampled by SulTRAC in 2009 and 2010, including 79 residences, five recreational areas, one school, and three industrial/commercial properties. The industrial/commercial properties were addressed in the same manner as the residential and recreational areas. The Carmelite Home for Girls, located on Grasselli Avenue, is both a school and a residence. For the purposes of this discussion, the Carmelite Home for Girls was addressed as a residential property with two front yards and two back yards. EPA measured soil lead concentrations in 80 samples collected from 69 properties in OU1 in 2003. As noted in Section 1.3.2, 13 of these properties were remediated as part of a TCRA in 2008. The samples from the properties remediated during the TCRA were excluded from the data set presented in this RI report; therefore, 56 properties from the 2003 EPA event are included. The 2003 EPA sampling locations were not re-sampled during the Phase I or Phase II sampling; however, the 2003 data are included in this RI report to assist in characterizing the extent of contamination at OU1.

A total of 780 unique soil samples were collected during the 2003 and 2009 sampling events and were analyzed by XRF for total lead. XRF samples were collected from surface soil (0-2 inches bgs; 0-3 inches bgs; 0-6 inches bgs) and subsurface soil (6-12 inches bgs; 12-18 inches bgs; 18-24 inches bgs) intervals. XRF results are included in Tables 5-5 through 5-8, where the maximum lead result between CLP lead and XRF lead is reported for surface (0-6 inches bgs) and subsurface (6-24 inches bgs) results on a yard basis. All XRF lead results are presented in Appendix A, Table A-1.

Including all three sampling events, a total of 780 soil samples from OU1 were screened for total lead with the XRF and 369 soil samples (including 36 duplicate samples) were submitted to the CLP laboratory for total metals analysis. Additionally, eight soil samples were analyzed for VOCs, 15 samples were analyzed for SVOCs, 215 samples (including 21 duplicate samples) were analyzed for PAHs, 10 samples were analyzed for PCBs and pesticides, and six soil samples were sieved and each size fraction was analyzed for total metals. Tables A-1 through A-7 in Appendix A present the analytical results for XRF lead, CLP Metals, VOCs, SVOCs, PAHs, PCBs and pesticides, and CLP sieved metals, respectively.

Duplicate samples were collected for all matrices as described in the SAP and Amended SAP (SulTRAC 2009b, SulTRAC 2010a). For duplicate samples, the text and statistical data presented in this section consider only the maximum value of an analyte detected in the original or duplicate sample. Tables A-1 through A-7 in Appendix A present all analytical results, including both original and duplicate sample results. Statistical handling of duplicate sample results in the risk assessment was based on the procedures outlined in Section 7.0 of this RI report.

Samples collected during RI sampling were identified based on the property type where each specific sample was collected. Each residential property had a unique sample identifier with the following format:

Street – sequential number – yard location – depth – sample type

Sample identifiers consisted of the first three letters or numbers of a street name (e.g., DRU for Drummond, 151 for 151st Street); a sequential number (e.g., "001" for the first sample collected); a yard designator ("F" for front yard facing street, "B" for back yard, and "D" for drip zone); a depth designator ("0 – 6" for zero to 6 inches bgs); and a suffix designating sample type ("D" for duplicate sample, "V" for vegetable garden, "F" for flower garden, "P" for play area sample, and "R" for equipment rinsate).

In addition, each residential location was further identified by sample type. The sample types for residential samples included "F" for front facing yard, "B" for back yard, "D" for drip zone, "FD" for field duplicate, "VG" for vegetable garden, "FG" for flower garden, and "P" for play area. For example, a sample collected from 12 to 18 inches bgs from a play area in the back yard of a residential property at 4856 Drummond Street, and which was the 231st sample collected by the sample team, would be designated as DRU231-B-12-18-P. The sample type for this sample would be "P" for play area.

Non-residential properties, including schools and public parks, sampled during the 2009 Phase I sampling and the 2010 data-gap sampling had a unique sample identifier with the following format:

Street – sequential number – quadrant – depth – sample type

Sample identifiers consisted of the first three letters or numbers of a street name (e.g., DRU for Drummond, 151 for 151st Street); a sequential number (e.g., "001" for the first sample collected); a quadrant designator ("A", "B", "C", or "D"); a depth designator ("0 – 6" for zero to 6 inches bgs); and a suffix designating sample type ("D" for duplicate sample, "P" for play area sample, and "R" for equipment rinsate). In addition, each non-residential location was further identified by sample type. The sample types for non-residential samples included "QA" for quadrant A, "QB" for quadrant B, "QC" for quadrant C, "QD" for quadrant D, "FD" for field duplicate, and "P" for play area. For example, a duplicate sample collected from 18 to 24 inches bgs in quadrant C at Carrie Gosh School, located at 455 E. 148^{th} Street, which was the 119th sample collected by the sample team, would be designated 148119-C-18-24-D. The sample type for this sample would be "FD."

In March 2010, the EPA FIELDS Group performed simple linear regression and regression diagnostics to find the "best-fit" linear relationship between the XRF results for lead levels in soil and the corresponding laboratory results using SAS® software (Appendix D) (EPA 2010a). This relationship was quantified into a model (equation) of the XRF results for lead and their corresponding laboratory results. Details on the regression diagnostics are presented in Appendix D.

SulTRAC used the following "best-fit" linear relationship to adjust all of the XRF lead results to obtain more representative total lead results in the soil:

$$\ln(adjusted\ Pb\ Concentration) = -0.06205 + [(1.03769) \times \ln(measured\ Pb\ Concentration)]$$

A regression analysis of the XRF and CLP results for lead showed that the two results correlate better at low concentrations (less than 500 mg/kg) than at high concentrations (greater than 2,000 mg/kg). Although the linear relationship between the two results is less clear at higher concentrations, the two results correlate well at the regulatory threshold of 400 mg/kg. The adjusted XRF lead results, including both the 2003 EPA RCRA and SulTRAC RI results, exceeded the SSL of 400 mg/kg at a total of 75 properties (55 percent). The lateral distribution of lead at the Site, the lateral distribution within each property, the vertical distribution, size fractionation, and correlation with fill types, are discussed below in Section 5.4, Distribution of Contaminants.

5.3 STATISTICAL SUMMARY OF ANALYTICAL RESULTS

Soil sample results were compared to SSLs to identify COIs. The analytical results for those COIs where an analytical result exceeded a screening criterion are discussed in this section.

5.3.1 Metals

A total of 88 properties were sampled and evaluated for metals during the RI. From these 88 properties, 232 distinct yards, including front yards, back yards, drip zones, and quadrants, were sampled. Flower gardens, vegetable gardens, and play areas were combined into their respective yards for the purposes of this discussion. The 232 yards were composed of 77 front yards, 72 back yards, 60 drip zones, and 23 recreational quadrants. Samples collected from each of the yards were analyzed for lead by either XRF or

TAL metals by CLP. A subset of the 136 yards at 73 properties was analyzed for the 24 TAL metals by CLP.

In total, 730 unique samples were analyzed by XRF for lead only; and 333 unique samples (including 36 field duplicate samples) were analyzed by a CLP laboratory for TAL metals. Ten of the 24 TAL metals were detected at concentrations above their respective SSLs in at least one soil sample. Tables 5-5 through 5-8 summarize the results of all COIs in OU1, for surface and subsurface samples in residential and recreational properties, respectively. Appendix Table A-1 presents the adjusted XRF results for lead for each sample analyzed; Appendix Table A-2 presents the full set of TAL metals analyzed by the CLP laboratory for each sample. Results for the individual metal analytes are discussed below in order of the number of SSL exceedances, with the most numerous exceedances discussed first. In the following discussion, a yard was considered to exceed an SSL if a composite sample or discrete sample from any depth exceeded an SSL.

5.3.1.1 Lead

All samples collected during the RI sampling events were analyzed for lead. Due to the multiple types of lead analyses performed, this section of the RI report is organized as follows: First, the lead results from the RI sampling are presented. Next, the lead results from both the RI sampling and the historical 2003 EPA RCRA XRF results are combined and presented. Lastly, the results for the subset of samples analyzed for TCLP lead are presented.

Lead Results – RI:

During the 2009/2010 SulTRAC RI sampling events, 88 properties, consisting of 232 yards, were sampled and analyzed for lead by a combination of XRF and CLP TAL Metals. The 232 yards were composed of 77 front yards, 72 back yards, 60 drip zones, and 23 recreational quadrants. The following yards were sampled and analyzed for lead by CLP: 49 front yards, 49 back yards, 20 drip zones, and 18 recreational quadrants. The results discussed below include both XRF and CLP results from the RI sampling events. The results are discussed below on a yard basis.

The RSL for lead in residential soils is 400 mg/kg (EPA 2010c). The IDEM RISC direct soil contact value for lead in residential soils is also 400 mg/kg (IDEM 2009). The BTVs for lead in surface and subsurface soils are 112 and 56.6 mg/kg, respectively. The lead SSL is equal to the RSL and IDEM RISC values of 400 mg/kg, as presented in Table 5-1. Based on the 2009/2010 SulTRAC RI sampling events:

- Surface soil from 30 front yards (39 percent) exceeded the SSL for lead. Subsurface soil from 23 front yards (30 percent) exceeded the SSL for lead. The maximum detected soil lead concentration in a front-yard sample was 16,700 mg/kg, from subsurface soil on Aster Avenue. The sample (AST062-F-12-18) was analyzed by XRF, collected in December 2009 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

- Surface soil from 34 back yards (47 percent) exceeded the SSL for lead. Subsurface soil from 27 back yards (38 percent) exceeded the SSL for lead. The maximum detected soil lead concentration in a back yard sample was 27,100 mg/kg, from subsurface soil on East 150th Place. The sample (150057-B-18-24) was analyzed by XRF, collected in December 2009 from 18-24" bgs, and was composed of soil type **Fs** – Fill with slag.

- Surface soil from 35 drip zones (58 percent) exceeded the SSL for lead. No subsurface soil samples were collected from drip zones. The maximum detected soil lead concentration in a drip zone sample was 5,290 mg/kg, from surface soil on Melville Avenue. The sample (MEL010-D-0-6) was analyzed by CLP, collected in December 2009 from 0-6" bgs, and was composed of soil type **Ot** – Organic topsoil.

- Surface soil from 7 recreational quadrants (30 percent) exceeded the SSL for lead. Subsurface soil from 9 recreational quadrants (39 percent) exceeded the SSL for lead. The maximum detected soil lead concentration in a recreational quadrant sample was 6,770 mg/kg, from subsurface soil on Magnolia Lane, quadrant B. The sample (GOO084-B-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

During the RI sampling events, a total of 232 yards in OU1 were analyzed for lead (by either CLP or XRF), of which surface and/or subsurface soil in 123 yards (53 percent) exceeded the SSL. Yards that exceeded the SSL for lead are shown on Figures 5-4 through 5-6. Lead exceeded the SSL more frequently in surface soils than in subsurface soils. Additional discussion of the lead results is provided below in Section 5.4, Distribution of Constituents of Interest.

Lead Results – Historical and RI:

During the 2003 EPA RCRA investigation, 66 surface soil samples from 56 properties were collected from OU1 and were analyzed by XRF for lead. The 2003 EPA RCRA data were collected from the front and back yards of residential properties, as well as from quadrant areas in parks. No drip zone samples were collected in the 2003 EPA RCRA investigation. Compiling the 2003 EPA RCRA and the 2009/2010 SulTRAC RI samples together yields samples that were collected from 295 yards, composed of 90 front yards, 106 back yards, 60 drip zones, and 39 recreational quadrants. Figure 5-1 shows the sampling locations from the 2003 EPA RCRA investigation, all of which were from surface soils. This work was not performed by SulTRAC and, therefore, is not a focus of this RI report. The 2003 EPA RCRA data are not included in the Risk Assessment presented in Section 7.0 of this report. A brief summary of the data is included here for completeness and to illustrate the sample coverage in OU1.

These data will be considered during the Feasibility Study (FS) Phase at the USS Lead Site when determining the limits of remediation. Based on the 2009/2010 SulTRAC RI data and the 2003 EPA RCRA investigation data:

- Surface soil from 34 front yards (38 percent) exceeded the SSL for lead. Incorporating the 2003 EPA RCRA and 2009/2010 SulTRAC RI data, the maximum detected soil lead concentration in a front yard sample was 16,700 mg/kg, from subsurface soil on Aster Avenue. The sample (AST062-F-12-18) was analyzed by CLP, collected in December 2009 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

- Surface soil from 48 back yards (45 percent) exceeded the SSL for lead. Incorporating the 2003 EPA RCRA and 2009/2010 SulTRAC RI data, the maximum detected soil lead concentration in a back yard sample was 27,100 mg/kg, from subsurface soil on East 150th Place. The sample (150057-B-18-24) was analyzed by CLP, collected in December 2009 from 18-24" bgs, and was composed of soil type **Fs** – Fill with slag.

- No drip zone samples were collected in the 2003 EPA RCRA investigation.

- Surface soil from 17 recreational quadrants (44 percent) exceeded the SSL for lead. The maximum detected soil lead concentration in a recreational quadrant sample was 6,770 mg/kg from subsurface soil on Magnolia Lane, quadrant B. The sample (GOO084-B-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

Compiling the 2003 EPA RCRA and the 2009/2010 SulTRAC RI samples yielded 295 yards in OU1 that were analyzed for lead, of which surface and/or subsurface soil in 134 yards (45 percent) exceeded the SSL. Yards that exceeded the SSL for lead are shown on Figures 5-4 through 5-6. Lead exceeded the SSL more frequently in surface soils than in subsurface soils. Additional discussion of the lead results is included below in Section 5.4, Distribution of Constituents of Interest.

TCLP Lead Results:

As part of the 2008 TCRA, one composite soil sample was submitted for waste characterization analysis (Weston 2009). The total lead concentration in that composite sample was not specified in the Removal Action report, but lead concentrations in these soils ranged from 1,200 to 3,000 mg/kg. TCLP extraction and analysis of metals were performed on the composite sample, and that sample did not exceed the TCLP disposal criterion of 5 milligrams per liter (mg/L).

During the RI soil sampling event in August 2010, three TCLP samples were collected to assess the total lead concentration levels that might require disposal as RCRA hazardous waste as part of Remedial Actions involving soil removal from the Site. Three properties were selected for testing based on the results of XRF lead screening from December 2009. The properties selected represented the breadth of total lead concentrations, ranging from just above the lead SSL of 400 mg/kg to near the maximum concentration measured. Total lead analysis was requested along with TCLP lead for direct comparison. Data are summarized in Table 5-9.

Table 5-9: Total Lead *vs.* TCLP Lead Concentrations

Sample ID	Address	Total Pb (mg/kg)	TCLP Pb (mg/L)
MCL-TCLP-0-6	XXX McCook Avenue	590	0.12
GLA-TCLP-6-12	XXX Gladiola Avenue	3,000	6.2
AST-TCLP-6-12	XXX Aster Avenue	12,000	10

A plot of the data summarized above was generated to illustrate total *vs.* TCLP lead concentrations. An exponential regression was performed to generate a "best fit" curve for the data, as shown in Figure 5-7. Based on this very limited data set, the total lead concentration in soil that may require disposal as RCRA hazardous waste is predicted to be approximately 2,400 mg/kg. SulTRAC estimates that soil results containing total lead concentrations above 2,400 mg/kg may exhibit characteristics of hazardous waste and require disposal as hazardous waste based on preliminary extrapolation of TCLP results for these three samples.

5.3.1.2 Arsenic

During the 2009/2010 SulTRAC RI sampling event, 73 properties, consisting of 136 yards, were sampled and analyzed for arsenic by CLP TAL Metals. The 136 yards were composed of 49 front yards, 49 back yards, 20 drip zones, and 18 recreational quadrants. The results are discussed below on a yard basis. As noted above, lead is the primary contaminant driving the remedy at the USS Lead Site. Arsenic is a naturally occurring background compound, and an appropriate RSL is needed to distinguish the naturally occurring arsenic concentrations at the site from those that may be impacted by activities in and around the site. Although arsenic concentrations are screened against the SSL in the following section of this report using a uniform methodology to maintain a consistent screening approach, the SSL is not considered the appropriate RSL to trigger cleanup of a property, as discussed in Section 8.4.2. The RSL for arsenic in residential soils is 0.39 mg/kg (EPA 2010c). The IDEM RISC direct soil contact value for arsenic in residential soils is 3.9 mg/kg (IDEM 2009). The BTVs for arsenic in surface and subsurface soils are 14.1 and 13.2 mg/kg, respectively. The arsenic SSL is equal to the surface and subsurface BTVs for arsenic, as presented in Table 5-1. Based on the 2009/2010 SulTRAC RI sampling events:

- Surface soil from 16 front yards (33 percent) exceeded the surface SSL for arsenic. Subsurface soil from 15 front yards (31 percent) exceeded the subsurface SSL for arsenic. The maximum detected soil arsenic concentration in a front yard sample was 567 mg/kg, from subsurface soil on

Aster Avenue. The sample (AST062-F-12-18) was analyzed by CLP, collected in December 2009 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

- Surface soil from 20 back yards (41 percent) exceeded the surface SSL for arsenic. Subsurface soil from 18 back yards (37 percent) exceeded the subsurface SSL for arsenic. The maximum detected soil arsenic concentration in a back yard sample was 239 mg/kg, from subsurface soil on East 150th Place. The sample (150057-B-18-24) was analyzed by CLP, collected in December 2009 from 18-24" bgs, and was composed of soil type **Fs** – Fill with slag.

- Surface soil from 11 drip zones (55 percent) exceeded the surface SSL for arsenic. No subsurface soil samples were collected from drip zones. The maximum detected soil arsenic concentration in a drip zone sample was 169 mg/kg, from surface soil on Drummond Street. The sample (DRU051-D-0-6) was analyzed by CLP, collected in December 2009 from 0-6" bgs, and was composed of soil type **F** – Fill.

- Surface soil from 5 recreational quadrants (28 percent) exceeded the surface SSL for arsenic. Subsurface soil from 7 recreational quadrants (38 percent) exceeded the subsurface SSL for arsenic. The maximum detected soil arsenic concentration in a recreational quadrant sample was 414 mg/kg, from subsurface soil on Magnolia Lane, quadrant A. The sample (GOO084-A-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

During the RI sampling events, a total of 136 yards in OU1 were analyzed for arsenic, of which surface and/or subsurface soil in 75 yards (55 percent) exceeded the SSL. Yards that exceeded the SSL for arsenic are shown on Figures 5-8 through 5-10. Arsenic exceeded the SSL more frequently in surface soils than in subsurface soils.

5.3.1.3 Antimony

During the 2009/2010 SulTRAC RI sampling events, 73 properties, consisting of 136 yards, were sampled and analyzed for antimony by CLP TAL Metals. The 136 yards were composed of 49 front yards, 49 back yards, 20 drip zones, and 18 recreational quadrants. The results are discussed below on a yard basis.

The RSL for antimony in residential soils is 31 mg/kg (EPA 2010c). The IDEM RISC direct soil contact value for antimony in residential soils is 140 mg/kg (IDEM 2009). The BTV for antimony in surface and subsurface soils is 8.3 mg/kg. The SSL is equal to the RSL for antimony, as presented in Table 5-1. Based on the 2009/2010 SulTRAC RI sampling events:

- None of the surface soil from front yards (0 percent) exceeded the SSL for antimony. Subsurface soil from 5 front yards (10 percent) exceeded the SSL for antimony. The maximum detected soil antimony concentration in a front yard sample was 994 mg/kg, from subsurface soil on Aster Avenue. The sample (AST062-F-12-18) was analyzed by CLP, collected in December 2009 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

- Surface soil from 2 back yards (4 percent) exceeded the SSL for antimony. Subsurface soil from 4 back yards (8 percent) exceeded the SSL for antimony. The maximum detected soil antimony concentration in a back yard sample was 455 mg/kg, from subsurface soil on Aster Avenue. The sample (AST059-B-12-18) was analyzed by CLP, collected in December 2009 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

- None of the surface soil from drip zones (0 percent) exceeded the SSL for antimony. No subsurface soil samples were collected from drip zones.

- None of the surface soil from recreational quadrants (0 percent) exceeded the SSL for antimony. Subsurface soil from 3 recreational quadrants (17 percent) exceeded the SSL for antimony. The maximum detected soil antimony concentration in a recreational quadrant sample was 143 mg/kg, from subsurface soil on Magnolia Lane, quadrant A. The sample (GOO084-A-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

During the RI sampling events, a total of 136 yards in OU1 were analyzed for antimony, of which surface and/or subsurface soil in 13 yards (10 percent) exceeded the SSL. Antimony exceeded the SSL more frequently in subsurface soils than in surface soils. Nine of the thirteen yards where antimony concentrations exceeded the SSL were located in the East Chicago Housing Authority complex, which is in the southwest corner of OU1.

5.3.1.4 Cadmium

During the 2009/2010 SulTRAC RI sampling events, 73 properties, consisting of 136 yards, were sampled and analyzed for cadmium by CLP TAL Metals. The 135 yards were composed of 49 front yards, 49 back yards, 20 drip zones, and 18 recreational quadrants. The results are discussed below on a yard basis.

The RSL for cadmium in residential soils is 70 mg/kg (EPA 2010c). The IDEM RISC direct soil contact value for cadmium in residential soils is 12 mg/kg (IDEM 2009). The BTVs for cadmium in surface and subsurface soils are 1.57 and 8.89 mg/kg, respectively. The cadmium SSL is equal to the IDEM RISC value of 12 mg/kg, as presented in Table 5-1. Based on the 2009/2010 SulTRAC RI sampling events:

- None of the surface soil from front yards (0 percent) exceeded the SSL for cadmium. Subsurface soil from 2 front yards (4 percent) exceeded the SSL for cadmium. The maximum detected soil cadmium concentration in a front yard sample was 27.9 mg/kg, from subsurface soil on Aster Avenue. The sample (AST062-F-6-12) was analyzed by CLP, collected in December 2009 from 6-12" bgs, and was composed of soil type **Fs** – Fill with slag.

- None of the surface soil from back yards (0 percent) exceeded the SSL for cadmium. Subsurface soil from 2 back yards (4 percent) exceeded the SSL for cadmium. The maximum detected soil cadmium concentration in a back yard sample was 111 mg/kg, from subsurface soil on Ivy Street.

The sample (IVY038-B-12-18) was analyzed by CLP, collected in December 2009 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

- Surface soil from 1 drip zone (5 percent) exceeded the SSL for cadmium. No subsurface soil samples were collected from drip zones. The maximum detected soil cadmium concentration in a drip zone sample was 14.4 mg/kg, from surface soil on Melville Avenue. The sample (MEL010-D-0-6) was analyzed by CLP, collected in December 2009 from 0-6" bgs, and was composed of soil type **Ot** – Organic topsoil.
- None of the surface or subsurface soil from recreational quadrants (0 percent) exceeded the SSL for cadmium.

During the RI sampling events, a total of 136 yards in OU1 were analyzed for cadmium, of which surface and/or subsurface soil in 5 yards (4 percent) exceeded the SSL.

5.3.1.5 Cobalt

During the 2009/2010 SulTRAC RI sampling events, 73 properties, consisting of 136 yards, were sampled and analyzed for cobalt by CLP TAL Metals. The 136 yards were composed of 49 front yards, 49 back yards, 20 drip zones, and 18 recreational quadrants. The results are discussed below on a yard basis.

The RSL for cobalt in residential soils is 23 mg/kg (EPA 2010c). There is no IDEM RISC direct soil contact value for cobalt in residential soils (IDEM 2009). The BTV for cobalt in surface and subsurface soils is 7.7 mg/kg. The cobalt SSL is equal to the RSL value of 23 mg/kg, as presented in Table 5-1. Based on the 2009/2010 SulTRAC RI sampling events:

- None of the surface or subsurface soil from front yards (0 percent) exceeded the SSL for cobalt.
- None of the surface or subsurface soil from back yards (0 percent) exceeded the SSL for cobalt.
- Surface soil from 1 drip zone (5 percent) exceeded the SSL for cobalt. No subsurface soil samples were collected from drip zones. The maximum detected soil cobalt concentration in a drip zone sample was 24.2 mg/kg from subsurface soil on Melville Avenue. The sample (MEL010-D-0-6) was analyzed by CLP, collected in December 2009 from 0-6" bgs, and was composed of soil type **Ot** – Organic topsoil.
- None of the surface or subsurface soil from recreational quadrants (0 percent) exceeded the SSL for cobalt.

During the RI sampling events, a total of 136 yards in OU1 were analyzed for cobalt; surface and/or subsurface soil in 1 yard (less than 1 percent) exceeded the SSL.

5.3.1.6 Copper

During the 2009/2010 SulTRAC RI sampling events, 73 properties, consisting of 136 yards, were sampled and analyzed for copper by CLP TAL Metals. The 136 yards were composed of 49 front yards, 49 back yards, 20 drip zones, and 18 recreational quadrants. The results are discussed below on a yard basis.

The RSL for copper in residential soils is 3,100 mg/kg (EPA 2010c). The IDEM RISC direct soil contact value for copper in residential soils is 14,000 mg/kg (IDEM 2009). The BTVs for copper in surface and subsurface soils are 31.3 and 33.1 mg/kg, respectively. The copper SSL is equal to the RSL value of 3,100 mg/kg, as presented in Table 5-1. Based on the 2009/2010 SulTRAC RI sampling events:

- None of the surface or subsurface soil from front yards (0 percent) exceeded the SSL for copper.
- None of the surface soil from back yards (0 percent) exceeded the SSL for copper. Subsurface soil from 1 back yard (2 percent) exceeded the SSL for copper. The maximum detected soil copper concentration in a back yard sample was 29,600 mg/kg from subsurface soil on Ivy Street. The sample (IVY038-B-6-12-D) was analyzed by CLP, collected in December 2009 from 6-12" bgs, and was composed of soil type **Fs** – Fill with slag.
- None of the surface soil from drip zones (0 percent) exceeded the SSL for copper. No subsurface soil samples were collected from drip zones.
- None of the surface or subsurface soil from recreational quadrants (0 percent) exceeded the SSL for copper.

During the RI sampling events, a total of 136 yards in OU1 were analyzed for copper; surface and/or subsurface soil in 1 yard (less than 1 percent) exceeded the SSL.

5.3.1.7 Iron

During the 2009/2010 SulTRAC RI sampling events, 73 properties, consisting of 136 yards, were sampled and analyzed for iron by CLP TAL Metals. The 136 yards were composed of 49 front yards, 49 back yards, 20 drip zones, and 18 recreational quadrants. The results are discussed below on a yard basis.

The RSL for iron in residential soils is 55,000 mg/kg (EPA 2010c). There is no IDEM RISC direct soil contact value for iron in residential soils (IDEM 2009). The BTV for iron in surface and subsurface soils is 17,618 mg/kg. The iron SSL is equal to the RSL value of 55,000 mg/kg, as presented in Table 5-1. Based on the 2009/2010 SulTRAC RI sampling events:

- None of the surface soil from front yards (0 percent) exceeded the SSL for iron. Subsurface soil from 1 front yard (2 percent) exceeded the SSL for iron. The maximum detected soil iron concentration in a front yard sample was 101,000 mg/kg from subsurface soil on Euclid Avenue. The sample (EUC025-F-12-18) was analyzed by CLP, collected in December 2009 from 12-18" bgs, and was composed of soil type **Fc** – Fill with construction debris.

- Surface soil from 1 back yard (2 percent) exceeded the SSL for iron. Subsurface soil from 1 back yard (2 percent) exceeded the SSL for iron. The maximum detected soil iron concentration in a back yard sample was 91,300 mg/kg, from subsurface soil on Euclid Avenue. The sample (EUC025-B-6-12) was analyzed by CLP, collected in December 2009 from 6-12" bgs, and was composed of soil type **F** – Fill.
- None of the surface soil from drip zones (0 percent) exceeded the SSL for iron. No subsurface soil samples were collected from drip zones.
- None of the surface or subsurface soil from recreational quadrants (0 percent) exceeded the SSL for iron.

During the RI sampling events, a total of 136 yards in OU1 were analyzed for iron, of which surface and/or subsurface soil in 2 yards (1 percent) exceeded the SSL. Both yards that exceeded the iron SSL were from the same property on Euclid Avenue.

5.3.1.8 Manganese

During the 2009/2010 SulTRAC RI sampling events, 73 properties, consisting of 136 yards, were sampled and analyzed for manganese by CLP TAL Metals. The 136 yards were composed of 49 front yards, 49 back yards, 20 drip zones, and 18 recreational quadrants. The results are discussed below on a yard basis.

The RSL for manganese in residential soils is 1,800 mg/kg (EPA 2010c). There is no IDEM RISC direct soil contact value for manganese in residential soils (IDEM 2009). The BTV for manganese in surface and subsurface soils is 478 mg/kg. The manganese SSL is equal to the RSL value of 1,800 mg/kg, as presented in Table 5-1. Based on the 2009/2010 SulTRAC RI sampling events:

- Surface soil from 1 front yard (2 percent) exceeded the SSL for manganese. Subsurface soil from 2 front yards (4 percent) exceeded the SSL for manganese. The maximum detected soil manganese concentration in a front yard sample was 4,780 mg/kg, from subsurface soil on Melville Avenue, from a flower garden. The sample (MEL012-F-12-18-F) was analyzed by CLP, collected in December 2009 from 12-18" bgs, and was composed of soil type **Ot** – Organic topsoil.
- Surface soil from 2 back yards (4 percent) exceeded the SSL for manganese. Subsurface soil from 1 back yard (2 percent) exceeded the SSL for manganese. The maximum detected soil manganese concentration in a back yard sample was 3,490 mg/kg, from subsurface soil on Euclid Avenue. The sample (EUC025-B-6-12) was analyzed by CLP, collected in December 2009 from 6-12" bgs, and was composed of soil type **F** – Fill.

- Surface soil from 1 drip zone (5 percent) exceeded the SSL for manganese. No subsurface soil samples were collected from drip zones. The maximum detected soil manganese concentration in a drip zone sample was 8,180 mg/kg, from surface soil on Euclid Avenue. The sample (EUC095-D1-0-6) was analyzed by CLP, collected in August 2010 from 0-6" bgs, and was composed of soil type **Fs** – Fill with slag.

- None of the surface or subsurface soil from recreational quadrants (0 percent) exceeded the SSL for manganese.

During the RI sampling events, a total of 136 yards in OU1 were analyzed for manganese, of which surface and/or subsurface soil in 5 yards (4 percent) exceeded the SSL.

5.3.1.9 Mercury

During the 2009/2010 SulTRAC RI sampling events, 73 properties, consisting of 136 yards, were sampled and analyzed for mercury by CLP TAL Metals. The 136 yards were composed of 49 front yards, 49 back yards, 20 drip zones, and 18 recreational quadrants. The results are discussed below on a yard basis.

The RSL for mercury in residential soils is 5.6 mg/kg (EPA 2010c). The IDEM RISC direct soil contact value for mercury in residential soils is 100 mg/kg (IDEM 2009). The BTV for mercury in surface and subsurface soils is 0.16 mg/kg. The mercury SSL is equal to the RSL value of 5.6 mg/kg, as presented in Table 5-1. Based on the 2009/2010 SulTRAC RI sampling events:

- None of the surface or subsurface soil from front yards (0 percent) exceeded the SSL for mercury.

- Surface soil from 1 back yard (2 percent) exceeded the SSL for mercury. Subsurface soil from 1 back yard (2 percent) exceeded the SSL for mercury. The maximum detected soil mercury concentration in a back yard sample was 6.2 mg/kg from surface soil on Melville Avenue. The sample (MEL016-B-0-6) was analyzed by CLP, collected in December 2009 from 0-6" bgs, and was composed of soil type **F** – Fill.

- None of the surface soil from drip zones (0 percent) exceeded the SSL for mercury. No subsurface soil samples were collected from drip zones.

- None of the surface or subsurface soil from recreational quadrants (0 percent) exceeded the SSL for mercury.

During the RI sampling events, a total of 136 yards in OU1 were analyzed for mercury, of which surface and/or subsurface soil in 1 yard (less than 1 percent) exceeded the SSL.

5.3.1.10 Zinc

During the 2009/2010 SulTRAC RI sampling events, 73 properties, consisting of 136 yards, were sampled and analyzed for zinc by CLP TAL Metals. The 136 yards were composed of 49 front yards, 49 back yards, 20 drip zones, and 18 recreational quadrants. The results are discussed below on a yard basis.

The RSL for zinc in residential soils is 23,000 mg/kg (EPA 2010c). The IDEM RISC direct soil contact value for zinc in residential soils is 100,000 mg/kg (IDEM 2009). The BTV for zinc in surface and subsurface soils is 195 mg/kg. The zinc SSL is equal to the RSL value of 23,000 mg/kg, as presented in Table 5-1. Based on the 2009/2010 SulTRAC RI sampling events:

- None of the surface or subsurface soil from front yards (0 percent) exceeded the SSL for zinc.
- None of the surface soil from back yards (0 percent) exceeded the SSL for zinc. Subsurface soil from 1 back yard (2 percent) exceeded the SSL for zinc. The maximum detected soil zinc concentration in a back yard sample was 44,600 mg/kg, from subsurface soil on Aster Avenue. The sample (AST059-B-12-18) was analyzed by CLP, collected in December 2009 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.
- None of the surface soil from drip zones (0 percent) exceeded the SSL for zinc. No subsurface soil samples were collected from drip zones.
- None of the surface soil from recreational quadrants (0 percent) exceeded the SSL for zinc. Subsurface soil from 1 recreational quadrant (6 percent) exceeded the SSL for zinc. The maximum detected soil zinc concentration in a recreational quadrant sample was 32,900 mg/kg, from subsurface soil on Magnolia Lane, quadrant B. The sample (GOO084-B-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of soil type **Fs** – Fill with slag.

During the RI sampling events, a total of 136 yards in OU1 were analyzed for zinc, of which surface and/or subsurface soil in 2 yards (1 percent) exceeded the SSL.

5.3.1.11 Metals in Soil Summary

Lead and several other metals, including arsenic and antimony, frequently exceeded the SSL for residential soils in OU1. Metals most frequently exceeded their respective SSL in soil type **F** – Fill. Lead exceeded the SSL in 48% of front yards, 57% of back yards, 58% of drip zones, and 43% of quadrants. Due to historical site activities; lead is the primary COI at the Site. In addition to lead, arsenic and antimony exceeded their SSLs and tended to be co-located with lead concentrations above the SSL. For example, at the subset of properties analyzed for metals, both arsenic and lead exceeded the SSL in 71% of front yards, 87% of back yards, and 82% of drip zones sampled. All front yards and back yards that exceeded the antimony SSL also exceeded the lead SSL. There is a positive correlation between lead and arsenic, as well as between lead and antimony.

5.3.2 Volatile Organic Compounds

VOCs were analyzed for eight soil samples from eight separate properties in OU1 shown on Figure 5-2. A summary of the VOC soil SSLs is presented in Table 5-3. No BTVs were calculated for any VOC compounds. Two VOCs—benzene and trichlorofluoromethane—were detected in the samples submitted for VOC analysis. Benzene was detected in three of the eight samples, at concentrations ranging up to 2.6 micrograms per kilogram (µg/kg). The SSL for benzene is 1,100 µg/kg. Trichlorofluoromethane was detected in three of the eight samples submitted, at concentrations ranging up to 0.6 µg/kg. The SSL for trichlorofluoromethane is 790,000 µg/kg. No soil samples exceeded the SSLs for any VOC. All VOC results are included in Appendix A, Table A-3.

5.3.3 Semi-Volatile Organic Compounds

As stated in Section 5.1, although SVOCs (including PAHs) are discussed below, there is no reasonable expectation that consistent releases of these compounds into the OU1 area are associated with a metals smelting facility (USS Lead). Rather, as discussed further in Section 8, detections for these compounds are associated with other anthropogenic sources typical of a metropolitan industrial area, and results discussed herein are intended for completeness of the RI report only.

During the 2009/2010 SulTRAC RI sampling events, 26 properties, consisting of 53 yards, were sampled and analyzed for SVOCs/PAHs by CLP. For the purposes of this RI report, SVOC and PAH results are combined due to the overlapping analyte lists and are referred to as "PAH analyses." All of the compounds exceeding SSLs were included in both the PAH and SVOC analytical methods. The 53 yards were composed of 18 front yards, 13 back yards, 9 drip zones, and 13 recreational quadrants. The results are discussed below on a yard basis.

A summary of the PAH soil SSLs is presented in Table 5-2. Six PAHs were detected at concentrations above the SSLs in at least one soil sample. Tables 5-5 through 5-8 summarize the COIs that exceeded SSLs for all soil samples by yard. Tables A-4 and A-5 in Appendix A present the full set of SVOC and PAH results, respectively. SSLs were used as conservative screening levels for PAHs. However, PAH concentrations in soils in OU1 are comparable to urban soils in the Chicago metropolitan area (USGS 2003), which are considerably higher than the site-specific BTVs. Although BTVs are presented as the basis for comparison in this section of this RI report, EPA has determined that BTVs are not the appropriate standard to trigger a remedial action, as discussed further in Section 8.4.3.

Results for the individual PAHs are discussed below in order of the number of SSL exceedances, with the most frequent exceedances discussed first.

5.3.3.1 Benzo(a)pyrene

The RSL for benzo(a)pyrene in residential soils is 15 µg/kg (EPA 2010c). The IDEM RISC direct soil contact value for benzo(a)pyrene in residential soils is 500 µg/kg (IDEM 2009). The BTVs for benzo(a)pyrene in surface and subsurface soils are 97 and 39 µg/kg, respectively. The SSL is equal to the BTV for both surface and subsurface benzo(a)pyrene, as presented in Table 5-2. Based on the 2009/2010 SulTRAC RI sampling events:

- Surface soil from 10 front yards (56 percent) exceeded the surface SSL for benzo(a)pyrene. Subsurface soil from 17 front yards (94 percent) exceeded the subsurface SSL for benzo(a)pyrene. The maximum detected soil benzo(a)pyrene concentration in a front yard sample was 4,700 µg/kg, from subsurface soil on Parrish Avenue, field duplicate. The sample (PAR092-F-6-12-D) was analyzed by CLP, collected in August 2010 from 6-12" bgs, and was composed of a combination of soil types **Fc** – Fill with construction debris, and **Fs** – Fill with slag.

- Surface soil from 10 back yards (77 percent) exceeded the surface SSL for benzo(a)pyrene. Subsurface soil from 11 back yards (85 percent) exceeded the subsurface SSL for benzo(a)pyrene. The maximum detected soil benzo(a)pyrene concentration in a back yard sample was 2,500 µg/kg, from subsurface soil on Carey Street. The sample (CAR032-B-6-12) was analyzed by CLP, collected in December 2009 from 6-12" bgs, and was composed of soil type **Fc** – Fill with construction debris.

- Surface soil from 9 drip zones (100 percent) exceeded the surface SSL for benzo(a)pyrene. No subsurface soil samples were collected from drip zones. The maximum detected soil benzo(a)pyrene concentration in a drip zone sample was 8,600 µg/kg, from surface soil on Alexander Avenue. The sample (ALE089-D1-0-6) was analyzed by CLP, collected in August 2010 from 0-6" bgs, and was composed of soil type **F** – Fill.

- Surface soil from 11 recreational quadrants (85 percent) exceeded the surface SSL for benzo(a)pyrene. Subsurface soil from 12 recreational quadrants (92 percent) exceeded the subsurface SSL for benzo(a)pyrene. The maximum detected soil benzo(a)pyrene concentration in a recreational quadrant sample was 5,600 µg/kg, from subsurface soil on East 148th Street. The sample (148086-B-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of a combination of soil types **Fc** – Fill with construction debris, and **Fs** – Fill with slag.

During the RI sampling events, a total of 53 yards in OU1 were analyzed for benzo(a)pyrene, of which surface and/or subsurface soil in 50 yards (94 percent) exceeded the SSL. Yards that exceeded the SSL for any PAH/SVOC compound are shown on Figures 5-11 through 5-13.

5.3.3.2 *Dibenz(a,h)anthracene*

The RSL for dibenz(a,h)anthracene in residential soils is 15 µg/kg (EPA 2010c). The IDEM RISC direct soil contact value for dibenz(a,h)anthracene in residential soils is 500 µg/kg (IDEM 2009). The BTVs for dibenz(a,h)anthracene in surface and subsurface soils are 26 and 9.4 µg/kg, respectively. The SSL for dibenz(a,h)anthracene for surface sample results is equal to the BTV; for subsurface results, the SSL is equal to the RSL, as presented in Table 5-2. Based on the 2009/2010 SulTRAC RI sampling events:

- Surface soil from 11 front yards (61 percent) exceeded the surface SSL for dibenz(a,h)anthracene. Subsurface soil from 15 front yards (83 percent) exceeded the subsurface SSL for dibenz(a,h)anthracene. The maximum detected soil dibenz(a,h)anthracene concentration in a front yard sample was 1,100 µg/kg, from subsurface soil on Parrish Avenue, field duplicate. The sample (PAR092-F-6-12-D) was analyzed by CLP, collected in August 2010 from 6-12" bgs, and was composed of a combination of soil types **Fc** – Fill with construction debris, and **Fs** – Fill with slag.

- Surface soil from 10 back yards (77 percent) exceeded the surface SSL for dibenz(a,h)anthracene. Subsurface soil from 10 back yards (77 percent) exceeded the subsurface SSL for dibenz(a,h)anthracene. The maximum detected soil dibenz(a,h)anthracene concentration in a back yard sample was 380 µg/kg, from subsurface soil on Carey Street. The sample (CAR032-B-6-12) was analyzed by CLP, collected in December 2009 from 6-12" bgs, and was composed of soil type **Fc** – Fill with construction debris.

- Surface soil from 9 drip zones (100 percent) exceeded the surface SSL for dibenz(a,h)anthracene. No subsurface soil samples were collected from drip zones. The maximum detected soil dibenz(a,h)anthracene concentration in a drip zone sample was 1,100 µg/kg, from surface soil on Alexander Avenue. The sample (ALE089-D1-0-6) was analyzed by CLP, collected in August 2010 from 0-6" bgs, and was composed of soil type **F** – Fill.

- Surface soil from 11 recreational quadrants (85 percent) exceeded the surface SSL for dibenz(a,h)anthracene. Subsurface soil from 12 recreational quadrants (92 percent) exceeded the subsurface SSL for dibenz(a,h)anthracene. The maximum detected soil dibenz(a,h)anthracene concentration in a recreational quadrant sample was 1,800 µg/kg, from subsurface soil on East 148th Street. The sample (148086-B-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of a combination of soil types **Fc** – Fill with construction debris, and **Fs** – Fill with slag.

During the RI sampling events, a total of 53 yards in OU1 were analyzed for dibenz(a,h)anthracene, of which surface and/or subsurface soil in 49 yards (92 percent) exceeded the SSL. Yards that exceeded the SSL for any PAH/SVOC compound are shown on Figures 5-11 through 5-13.

5.3.3.3 *Benzo(b)fluoranthene*

The RSL for benzo(b)fluoranthene in residential soils is 150 µg/kg (EPA 2010c). The IDEM RISC direct soil contact value for benzo(b)fluoranthene in residential soils is 5,000 µg/kg (IDEM 2009). The BTVs for benzo(b)fluoranthene in surface and subsurface soils are 160 and 150 µg/kg, respectively. The benzo(b)fluoranthene SSL is equal to the BTV for surface sample results, and to the RSL for subsurface results, as presented in Table 5-2. Based on the 2009/2010 SulTRAC RI sampling events:

- Surface soil from 11 front yards (61 percent) exceeded the surface SSL for benzo(b)fluoranthene. Subsurface soil from 13 front yards (72 percent) exceeded the subsurface SSL for benzo(b)fluoranthene. The maximum detected soil benzo(b)fluoranthene concentration in a front yard sample was 5,200 µg/kg, from surface soil on Alexander Avenue. The sample (ALE089-F-0-6) was analyzed by CLP, collected in August 2010 from 0-6" bgs, and was composed of soil type **F** – Fill.

- Surface soil from 10 back yards (77 percent) exceeded the surface SSL for benzo(b)fluoranthene. Subsurface soil from 9 back yards (69 percent) exceeded the subsurface SSL for benzo(b)fluoranthene. The maximum detected soil benzo(b)fluoranthene concentration in a back yard sample was 3,900 µg/kg, from subsurface soil on Carey Street. The sample (CAR032-B-6-12) was analyzed by CLP, collected in December 2009 from 6-12" bgs, and was composed of soil type **Fc** – Fill with construction debris.

- Surface soil from 8 drip zones (89 percent) exceeded the surface SSL for benzo(b)fluoranthene. No subsurface soil samples were collected from drip zones. The maximum detected soil benzo(b)fluoranthene concentration in a drip zone sample was 11,000 µg/kg, from surface on Alexander Avenue. The sample (ALE089-D1-0-6) was analyzed by CLP, collected in August 2010 from 0-6" bgs, and was composed of soil type **F** – Fill.

- Surface soil from 10 recreational quadrants (77 percent) exceeded the surface SSL for benzo(b)fluoranthene. Subsurface soil from 12 recreational quadrants (92 percent) exceeded the subsurface SSL for benzo(b)fluoranthene. The maximum detected soil benzo(b)fluoranthene concentration in a recreational quadrant sample was 5,600 µg/kg, from subsurface soil on East 148th Street. The sample (148086-B-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of a combination of soil types **Fc** – Fill with construction debris, and **Fs** – Fill with slag.

During the RI sampling events, a total of 53 yards in OU1 were analyzed for benzo(b)fluoranthene, of which surface and/or subsurface soil in 45 yards (85 percent) exceeded the SSL. Yards that exceeded the SSL for any PAH/SVOC compound are shown on Figures 5-11 through 5-13.

5.3.3.4 *Benzo(a)anthracene*

The RSL for benzo(a)anthracene in residential soils is 150 µg/kg (EPA 2010c). The IDEM RISC direct soil contact value for benzo(a)anthracene in residential soils is 5,000 µg/kg (IDEM 2009). The BTVs for benzo(a)anthracene in surface and subsurface soils are 91 and 62.1 µg/kg, respectively. The SSL is equal to the RSL for both surface and subsurface benzo(a)anthracene, as presented in Table 5-2.

Based on the 2009/2010 SulTRAC RI sampling events:

- Surface soil from 9 front yards (50 percent) exceeded the SSL for benzo(a)anthracene. Subsurface soil from 11 front yards (61 percent) exceeded the SSL for benzo(a)anthracene. The maximum detected soil benzo(a)anthracene concentration in a front yard sample was 6,100 µg/kg, from surface soil on Alexander Avenue. The sample (ALE089-F-0-6) was analyzed by CLP, collected in August 2010 from 0-6" bgs, and was composed of soil type **F** – Fill.

- Surface soil from 9 back yards (69 percent) exceeded the SSL for benzo(a)anthracene. Subsurface soil from 8 back yards (62 percent) exceeded the SSL for benzo(a)anthracene. The maximum detected soil benzo(a)anthracene concentration in a back yard sample was 3,200 µg/kg from subsurface soil on Carey Street. The sample (CAR032-B-6-12) was analyzed by CLP, collected in December 2009 from 6-12" bgs, and was composed of soil type **Fc** – Fill with construction debris.

- Surface soil from 7 drip zones (78 percent) exceeded the SSL for benzo(a)anthracene. No subsurface soil samples were collected from drip zones. The maximum detected soil benzo(a)anthracene concentration in a drip zone sample was 10,000 µg/kg, from surface soil on Alexander Avenue. The sample (ALE089-D1-0-6) was analyzed by CLP, collected in August 2010 from 0-6" bgs, and was composed of soil type **F** – Fill.

- Surface soil from 9 recreational quadrants (69 percent) exceeded the SSL for benzo(a)anthracene. Subsurface soil from 10 recreational quadrants (77 percent) exceeded the SSL for benzo(a)anthracene. The maximum detected soil benzo(a)anthracene concentration in a recreational quadrant sample was 5,400 µg/kg from subsurface soil on East 148th Street. The sample (148086-B-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of a combination of soil types **Fc** – Fill with construction debris, and **Fs** – Fill with slag.

During the RI sampling events, a total of 53 yards in OU1 were analyzed for benzo(a)anthracene, of which surface and/or subsurface soil in 40 yards (75 percent) exceeded the SSL. Yards that exceeded the SSL for any PAH/SVOC compound are shown on Figures 5-11 through 5-13.

5.3.3.5 *Indeno(1,2,3-cd)pyrene*

The RSL for indeno(1,2,3-cd)pyrene in residential soils is 150 µg/kg (EPA 2010c). The IDEM RISC direct soil contact value for indeno(1,2,3-cd)pyrene in residential soils is 5,000 µg/kg (IDEM 2009). The BTVs for indeno(1,2,3-cd)pyrene in surface and subsurface soils are 80 and 32 µg/kg, respectively. The SSL is equal to the RSL for both surface and subsurface sample results for indeno(1,2,3-cd)pyrene, as presented in Table 5-2. Based on the 2009/2010 SulTRAC RI sampling events:

- Surface soil from 5 front yards (28 percent) exceeded the SSL for indeno(1,2,3-cd)pyrene. Subsurface soil from 9 front yards (50 percent) exceeded the SSL for indeno(1,2,3-cd)pyrene. The maximum detected soil indeno(1,2,3-cd)pyrene concentration in a front yard sample was 2,400 µg/kg, from subsurface soil on Parrish Avenue, field duplicate. The sample (PAR092-F-6-12-D) was analyzed by CLP, collected in August 2010 from 6-12" bgs, and was composed of a combination of soil types **Fc** – Fill with construction debris, and **Fs** – Fill with slag.

- Surface soil from 7 back yards (54 percent) exceeded the SSL for indeno(1,2,3-cd)pyrene. Subsurface soil from 7 back yards (54 percent) exceeded the SSL for indeno(1,2,3-cd)pyrene. The maximum detected soil indeno(1,2,3-cd)pyrene concentration in a back yard sample was 1,500 µg/kg, from subsurface soil on Carey Street. The sample (CAR032-B-6-12) was analyzed by CLP, collected in December 2009 from 6-12" bgs, and was composed of soil type **Fc** – Fill with construction debris.

- Surface soil from 7 drip zones (78 percent) exceeded the SSL for indeno(1,2,3-cd)pyrene. No subsurface soil samples were collected from drip zones. The maximum detected soil indeno(1,2,3-cd)pyrene concentration in a drip zone sample was 4,200 µg/kg, from surface soil on Alexander Avenue. The sample (ALE089-D1-0-6) was analyzed by CLP, collected in August 2010 from 0-6" bgs, and was composed of soil type **F** – Fill.

- Surface soil from 5 recreational quadrants (38 percent) exceeded the SSL for indeno(1,2,3-cd)pyrene. Subsurface soil from 10 recreational quadrants (77 percent) exceeded the SSL for indeno(1,2,3-cd)pyrene. The maximum detected soil indeno(1,2,3-cd)pyrene concentration in a recreational quadrant sample was 3,800 µg/kg from subsurface soil on East 148th Street. The sample (148086-B-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of a combination of soil types **Fc** – Fill with construction debris, and **Fs** – Fill with slag.

During the RI sampling events, a total of 53 yards in OU1 were analyzed for indeno(1,2,3-cd)pyrene, of which surface and/or subsurface soil in 34 yards (64 percent) exceeded the SSL. Yards that exceeded the SSL for any PAH/SVOC compound are shown on Figures 5-11 through 5-13.

5.3.3.6 *Benzo(k)fluoranthene*

The RSL for benzo(k)fluoranthene in residential soils is 1,500 µg/kg (EPA 2010c). The IDEM RISC direct soil contact value for benzo(k)fluoranthene in residential soils is 50,000 µg/kg (IDEM 2009). The BTVs for benzo(k)fluoranthene in surface and subsurface soils are 48 and 16 µg/kg, respectively. The SSL is equal to the RSL for both surface and subsurface sample results for benzo(k)fluoranthene, as presented in Table 5-2. Based on the 2009/2010 SulTRAC RI sampling events:

- Surface soil from 2 front yards (11 percent) exceeded the SSL for benzo(k)fluoranthene. Subsurface soil from 1 front yard (6 percent) exceeded the SSL for benzo(k)fluoranthene. The maximum detected soil benzo(k)fluoranthene concentration in a front yard sample was 5,100 µg/kg, from subsurface soil on Parrish Avenue, field duplicate. The sample (PAR092-F-6-12-D) was analyzed by CLP, collected in August 2010 from 6-12" bgs, and was composed of a combination of soil types **Fc** – Fill with construction debris, and **Fs** – Fill with slag.

- None of the surface or subsurface soil from back yards (0 percent) exceeded the SSL for benzo(k)fluoranthene.

- Surface soil from 1 drip zone (11 percent) exceeded the SSL for benzo(k)fluoranthene. No subsurface soil samples were collected from drip zones. The maximum detected soil benzo(k)fluoranthene concentration in a drip zone sample was 4,200 µg/kg, from surface soil on Alexander Avenue. The sample (ALE089-D1-0-6) was analyzed by CLP, collected in August 2010 from 0-6" bgs, and was composed of soil type **F** – Fill.

- Surface soil from 1 recreational quadrant (8 percent) exceeded the SSL for benzo(k)fluoranthene. Subsurface soil from 1 recreational quadrant (8 percent) exceeded the SSL for benzo(k)fluoranthene. The maximum detected soil benzo(k)fluoranthene concentration in a recreational quadrant sample was 4,700 µg/kg, from subsurface soil on East 148th Street. The sample (148086-B-12-18) was analyzed by CLP, collected in August 2010 from 12-18" bgs, and was composed of a combination of soil types **Fc** – Fill with construction debris, and **Fs** – Fill with slag.

During the RI sampling events, a total of 53 yards in OU1 were analyzed for benzo(k)fluoranthene, of which surface and/or subsurface soil in 4 yards (8 percent) exceeded the SSL. Yards that exceeded the SSL for any PAH/SVOC compound are shown on Figures 5-11 through 5-13.

5.3.3.7 *Summary*

As discussed in greater detail in Section 8.4.3, PAHs are ubiquitous contaminants in urban environments. Although the BTV (or RSL in select cases) was chosen as the SSL for PAHs using the same methodology as for other COIs, PAHs are prevalent in soils in the greater Chicago metropolitan area at concentrations significantly higher than any of the criteria considered in determining SSLs. Further, EPA has determined that PAHs cannot be definitively identified as a COI associated with the industrial operations at the USS Lead Site. As a consequence, EPA has determined that the PAHs are not COIs associated with the site. The following discussion presents the results of the SSL comparison solely to describe the nature and extent of PAH distribution at the site as determined by this RI.

Overall, 94% of yards sampled for PAHs exceeded one or more PAH SSLs. The PAHs that most frequently exceeded their respective SSLs were benzo(a)pyrene, benzo(a)anthracene, and dibenz(a,h)anthracene, and the soil type that most frequently exceeded a PAH SSL was F – Fill. SulTRAC investigated the possibility of a correlation between the SSL exceedances of PAHs on properties compared with SSL exceedances of lead on similar properties and found that there is no significant correlation. For benzo(a)anthracene, only 50% of front yards, 35% of back yards, and 71% of drip zones that exceeded the SSL were co-located with a lead exceedance. For benzo(a)pyrene, only 41% of front yards, 29% of backyards, and 67% of drip zones that exceeded the SSL were co-located with a lead exceedance. For dibenz(a,h)anthracene, only 42% of front yards, 30% of back yards, and 67% of drip zones that exceeded the SSL were co-located with a lead exceedance. Lack of co-location between PAH SSL exceedances and lead SSL exceedances indicates that there is no significant correlation between lead and PAH concentrations at OU1.

5.3.4 Polychlorinated Biphenyls

PCB analyses were conducted for eight properties, comprising eight soil samples, during the December 2009 sampling event only. No duplicate samples were collected or analyzed for PCBs. A summary of the PCB soil SSLs is presented in Table 5-4. No BTVs were calculated for any PCB compounds. Analytical results for PCB analyses indicated that one Aroclor mixture was detected. Aroclor 1260 was detected in four of eight soil samples submitted for PCB analysis at concentrations ranging from 3.5 to 170 µg/kg. The RSL for Aroclor 1260 is 220 µg/kg, and the IDEM RISC value is 1,800 µg/kg (EPA 2010c, IDEM 2009). All PCB results are included in Appendix A, Table A-6. No soil samples exceeded the SSL for any PCB compounds.

5.3.5 Pesticides

Pesticide analyses were conducted for eight properties, comprising eight soil samples, during the December 2009 sampling event only. No duplicate samples were collected or analyzed for pesticides. A summary of the SSLs for pesticides in soil is presented in Table 5-4. No BTVs were calculated for any pesticide compounds. Analytical results for pesticide analyses indicated detections for sixteen different pesticides. All pesticide results are included in Appendix A, Table A-6. No soil samples exceeded the SSL for any pesticide compounds.

5.4 DISTRIBUTION OF CONSTITUENTS OF INTEREST

As discussed in Section 1.0 above, historical investigations at the Site indicated that lead is the primary COI at the USS Lead Site. However, the results of the RI discussed in Section 5.3 indicate that nine other soil analytes exceeded the SSLs during the RI. The distribution of the COIs, both laterally and vertically, across the Site is discussed below in Sections 5.4.1 through 5.4.3. In the following discussion, the terms “impact,” “impacts,” “impacted media,” and “impacted areas” refer to concentrations that exceed one or more SSLs.

This section is a discussion and analysis of the results of the RI. The analysis focuses on the site COIs lead, arsenic, and PAHs. The primary COI at the Site is lead; however, since arsenic and PAHs were also detected in soil they are included in all analytical discussions about the nature and extent of contamination. The investigation methods and prescribed remedy for lead are based on the guidance provided in the Handbook; hence, lead does not require as much discussion as arsenic and PAHs. Despite the additional text discussing arsenic and PAHs at the Site, lead is the primary COI and is the COI driving the remedy.

5.4.1 Graphical Review of Analytical Results for Multiple Chemicals of Interest

In this section, the COIs at OU1 are presented graphically using scatter plots to illustrate the frequency of lead and other COIs exceeding the SSLs at the same location. Investigating how frequently lead and other COIs exceed the SSLs will assist in future investigation and remediation planning for OU1.

Lead was analyzed for at all yards investigated during the RI. A subset of the yards was also analyzed for other metals and organic compounds. A review of analytical results for this RI indicates that analytes other than lead exceeded SSLs in a large percentage of the yards. Figure 5-14 illustrates the meaning of the scatter plots. Yards that plot in the lower right quadrant of the figure are contaminated by lead only, yards that plot in the upper left quadrant are contaminated by other (non-lead) COIs only, yards that plot in the upper right quadrant are contaminated by both lead and other COIs, and yards that plot in the lower left quadrant are not contaminated by lead or other COIs at concentrations above SSLs. Analyte concentrations were normalized by dividing the concentration by the analyte-specific SSL. Figures 5-15 through 5-17 present the distribution of COIs organized by yards in four groups (based on the four quadrants of each figure): (1) yards that did not exceed an SSL for any COI, (2) yards that exceeded only the SSL for lead, (3) yards that exceeded an SSL only for other COIs, and (4) yards that exceeded an SSL for lead and for other COIs.

Scatter-plot figures illustrating co-location of lead with other COIs are presented as Figures 5-15 through 5-17. The figures were constructed by plotting normalized lead concentrations against the normalized concentrations of other COIs for surface, subsurface, and drip zone results. The *x*-axis on Figures 5-15 through 5-17 is the normalized lead concentration, where a value of 1 represents the lead concentration equal to a lead SSL of 400 mg/kg; a value less than 1 represents a concentration less than the SSL, and a value greater than 1 represents a value greater than the SSL. The *y*-axis on Figures 5-15 through 5-17 is the maximum of the normalized concentrations of all other COIs present in that yard, where a value of 1 represents the maximum COI concentration equal to the COI-specific SSL. For example, in the surface soil in a front yard on Ivy Avenue, the lead concentration is 264 mg/kg and the arsenic concentration is 64.9 mg/kg; the normalized concentrations are 0.66 for lead and 4.6 for other contaminants (see Table 5-10). Therefore, the surface soil in a front yard on Ivy Avenue plots into the upper left corner of the figure (see Figure 5-14), which represents "Other COIs only" which exceed the SSLs.

Table 5-10: Scatter Plot Example Data

Analyte	Concentration (mg/kg)	SSL (mg/kg)	Normalized Value
Lead	264	400	264/400 (0.66)
Arsenic	64.9	14.1	64.9/14.1 (4.6)

Figures 5-15 through 5-17 show yards that exceeded the SSLs for lead only in surface (10%), subsurface (7%), and drip zone samples (20%), respectively. The same figures show that a significant portion of the yards exceeded an SSL for a COI other than lead in surface (25%), subsurface (35%), and drip zone samples (20%). A total of 232 yards were sampled for lead, but substantially fewer yards were sampled for other COIs. The relatively higher proportion of SSL exceedances for other COIs in the smaller number of yards sampled suggests that other COIs may be more prevalent in OU1 than are shown on Figures 5-8 through 5-13, which show the arsenic and PAH results for surface, subsurface, and drip zone samples, respectively. The SSL was used as a conservative screening level for arsenic and PAHs. However, arsenic and PAH concentrations in soils in OU1 are comparable to other urban soil background concentrations, which are considerably higher than the site-specific BTVs. As discussed in Section 8.4.2 and 8.4.3 below, BTVs were evaluated as part of the determination for recommended RALs.

Using the same approach described above for Figures 5-15 through 5-17, the normalized lead concentration for each yard was compared to the normalized arsenic (Figure 5-18) and PAH (Figure 5-19) concentrations. The maximum normalized result from the surface and subsurface samples from each yard was selected for lead, arsenic, and PAHs. Figure 5-18 shows that, typically, both arsenic and lead exceeded the SSL (45%) or neither arsenic nor lead exceeded the SSL (29%). Only a small group of yards (9%) exceeded the SSL for arsenic but did not exceed the SSL for lead, indicating that arsenic tends to be co-located with lead. Figure 5-19 shows that the overwhelming majority of yards sampled for PAHs exceeded one or more PAH SSLs (94%). Half of those locations that exceeded one or more PAH SSLs also exceeded the SSL for lead (47% of yards). Lead and PAH exceedances are poorly correlated; elevated PAH concentrations are unlikely to be indicators of lead impacts, and vice versa.

5.4.2 Lateral Distribution of Constituents of Interest

This section discusses the lateral distribution of COIs at the Site. This section first describes the lateral distribution across OU1 (Section 5.4.2.1) and then the lateral distribution within a single property (Section 5.4.2.2).

5.4.2.1 *Lateral Distribution of Lead Across OU1*

Based on the SulTRAC RI data, soils at 123 out of 232 yards sampled during the RI (53%) contained lead concentrations above the SSL. Table 5-11 lists the breakdown of yards exceeding the lead SSL.

Table 5-11: Sample Type Distribution of Lead Results

Sample Type	Depth	Above Lead SSL	Below Lead SSL	Total
Front Yard	Surface	30	46	76
	Subsurface	23	18	41
Back Yard	Surface	34	37	71
	Subsurface	27	10	37
Drip Zones	Surface	35	25	60
Recreational Quadrants	Surface	7	16	23
	Subsurface	9	6	15

Figures 5-4 through 5-6 show the lead results for surface, subsurface, and drip zone samples, respectively. The surface samples exceeded the lead SSL more frequently than the subsurface samples.

Including both the 2003 XRF results and the RI results, soils in 101 yards (front yard, back yard, or recreational quadrant) had surface lead concentrations above the SSL. Seventy-four of the 101 yards are west of Huish Avenue, concentrated in the southwest portion of OU1, north-northwest of OU2. Additionally, more yards in the area west of Huish Avenue exceeded SSLs for lead in both surface and subsurface soils than yards in the eastern half of OU1. The East Chicago Housing Authority complex is located in the southwest portion of the study area, south of Gosch Elementary School. Each of the nine properties sampled in the East Chicago Housing Authority complex contained lead results that exceeded the lead SSL. Only one of the front yards, back yards, and drop zones sampled (a front yard on Aster Avenue) did not exceed the SSL for lead. Five of the six highest lead concentrations in OU1 were detected in the East Chicago Housing Authority complex. The highest concentration detected in OU1 was 27,100 mg/kg in the 18-24" bgs interval on 150th Street. The average lead concentration in yards that exceeded the SSL in the East Chicago Housing Authority area was 2,442 mg/kg, which is significantly greater than both the average lead concentration in OU1 (1,538 mg/kg) and the SSL for lead (400 mg/kg).

The drip zone samples that exceeded the lead SSL (see Figure 5-6) are heavily weighted towards the western half of OU1. Twenty-three out of 26 drip zones sampled in the area west of Huish Avenue exceeded the lead SSL. In contrast, only 12 out of 34 of the drip zone samples east of Huish Avenue exceeded the lead SSL.

5.4.2.2 Lateral Distribution of Arsenic across OU1

Based on the SulTRAC RI data, soils at 75 out of 136 yards sampled during the RI (55%) contained arsenic concentrations above the SSL. Figures 5-8 through 5-10 show the arsenic results for surface, subsurface, and drip zone samples, respectively. The surface samples exceeded the arsenic SSL more frequently than the subsurface samples. The yards that exceeded the arsenic SSLs are not concentrated in any single area of the site. The distribution of arsenic suggests that arsenic's primary dispersion was a combination of impacted fill and aerial deposition. Aerial deposition of arsenic is discussed further in Section 5.4.3.2 below. If lead and arsenic are found to be co-located, then it is likely that the contamination originates from the same fill or deposition source.

The four highest arsenic concentrations were measured in soils collected from the East Chicago Housing Authority complex. The highest arsenic concentration in OU1 (567 mg/kg) was detected on Aster Avenue and was co-located with lead exceedances. Soils most frequently exceeded the SSL for arsenic in the eastern half of OU1.

The Public Housing Authority property was historically occupied by the former Anaconda Copper Company facility. According to the Lake County, Indiana assessor's office, the East Chicago Housing Authority complex was constructed in the early 1970s. The highest arsenic and lead concentrations in this area are possibly related to the historical operations at the Anaconda Copper Company facility.

The drip zone samples that exceeded the arsenic SSL (see Figure 5-9) followed a random dispersion pattern, as observed in the surface and subsurface arsenic figures outside the former Anaconda Copper property. The properties that exceeded the arsenic SSL in the drip zone samples are located towards the center of the site, flanking Huish Avenue; however, the sample density decreases towards the western and eastern site boundaries.

5.4.2.3 Lateral Distribution of PAHs across OU1

As noted in Section 5.1, although SVOCs (including PAHs) are discussed here, there is no reasonable expectation that consistent releases of these compounds into the OU1 area are associated with a metals smelting facility (USS Lead). Rather, as discussed further in Section 8, detections for these compounds are associated with other anthropogenic sources typical of a metropolitan industrial area, and results discussed herein are intended for completeness of this RI report only.

Based on the SulTRAC RI data, soils at 53 out of 56 yards sampled for PAHs during the RI (94%) contained one or more PAH concentrations above the SSL. Figures 5-11 through 5-13 show the PAH results for surface, subsurface, and drip zone samples, respectively. PAHs are a group of related compounds. If one or more PAH compounds exceeded an SSL, then the yard was noted as "PAH exceedance." The subsurface samples exceeded the SSLs for PAHs more frequently than the surface samples. Out of the 232 yards sampled during the RI sampling events, only 53 were sampled for PAHs. Of the 53 yards sampled, 50 of them (94%) exceeded one or more PAH SSLs in surface or subsurface soils. Due to the high percentage of yards exceeding the SSLs, the yards that exceeded PAH SSLs are not concentrated in any single area of the site. The distribution of PAH results suggests that PAHs are dispersed throughout OU1. The drip zone samples that exceed the PAH SSLs (see Figure 5-13) follow the same pattern observed in the surface and subsurface PAH figures; soils exceeded SSLs for PAHs everywhere PAHs were sampled.

5.4.2.4 *Lateral Distribution within a Property*

There is an approximately 75% chance that a property with one yard in excess of the SSL for lead will exceed the SSL for lead in the second yard as well. To evaluate the possibility of whether future sampling could be simplified and expedited by sampling one yard rather than both yards at a given residential property, SulTRAC evaluated sampling results from the RI to investigate whether contamination in front yards was correlated with contamination in back yards. As noted previously, flower gardens, vegetable gardens, and play areas were assigned to their respective yard (front or back) for the purpose of this RI. Of the 83 residential properties sampled, only those properties where both a front and back yard were sampled are included in the analysis. This led to 19 of these properties being excluded from the comparison of back and front yards because only one yard was sampled. SulTRAC assessed the possible correlation of contamination between the yards at a given property by evaluating the number of properties where both yards exceeded SSLs, compared to the properties where only one yard exceeded SSLs. The results of this comparison are shown in Table 5-16.

Table 5-16: Summary of Lead in OU1 Back Yards *vs.* Front Yards

Yard	No. Sampled	No. Exceeding SSL	No. Properties that exceed SSL in both front and back yards
Front	64	32	24
Back	64	31	

Of the 64 properties where both a front and back yard were sampled, both yards exceeded SSLs for lead at 24 properties, and either a front or back yard exceeded the SSL for lead at an additional 15 properties. As stated above, the results indicate that there is an approximately 75% chance that a property with one yard in excess of the SSL for lead will exceed the SSL for lead in the second yard as well.

5.4.2.5 Flower Garden, Vegetable Garden, and Play Area Results

Flower and vegetable gardens, and play areas at OU1 often had the most contaminated sample on a property. As detailed in Section 3.1 above, a subset of the yards sampled during the RI contained flower gardens, vegetable gardens, and/or play areas. If a flower garden, vegetable garden, and/or play area was present, a discrete sample was collected from the garden or play area. Thirty-four flower gardens, vegetable gardens, and/or play areas from 25 properties were sampled during the RI. In previous discussions, the garden/play area results were combined with composite sample results from the same yard in order to summarize the analytes that exceeded SSLs in each yard.

In this section, the garden/play area samples have been considered separately. In evaluating the potential risks posed to site users, the Human Health Risk Assessment (HHRA; see Section 7.0 below) reviewed the results of the garden and play area samples. At twelve properties (48%), the most contaminated sample was a discrete sample collected from the garden or play area. Therefore, in approximately one-half of the properties that included a flower garden, vegetable garden, and/or play area, the maximum COI concentration was from the garden/play area. At two of the properties (one on Chicago Avenue and one on Magnolia Lane), the only exceedance at the property was collected from the play area. In other words, at two locations, the play areas were contaminated, but the samples collected from the yards were not. From the 12 properties with the most contaminated sample collected from the garden or play area, the most frequent COI exceedances in that sample were lead (7 properties) and arsenic (7 properties). Two of the properties also had PAH exceedances. In addition, the maximum manganese concentration detected in OU1 (4,780 mg/kg, on Melville Avenue) was collected from a flower garden.

5.4.2.6 Drip Zone Results

The majority of drip zone samples collected exceeded the SSL for lead and other COIs. Only 60 of the 88 total properties SulTRAC sampled had drip zones where soil samples could be collected. The remaining properties had concrete walkways that could not be sampled, or no drip zone area was present (e.g., properties without buildings). The sampling methodology used to collect soil samples from drip zones is discussed in Section 3.2 above.

Drip zone samples from 39 of the 60 properties (65%) where drip zone soils were sampled had analytical results that exceeded one or more SSLs. In addition, 24 of the 60 properties where drip zone samples were collected also exceeded the SSLs in both the front and back yards. Figure 5-3 presents the locations of drip zone samples; Figures 5-6, 5-9, and 5-13 present the results for the drip zone samples for lead, arsenic, and PAHs, respectively. The drip zone samples that exceed the lead SSL (see Figure 5-6) are heavily weighted towards the western half of OU1. The drip zone samples that exceeded the arsenic SSL (see Figure 5-9) follow a random dispersion pattern, as observed in the surface and subsurface arsenic figures (see Figures 5-7 and 5-8) outside the former Anaconda Copper property. The properties that exceeded the arsenic SSL in the drip zone samples are located towards the center of the site, flanking Huish Avenue; however, the sample density decreases towards the western and eastern site boundaries. The drip zone samples that exceed the PAH SSLs (see Figure 5-13) follow the same pattern observed in the surface and subsurface PAH figures: soils exceeded SSLs for PAHs everywhere PAHs were sampled. The majority of drip zone samples (55%) exceeded the SSL for lead and other COIs. 40% of the drip zone samples exceeded an SSL for lead only or one other COI only.

The purpose of collecting drip zone samples was to investigate the role of aerial deposition of contaminants in OU1. The geographically scattered elevated concentrations of the drip zone samples across OU1 suggest that the contamination present in the drip zones was not due primarily to aerial deposition.

5.4.3 Vertical Distribution across OU1

During the RI sampling events, SulTRAC sampled a full depth profile (surface to 2 feet bgs) for approximately half the sampling locations and observed that lead concentrations tended to decrease with depth. SulTRAC evaluated whether sampling the entire top 2 feet of soil in OU1 would be necessary to characterize a property or if a sample might be collected from a shallow depth (i.e., the top 6 or 12 inches) that could represent the entire 24-inch interval. In order to assess the vertical distribution of lead at the site, SulTRAC compared lead, arsenic, and PAH concentrations of soil samples by depth interval. A total of 232 yards from 88 properties were sampled, of which a subset of yards was sampled continuously at 6-inch intervals from the surface to 2 feet bgs or refusal. For lead, 170 yards from 88 properties were continuously sampled from front yards, back yards, and recreational quadrants. For arsenic, 40 yards from 22 properties were continuously sampled from front yards, back yards, and recreational quadrants. For PAHs, 34 yards from 23 properties were continuously sampled from front yards, back yards, and recreational quadrants. No drip zones are included because drip zone samples were collected only from the surface-depth interval (0-6 inches bgs).

5.4.3.1 *Lead*

SulTRAC sampled 170 yards for lead, continuously from the surface to 2 feet bgs or refusal. Of the 170 yards sampled:

- 82 (48%) did not exceed the lead SSL in any depth interval
- 88 (52%) exceeded the lead SSL in at least one depth interval, of which:
    - 29 (17%) exceeded the lead SSL in the surface soil only,
    - 17 (10%) exceeded the lead SSL in the subsurface soil only,
    - 42 (25%) exceeded the lead SSL in both surface and subsurface intervals.

More yards exceeded the lead SSL in surface samples only than in subsurface samples only; however, nearly half of the yards that exceeded the lead SSL did so in both surface and subsurface samples. Of the 17 yards that exceeded the lead SSL in subsurface soil only, the depth of the exceedance was split roughly evenly among the 6-12 inches, 12-18 inches, and 18-24 inches bgs intervals. These observations indicate that sampling surface soils (0 to 6 inches bgs) only would successfully detect lead contamination in 90% of the yards sampled.

More detailed analysis of lead concentrations in soils was performed to further refine understanding of site conditions at OU1 and to assess the presence or absence of aerial deposition of lead at OU1. Box plots were constructed as depicted in Figure 5-20, where all soil-lead data were plotted by depth interval. Soil data from the public housing area were not included in the vertical distribution analysis because the review of site history conducted for this RI revealed that this property was a former industrial facility that manufactured lead compounds. Soil-lead concentrations in this area likely result from direct deposition of contaminants from the former industrial facility. Soil-lead concentrations from remaining locations in OU1were plotted logarithmically in Figure 5-20 to visualize the full range of data. The decreasing trend in soil-lead concentrations with increasing depth is consistent with aerial deposition as a source for lead in soil at OU1.

Further evidence for the aerial deposition is illustrated in the histograms found on Figure 5-21. For the histograms on Figure 5-21, a soil lead concentration of 314 mg/kg was chosen to represent “clean” soil below the SSL of 400 mg/kg. The value of 314 mg/kg incorporates a safety margin of approximately 20% to account for analytical variability and is used in this RI report only for the purposes of this discussion. The depth interval with the smallest proportion of clean samples (soil-lead concentrations less than 0.314 mg/kg) is the 0-6" interval, and the frequency of clean soils increases with depth, as shown in Figure 5-21a. Conversely, as revealed in Figure 5-21b, the distributions are reversed, indicating a higher proportion of impacted soils closer to the surface. These findings, presented in Figures 5-20 and 5-21, indicate that aerial deposition is a significant contributor to the total soil-lead concentrations.

5.4.3.2 *Arsenic*

As noted above, lead is the primary contaminant driving the remedy at the USS Lead Site. Arsenic is a naturally occurring background compound, and an appropriate RSL is needed to distinguish the naturally occurring arsenic concentrations at the site from those that may be impacted by activities in and around the site. Arsenic concentrations are screened against the SSL in the following section of this report using a uniform methodology to maintain a consistent screening approach.

SulTRAC sampled 40 yards for arsenic, continuously from the surface to 2 feet bgs or refusal. Of the 40 yards sampled:

- 17 (43%) did not exceed the arsenic SSL in any depth interval
- 23 (57%) exceeded the arsenic SSL in at least one depth interval, of which:
    - 4 (10%) exceeded the arsenic SSL in the surface soil only
    - 6 (15%) exceeded the arsenic SSL in the subsurface soil only
    - 13 (32%) exceeded the arsenic SSL in both surface and subsurface intervals

Therefore, a similar number of yards exceeded the arsenic SSL for only surface or subsurface soils, but not both. The surface soil arsenic results did not indicate the subsurface conditions. For example, surface soil on a Magnolia Avenue property (12.2 mg/kg) did not exceed the arsenic SSL; however, the soil from the 12-18” subsurface soil sample at the same location had an arsenic concentration of 414 mg/kg. Of the 6 yards that exceeded the arsenic SSL in subsurface soil only, the depth of the exceedance was split equally between the 6-12", 12-18", and 18-24" bgs intervals. These observations indicate that sampling surface soils (0 to 6 inches) instead of the full 24” profile would successfully detect arsenic contamination in only 85% of the yards sampled.

More detailed analysis of arsenic concentrations in soils was performed to further refine understanding of site conditions at OU1 and to assess the presence or absence of aerial deposition of arsenic at OU1. Box plots were constructed as depicted in Figure 5-22, where soil arsenic data were plotted by depth interval. Soil data from the East Chicago Housing Authority complex were not included in the vertical distribution analysis because the review of site history conducted for this RI revealed that this property was a former industrial facility (Anaconda Copper Company). Significant soil disturbances from the removal of the industrial facility and construction of the housing area would not result in a vertical profile that could be compared to the remainder of the OU1 area, as soil arsenic concentrations in the public housing area likely result from direct deposition of contaminants from the former industrial facility. Properties where soil arsenic concentrations in the 0-6" interval were below background levels, while subsurface soil concentrations were above background, were also not included, as it was assumed that those areas had had clean fill placed over the original fill material. Soil arsenic concentrations were plotted in Figure 5-22 to visualize the full range of data. The decreasing trend in mean soil arsenic concentrations as well as the decreasing trend in maximum soil arsenic concentrations with increasing depth is consistent with aerial deposition as a source for arsenic in soil at OU1.

5.4.3.3 PAHs

As stated in Section 5.1, although SVOCs (including PAHs) are discussed here, there is no reasonable expectation that consistent releases of these compounds into the OU1 area are associated with a metals smelting facility (USS Lead). Rather, as discussed further in Section 8, detections for these compounds are associated with other anthropogenic sources typical of a metropolitan industrial area, and results discussed herein are intended for completeness of the RI report only.

SulTRAC sampled 34 yards for PAHs, continuously from the surface to 2 feet bgs or refusal. Of the 34 yards sampled:

- 0 (0 percent) did not exceed one or more PAH SSLs in any depth interval
- 34 (100%) exceeded one or more PAH SSLs in at least one depth interval, of which:
    - 0 (0 percent) exceeded one or more PAH SSLs in the surface soil only
    - 3 (9 percent) exceeded one or more PAH SSLs in the subsurface soil only
    - 31 (91 percent) exceeded one or more PAH SSLs in both surface and subsurface intervals

The majority of PAH results exceeded SSLs in both surface and subsurface soil. Unlike the arsenic and lead results presented above, PAHs tended to exceed SSLs in both surface and subsurface soils. Of the 3 yards that exceeded a PAH SSL in subsurface soil only, the depth of the exceedance was split 66% and 33% between the 6-12" and 18-24" bgs intervals, respectively. These observations indicate that sampling surface soils (0 to 6") would successfully detect PAH-impacted soil in 91% of the yards sampled.

5.4.3.4 ***Summary***

Any future sampling efforts, such as pre-remedial design sampling, should not focus exclusively on surface soils. At a few locations, the lower depth intervals exceeded the SSL but the upper intervals did not. For example, the 18-24" bgs sample from quadrant A at a Magnolia property had a lead concentration of 5,170 mg/kg, and the surface sample from the same location had a lead concentration of 234 mg/kg (see Tables 5-5 through 5-8). The observed vertical distributions of lead, arsenic, and PAHs indicate that there is a 15% chance that sampling only the surface soils (0-6" bgs) would miss contamination in the subsurface soils (6-24" bgs).

5.4.4 Distribution of Lead Based on Size Fractionation

During the 2009 RI sampling event, SulTRAC sieved six soil samples prior to lead analysis to evaluate whether the lead concentration is confined to a particular size fraction. The Handbook (EPA 2003a) recommends passing soils through a number 60 (250-micron) sieve and analyzing both the coarse and fine fractions. The purpose of sieving the soil samples is to represent the potential exposure of young children, the population most vulnerable to the adverse effects of lead exposure. Children inadvertently ingest lead in soil and dust when it adheres to their hands and clothing, and the finer soil particles are most likely to adhere to hands and clothing. Additionally, finer particles are preferentially brought into the home. Sieving is conducted to better represent the soil fraction ingested by the typical child. Six soil samples from the December 2009 RI sampling were selected for sieving and analysis of the inorganic TAL metals for both the coarse and fine material. The samples were selected to represent low, medium, and high lead concentrations. Samples were passed through a number 60 (250-micron) sieve by the CLP laboratory prior to analysis. Results for lead are summarized in Table 5-17. Full results for the sieved TAL metals are presented in Appendix A, Table A-7.

Table 5-17: Comparison of Unsieved and Sieved Lead Concentrations

Sample	Total Unsieved Lead Concentration (mg/kg)	Lead Concentration		RPD between Total and Fine (%)
		Coarse Fraction (mg/kg)	Fine Fraction (mg/kg)	
151037-B-0-6	2,860	2,520	3,170	10.3
CAR032-B-6-12	191	122	242	23.6
CHI017-C-0-6	244	189	266	8.6
EUC033-F-12-18	124	109	126	1.6
KEN030-F-18-24	20.5	11.9	21.8	6.1
MEL018-F-6-12	680	1,020	623	8.7

Notes:
mg/kg Milligram per kilogram
RPD Relative percent difference

The data presented show that the total lead concentration in the unsieved sample was intermediate between the lead concentrations in the coarse and fine fractions of the same sample, and represents the lead in the entire sample. Lead concentrations were higher in the fine fraction than in the coarse fraction in five of the six sieved sample pairs, indicating that lead shows a preference for being distributed in the fine particle size. The Relative Percent Difference (RPD) for lead concentrations between the bulk samples and fine fractions of those samples ranged from 1.6% to 23.6%, indicating that the bulk lead concentration is essentially the same as the fine fraction. This suggests that there is no need to sieve samples to obtain a representative lead concentration to discern the potential exposure of young children. The relatively low RPDs between the bulk and fine fractions do not support the application of a correction factor to adjust for fine particle concentrations. No additional samples were submitted for sieved metals analysis during the Summer 2010, Phase II RI sampling.

5.4.5 Correlation of Contamination with Soil Types

SulTRAC identified five main soil types in OU1 at the USS Lead Site: organic topsoil (**Ot**), fill (**F**), fill with construction debris (**Fc**), fill with slag (**Fs**), and native sands (**Ns**). Table 5-18 summarizes these five soil types.

Table 5-18: Summary of Soil Types Identified within OU1

SulTRAC Abbreviation	Brief Description	Detailed Description/Notes
Ot	Organic Topsoil	Loose black to grayish-brown silty sand, usually restricted to upper sample
F	Fill	Grayish-brown to brown to gray fine, loose, unsorted sand
Fc	Fill with Construction Debris	Grayish-brown to brown to gray fine, loose, unsorted sand with construction debris such as brick fragments, metal nails, and assorted glass pieces
Fs	Fill with Slag	Grayish-brown to brown to gray fine, loose, unsorted sand with pieces of slag
Ns	Native Sand	Yellowish-brown to brown to gray fine, loose, unsorted sand. Native soil to the region typically covered with fill (F, Fc, Fs)

SulTRAC collected five aliquots from each yard and composited them for analysis. Soil types were not always consistent from aliquot to aliquot. Soil types were designated by reviewing field notes of soil descriptions for each aliquot and assigning a dominant soil type for each composite sample. Composites that had four or five soils of the same type were assigned that soil type. For example, a sample with four aliquots of **Fs** and one aliquot of **Ns** was designated as **Fs**. A split designation was applied in cases where aliquots were split between two or three soil types. A sample that had three aliquots of **Ot** and two aliquots of **Fs** was given the split designation of **Ot/Fs**. The predominant (three aliquot) soil type (**Ot**) was listed first in the descriptor and the soil type with two aliquots (**Fs**) was listed second.

Lead, arsenic, and dibenz(a,h)anthracene concentrations in each of these soil types were compared using box-plot statistical graphs (Figures 5-23, 5-24, and 5-25, respectively). Note that the soil types shown on Figure 5-23 are frequently composed of a mixture of multiple soil types. In the case of "**Ns**," not all fractions are composed entirely of **Ns**; often, they are a mixture of native sand and various fill materials. Due to the number of dibenz(a,h)anthracene SSL exceedances, this compound was selected to be representative of all PAH compounds in the USS Lead Site soil. Samples were separated by soil type, and the range of analyte concentrations and the statistical distribution of concentrations were calculated and plotted. Samples consisting of multiple soil types, such as **Ot/Fs**, were excluded from this analysis because the samples were a mixture of two or more soil types. Data are presented below for lead, arsenic, and dibenz(a,h)anthracene, and then results of the analysis are discussed.

5.4.5.1 *Lead Concentrations and Soil Type*

Including both XRF and CLP analysis for lead, 866 soil samples were analyzed statistically and plotted to compare lead concentration and soil type. The natural logarithm (*ln*) of the soil lead concentrations was used to better visualize the distribution of lead across soil types. Statistical comparisons of the lead concentrations associated with different soil types are presented in Table 5-19 and graphically on Figure 5-23 (please see note regarding Figure 5-23 above).

Table 5-19: Statistical Comparison of Lead Concentrations and Soil Type

Statistical Measure	Soil Type				
	Ot	F	Fc	Fs	Ns
Q1	5.28	4.91	5.63	5.02	3.57
Minimum	2.22	4.08	5.02	3.25	2.20
Median	5.76	5.46	6.70	5.38	4.15
Mean	5.79	5.56	6.24	5.52	4.18
Maximum	8.57	7.64	7.03	8.82	7.41
Q3	6.35	6.15	6.79	5.78	4.55
No. of samples	162	390	57	122	135

Notes:
Numbers shown in this table are the natural log (*ln*) of lead concentrations.

F	Fill	Ot	Organic topsoil, black silty sand
Fc	Fill with construction debris	Q1	First quartile
Fs	Fill with slag	Q3	Third quartile
Ns	Native sand		

5.4.5.2 *Arsenic Concentrations and Soil Type*

The CLP arsenic results were analyzed statistically and plotted from 261 soil samples to compare the arsenic concentrations with the soil types. The *ln* of the soil arsenic concentrations was used to better visualize the distribution of arsenic across soil types. Statistical comparisons of the arsenic concentrations associated with different soil types are presented in Table 5-20 and graphically on Figure 5-24.

Table 5-20: Statistical Comparison of Arsenic Concentrations and Soil Type

	Soil Type				
Statistical Measure	**Ot**	**F**	**Fc**	**Fs**	**Ns**
Q1	2.33	2.14	2.35	2.23	1.43
Minimum	1.77	0.00	2.05	1.13	0.41
Median	2.69	2.46	2.60	2.50	2.03
Mean	2.79	2.52	2.99	3.11	1.91
Maximum	4.31	5.28	5.15	6.34	3.30
Q3	3.19	2.82	3.23	3.47	2.24
No. of samples	41	121	15	53	31

Notes:

Numbers shown in this table are the natural log *(ln)* of arsenic concentrations.

F	Fill	Ot	Organic topsoil, black silty sand
Fc	Fill with construction debris	Q1	First quartile
Fs	Fill with slag	Q3	Third quartile
Ns	Native sand		

5.4.5.3 *Dibenz(a,h)anthracene Concentrations and Soil Type*

The CLP dibenz(a,h)anthracene results were analyzed statistically and plotted from 140 soil samples for the comparison of dibenz(a,h)anthracene concentration and soil type. The *ln* of the soil dibenz(a,h)anthracene concentrations was used to better visualize the distribution of this compound across soil types. Statistical comparisons of the dibenz(a,h)anthracene concentrations associated with different soil types are presented in Table 5-21 and graphically on Figure 5-25.

Table 5-21: Statistical Comparison of Dibenz(a,h)anthracene Concentrations and Soil Type

Statistical Measure	Soil Type				
	Ot	F	Fc	Fs	Ns
Q1	3.16	3.37	4.51	3.50	1.74
Minimum	2.22	2.01	3.61	1.22	0.00
Median	3.47	3.91	5.94	4.17	2.52
Mean	3.44	3.96	5.29	3.97	2.62
Maximum	4.23	7.00	6.31	5.67	5.39
Q3	3.78	4.52	6.06	4.71	3.37
No. of samples	11	71	7	31	20

Notes:

Numbers shown in this table are the natural log *(ln)* of dibenz(a,h)anthracene concentrations.

F	Fill	Ot	Organic topsoil, black silty sand
Fc	Fill with construction debris	Q1	First quartile
Fs	Fill with slag	Q3	Third quartile
Ns	Native sand		

5.4.5.4 *Contamination and Soil Type Summary*

Review of Figures 5-23 through 5-25 reveals the following apparent trends in the data:

- Lead and arsenic exhibited similar characteristics between analyte concentration and soil types. For example, samples of native sand (**Ns**) were generally below the SSLs for arsenic and lead. The few **Ns** samples that exceeded the RSL are likely to be the result of native soils mixed with fill material as part of the compositing sampling process. For example, a sample identified as **Ns** could contain four aliquots of **Ns** and one aliquot of **Fs** that would cause the bulk concentration of the sample to exceed the RSL.

- Dibenz(a,h)anthracene concentrations exceeded the SSL in all soil types, including **Ns**.

- Samples of each non-native soil type at the site exceeded the respective SSL in at least 25% of samples (4th quartile), with the exception of lead in fill with slag (**Fs**).

- Organic topsoil (**Ot**) and other types of fill (**F** and **Fs**), on average, did not contain concentrations of lead in excess of the SSL.

- All soil types exhibited a wide range of concentrations, which appear to be lognormally distributed based on visual inspection. This indicates that statements about analyte concentrations in a given soil type are difficult to support. However, results from the fill soil types (**F**, **Fc**, and **Fs**) were generally higher than other soil types (**Ot** and **Ns**).

In summary, there is a general correlation of analytes above the SSL with the fill soil types (**F**, **Fs**, **Fc**), and native sands are generally but not exclusively below the lead and arsenic SSLs. There are exceptions for each soil type at the site, so soil type is not a reliable indicator of the presence or absence of COIs. However, samples that only included native sand were free of contamination above SSLs; the samples that were classified as **Ns** that exceeded SSLs were predominantly composed of native sands but were mixed with a smaller portion of fill material.

5.5 SUMMARY

SulTRAC identified lead and other compounds as COIs at the USS Lead Site. Lead is the primary COI and is the constituent driving the remedy. SulTRAC collected surface and subsurface soil samples during the RI sampling events from a total of 88 properties, consisting of 232 distinct yards (front yards, back yards, quadrants, and drip zones), in order to define the nature and extent of contamination in OU1 of the USS Lead Site. The soil samples were analyzed for various combinations of total metals, VOCs, SVOCs, PAHs, PCBs, and pesticides. As noted in Sections 5.1 and 8.0, PAHs are not considered site-related but are included for completeness. Results from the RI soil investigation include:

- Ten metal analytes and 6 PAH analytes were identified as COIs
- 123/232 yards (53%) exceeded the SSL for lead in surface and/or subsurface soil
- 75/136 yards (55%) exceeded the SSL for arsenic in surface and/or subsurface soil
- 50/53 yards (94%) exceeded one or more SSLs for PAHs in surface and/or subsurface soil

A small percentage (22%) of the yards sampled during the RI were analyzed for PAHs; however, PAHs were the COIs that exceeded the SSLs in the highest proportion of samples. Data analysis indicated that lead and arsenic were generally correlated, whereas lead and PAHs were not correlated. The lack of PAH and lead correlation supports the concept that PAHs are not site-related compounds and are likely associated with other anthropogenic sources. It is unlikely that soils will exceed the arsenic SSL unless lead also exceeds the lead SSL.

The lateral extent of lead-impacted soil extended across all of OU1. The area west of Huish Avenue contained more exceedances of lead in both surface and subsurface soil samples than the eastern half of OU1. The East Chicago Housing Authority complex, in the southwest portion of the study area, contained lead exceedances in all nine properties (front yard, back yard, and/or drip zone) sampled. The highest arsenic and lead concentrations in OU1 were also found in the East Chicago Housing Authority. As stated in Section 5.4.3.2, arsenic in the East Chicago Housing Authority complex is likely attributable to the historical operations at the former industrial facility (Anaconda Copper Company). Significant soil disturbances from operations at the industrial facility and construction of the housing area would not result in a vertical profile that could be compared to the remainder of the OU1 area, as soil-arsenic concentrations in the public housing area likely result from direct deposition of contaminants from the former industrial facility. If this area is removed from the arsenic data set, it becomes evident that the remainder of the arsenic at OU1 is primarily dispersed due to aerial deposition.

An analysis of front and back yards reveals that there is an approximately 75% chance that COIs that exceed an SSL in one yard will indicate that COIs will exceed an SSL in the other yard as well. In addition, based on the observed vertical distributions of lead, arsenic, and PAHs, there is a 15% chance that sampling only the upper two depth intervals (0-6" and 6-12" bgs) will miss contamination in the lower two depth intervals (12-18" and 18-24" bgs). A comparison of soil type to COI concentration concluded that soil type is not a reliable indicator of the presence or absence of COIs, except that native sands were free of contamination above SSLs unless mixed with fill material.

FIGURES

Figure 5-1 Soil Sample Locations – Metals

REDACTED

Figure 5-2 Soil Sample Locations – Organics

REDACTED

Figure 5-3 Drip Zone Sample Locations

REDACTED

Figure 5-4 Lead Exceedances in OU1 Yards – Surface Soil

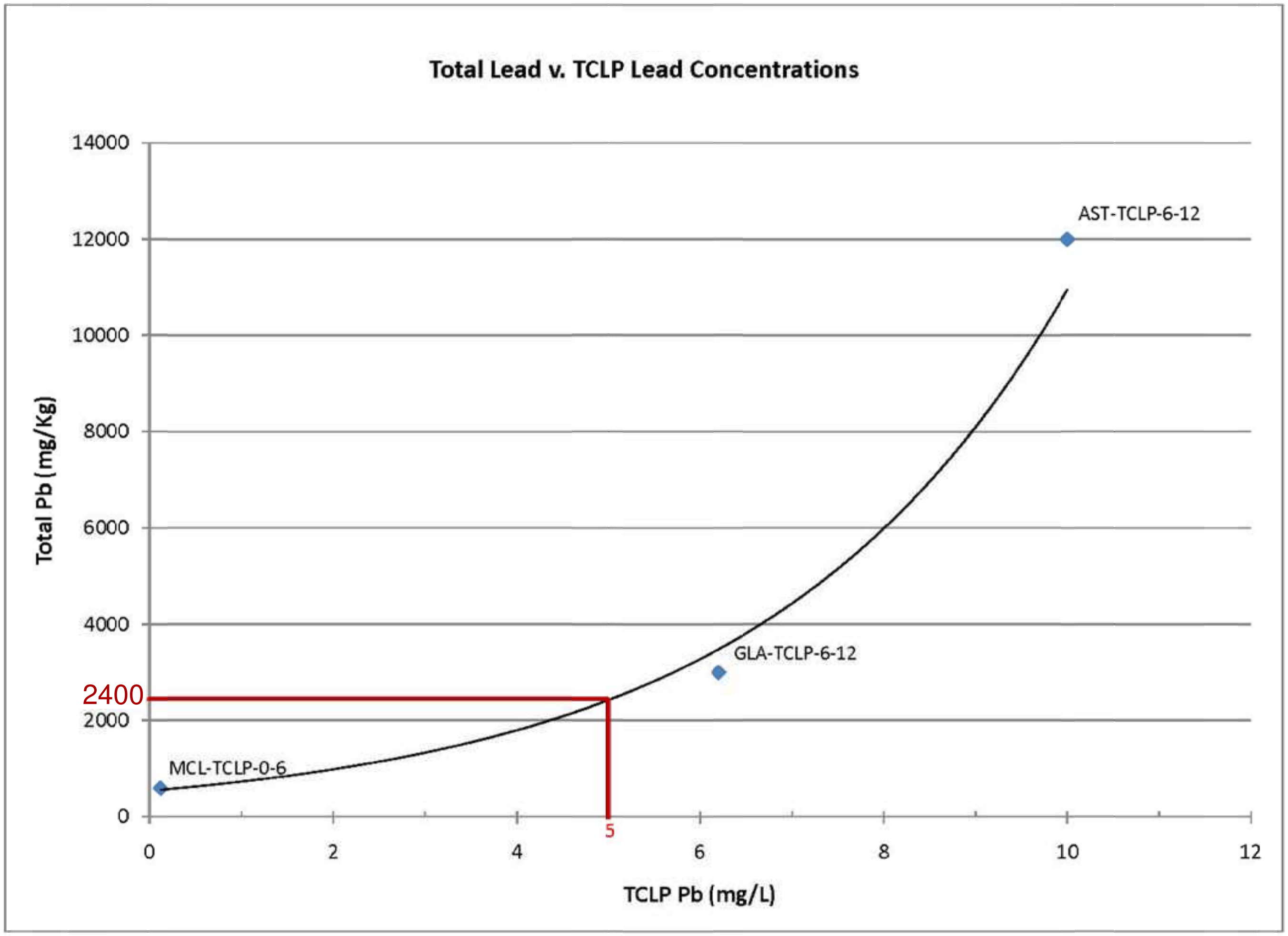
REDACTED

Figure 5-5 Lead Exceedances in OU1 Yards – Subsurface Soil

REDACTED

Figure 5-6 Lead Exceedances in Drip Zones

REDACTED



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

FIGURE 5-7

TOTAL LEAD vs. TCLP LEAD CONCENTRATIONS

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

SulTRAC

Figure 5-8 Arsenic Exceedances in OU1 Yards – Surface Soil

REDACTED

Figure 5-9 Arsenic Exceedances in OU1 Yards – Subsurface Soil

REDACTED

Figure 5-10 Arsenic Exceedances in Drip Zones

REDACTED

Figure 5-11 PAH Exceedances in OU1 Yards – Surface Soil

REDACTED

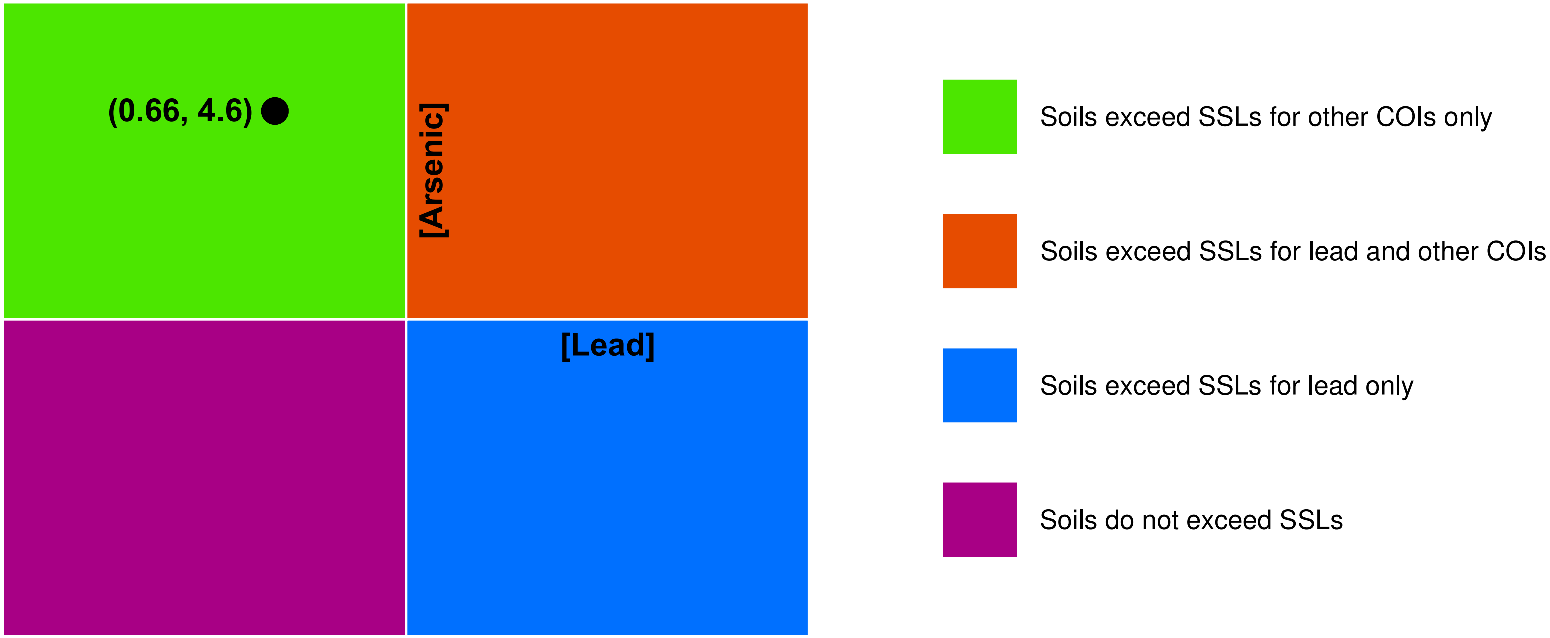
Figure 5-12 PAH Exceedances in OU1 Yards – Subsurface Soil

REDACTED

Figure 5-13 PAH Exceedances in Drip Zones

REDACTED

Example data from 4714 Ivy Ave.



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

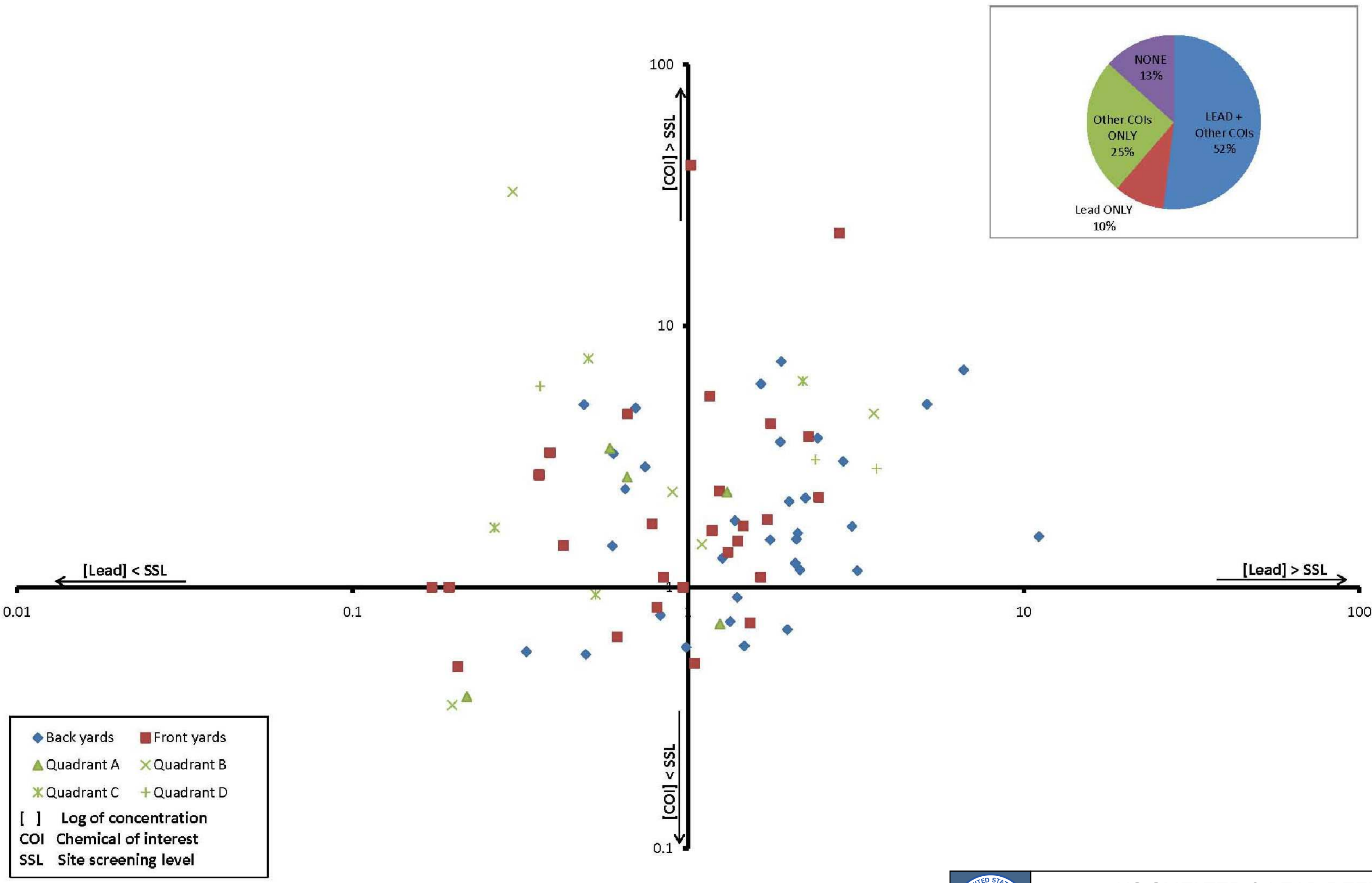
REMEDIAL INVESTIGATION REPORT

FIGURE 5-14

SCATTER PLOT EXAMPLE

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

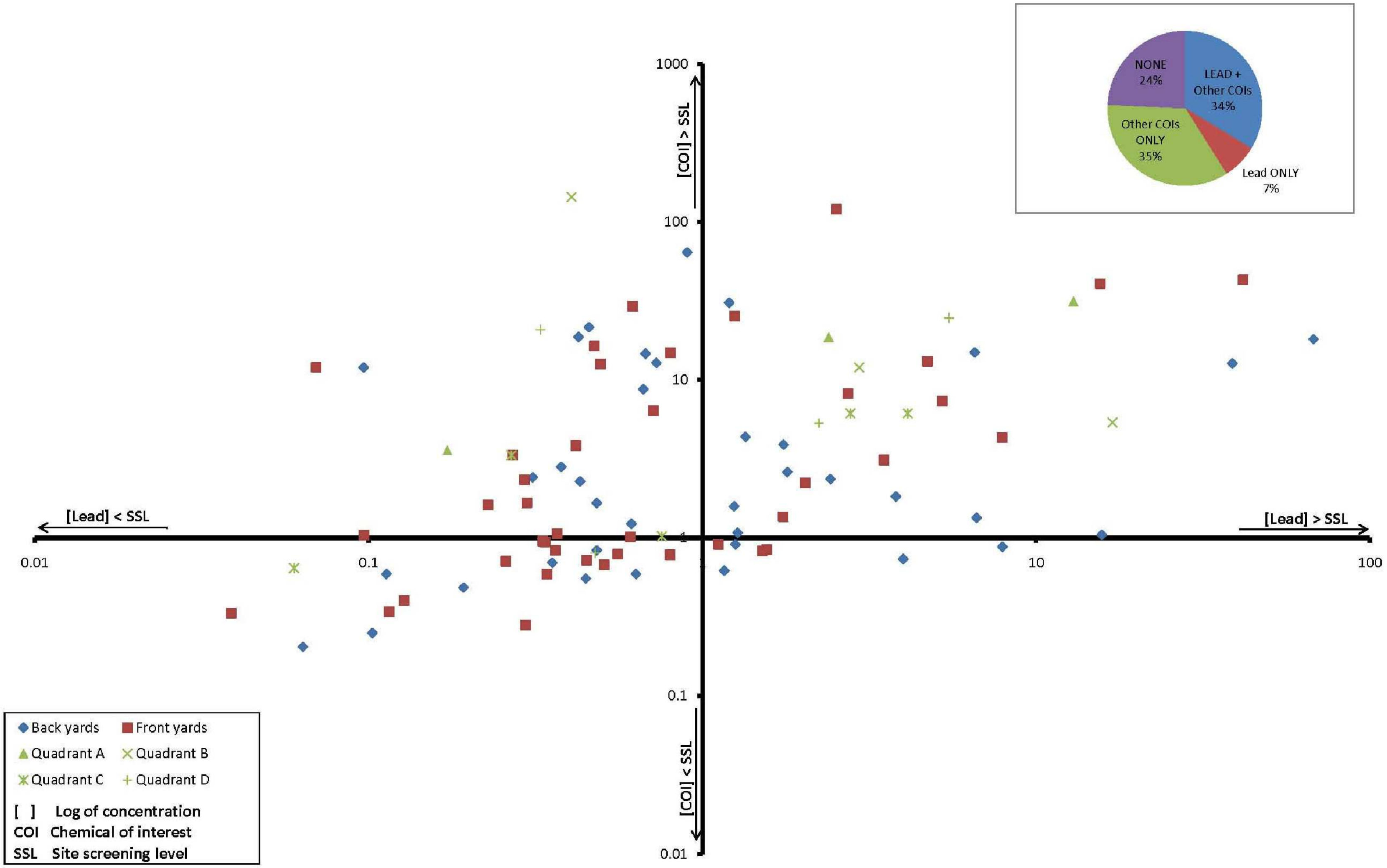
REMEDIAL INVESTIGATION REPORT

FIGURE 5-15

NORMALIZED COI CONCENTRATIONS COMPARED TO LEAD - SURFACE

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

SulTRAC



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

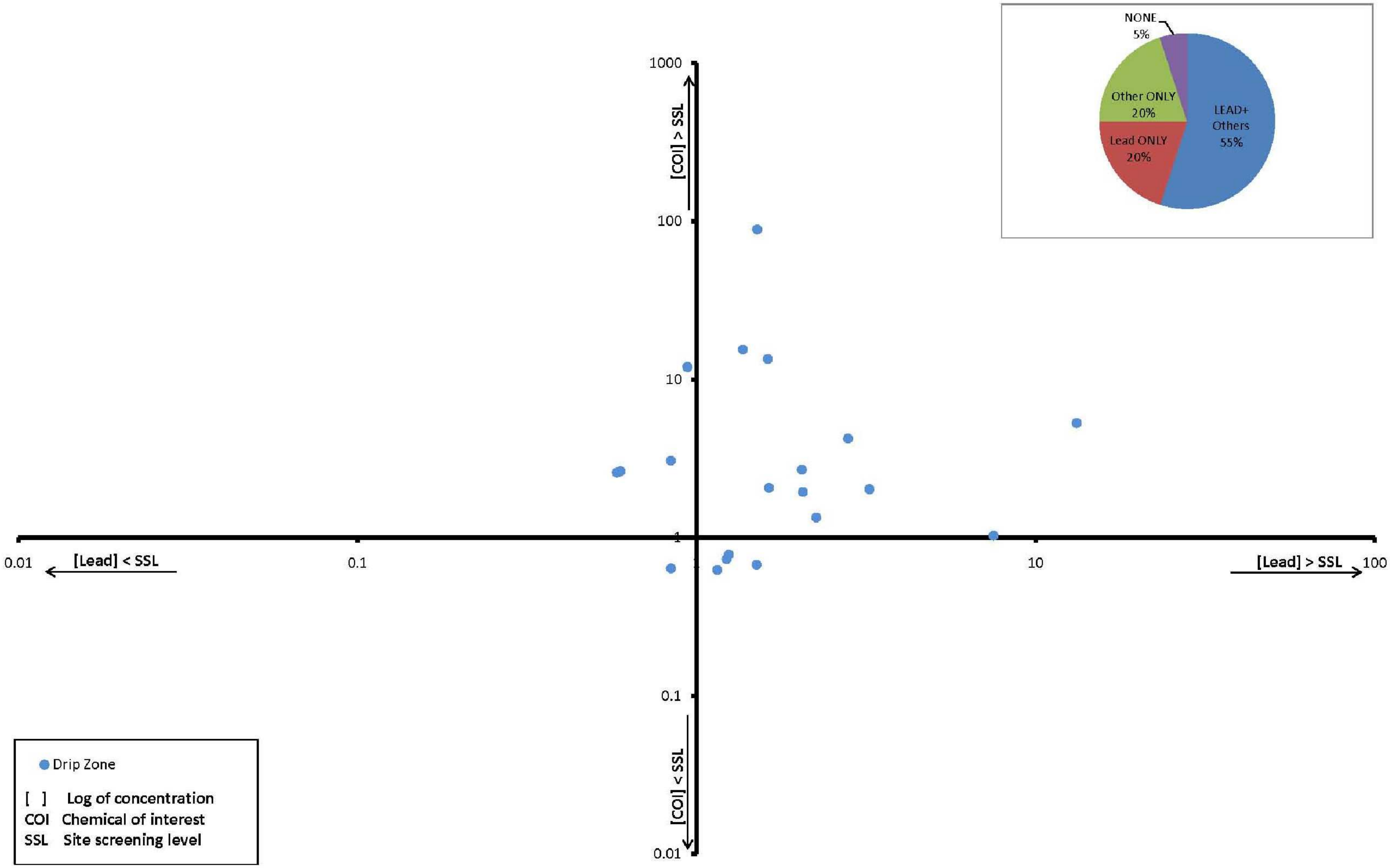
REMEDIAL INVESTIGATION REPORT

FIGURE 5-16

NORMALIZED COI CONCENTRATIONS COMPARED TO LEAD - SUBSURFACE

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

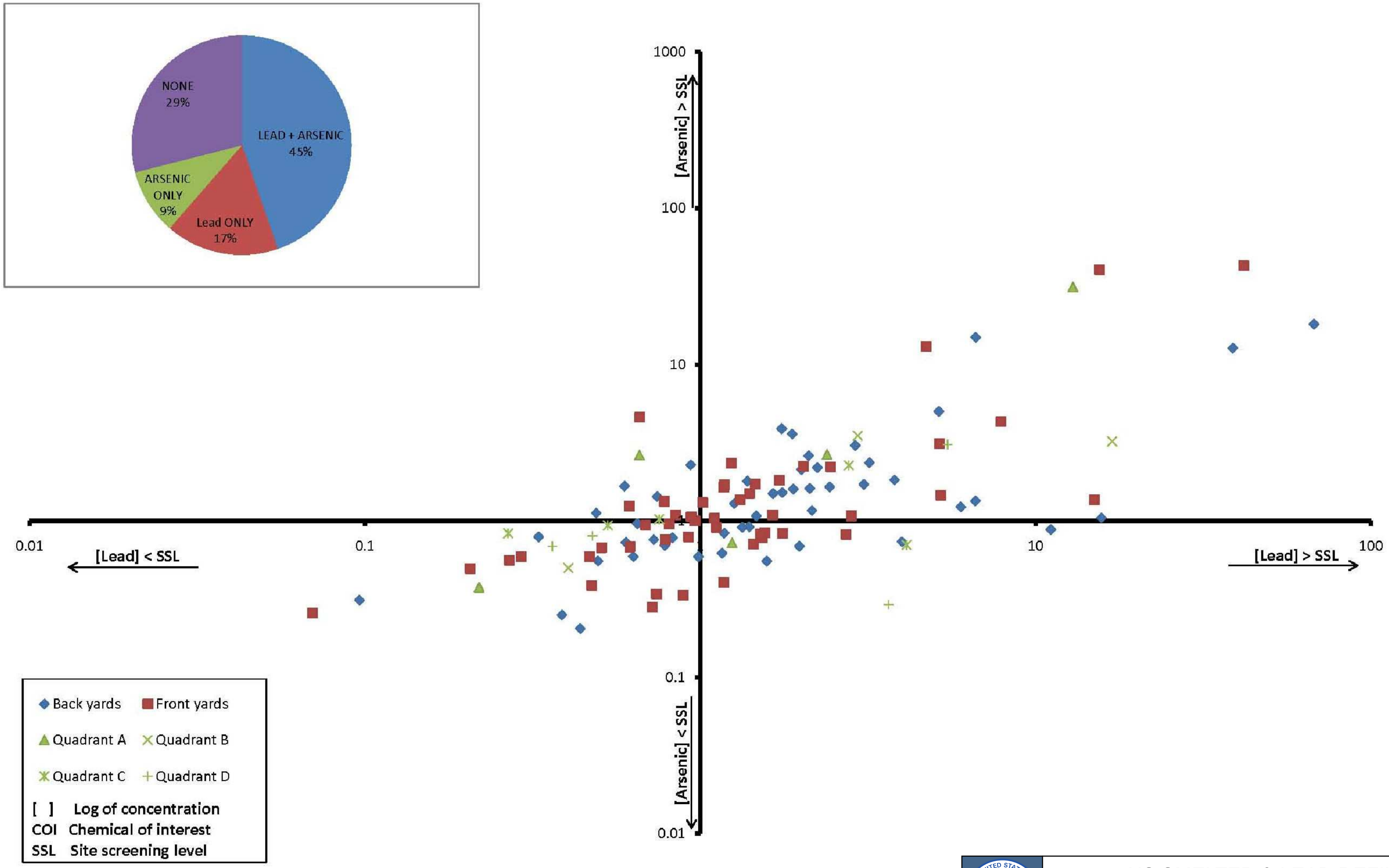
REMEDIAL INVESTIGATION REPORT

FIGURE 5-17

NORMALIZED COI CONCENTRATIONS COMPARED TO LEAD - DRIP ZONE

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

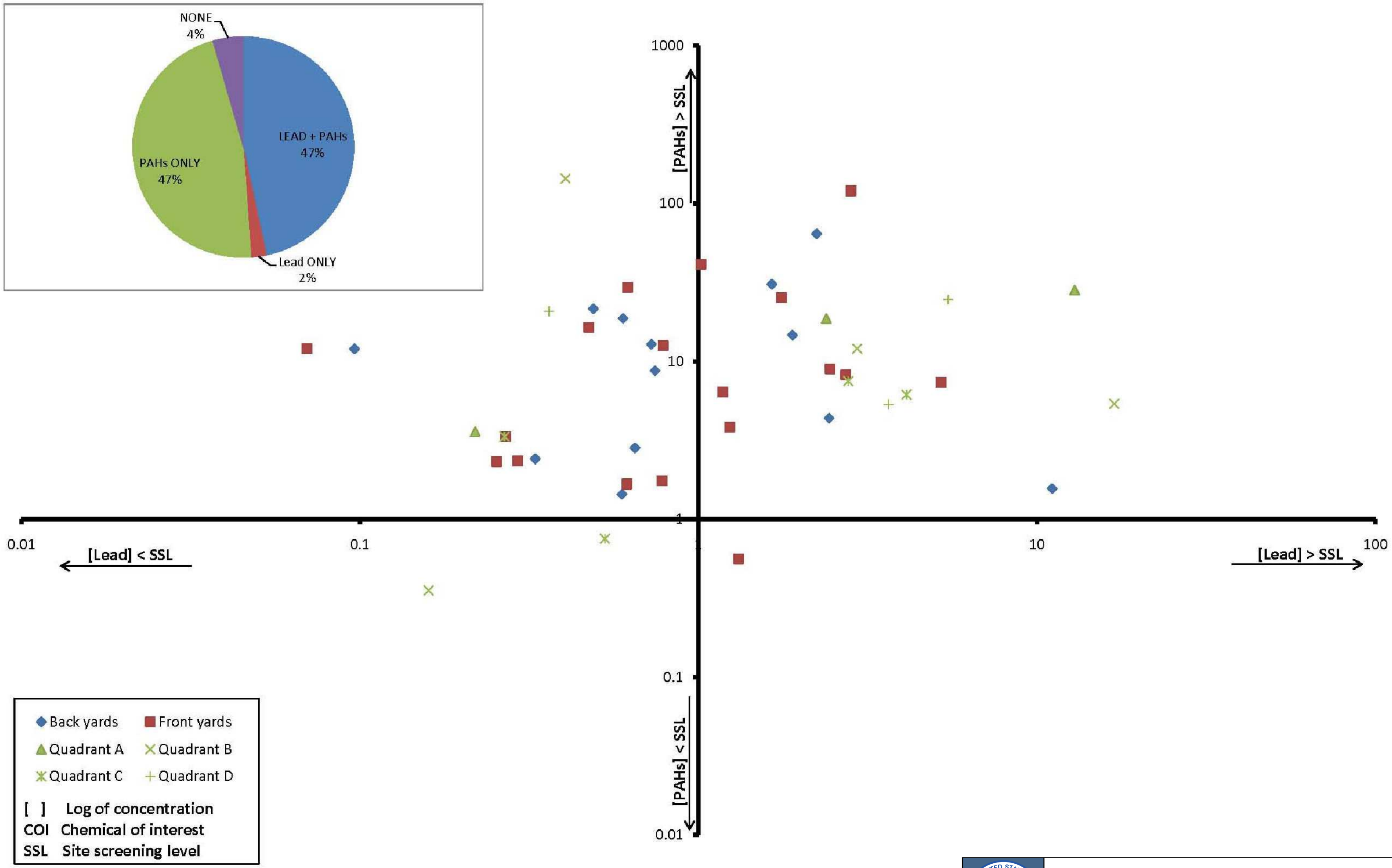
REMEDIAL INVESTIGATION REPORT

FIGURE 5-18

NORMALIZED ARSENIC CONCENTRATIONS COMPARED TO LEAD

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

SulTRAC



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

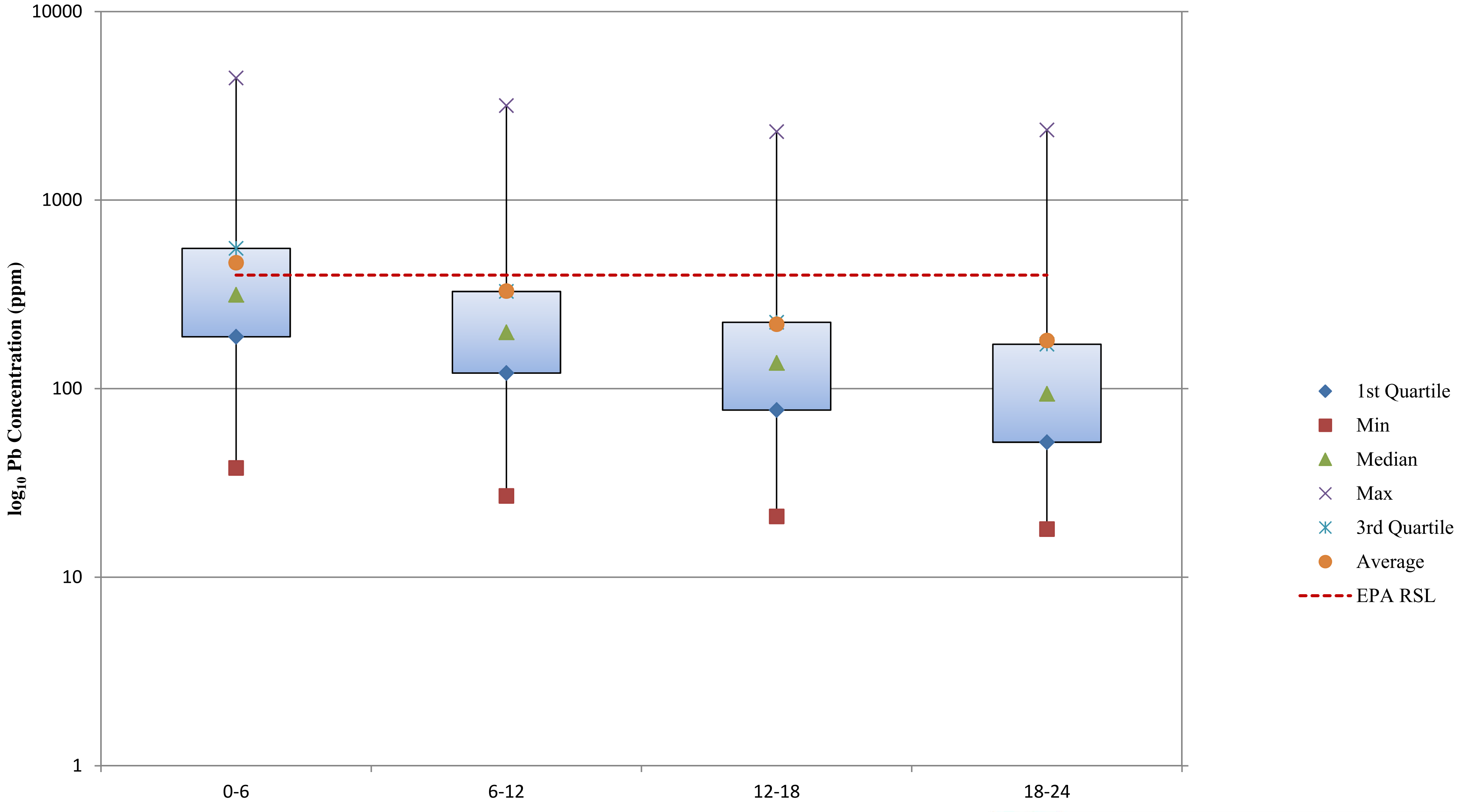
FIGURE 5-19

NORMALIZED PAH CONCENTRATIONS COMPARED TO LEAD

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC

Lead ($\log_{10}$)Concentrations in Soil as a Function of Depth



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

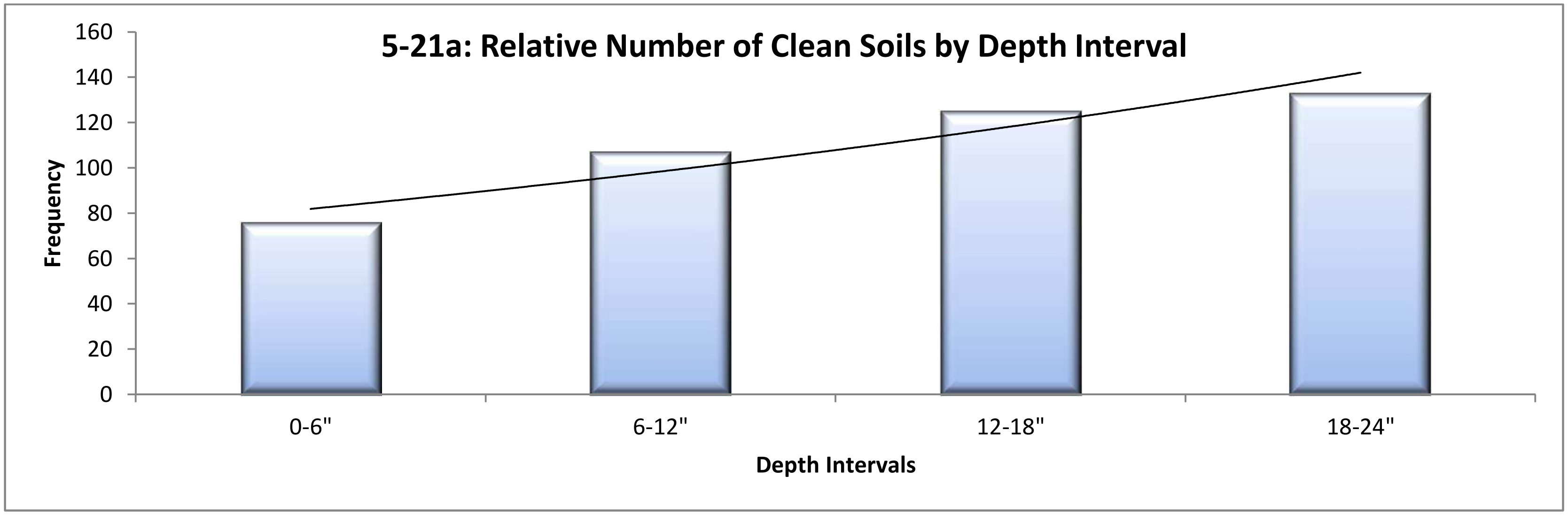
FIGURE 5-20

Lead ($\log_{10}$)Concentrations in Soil as a Function of Depth

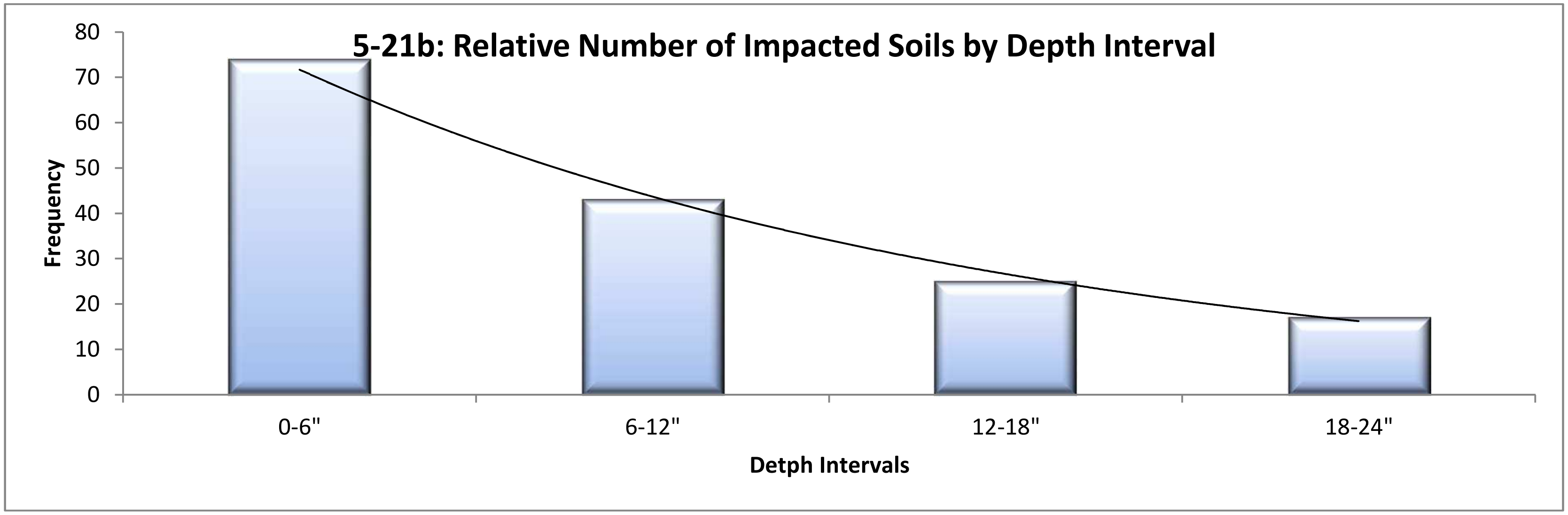
EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC

Histogram of Soil Lead Concentrations as a Function of Depth



5-21a: Relative Number of Clean Soils by Depth Interval



5-21b: Relative Number of Impacted Soils by Depth Interval

US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

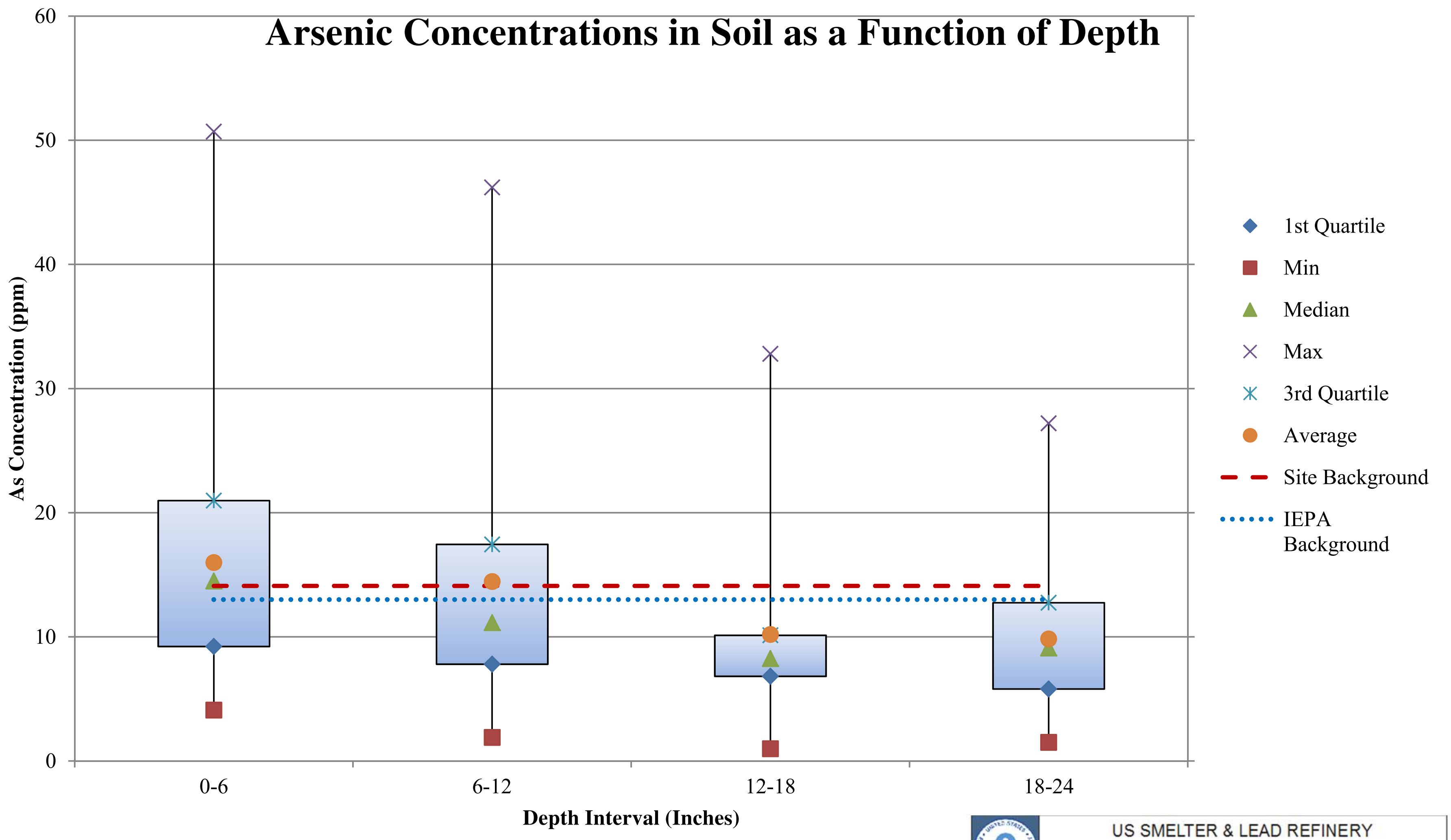
REMEDIAL INVESTIGATION REPORT

FIGURE 5-21

Histogram of Soil Lead Concentrations as a Function of Depth

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

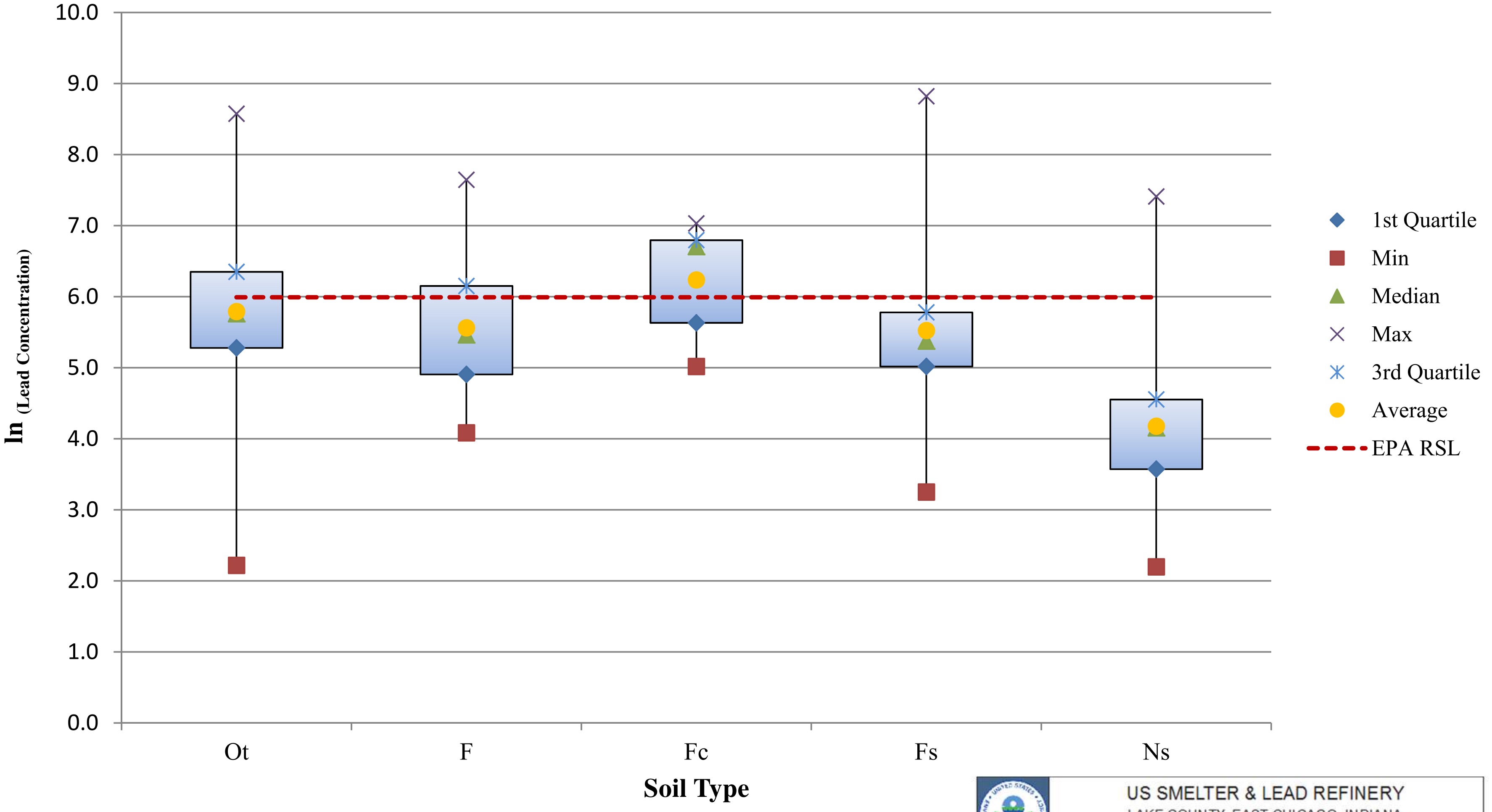
FIGURE 5-22

Arsenic Concentrations in Soil as a Function of Depth

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC

Box Plots Comparing Lead Concentrations by Soil Type



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

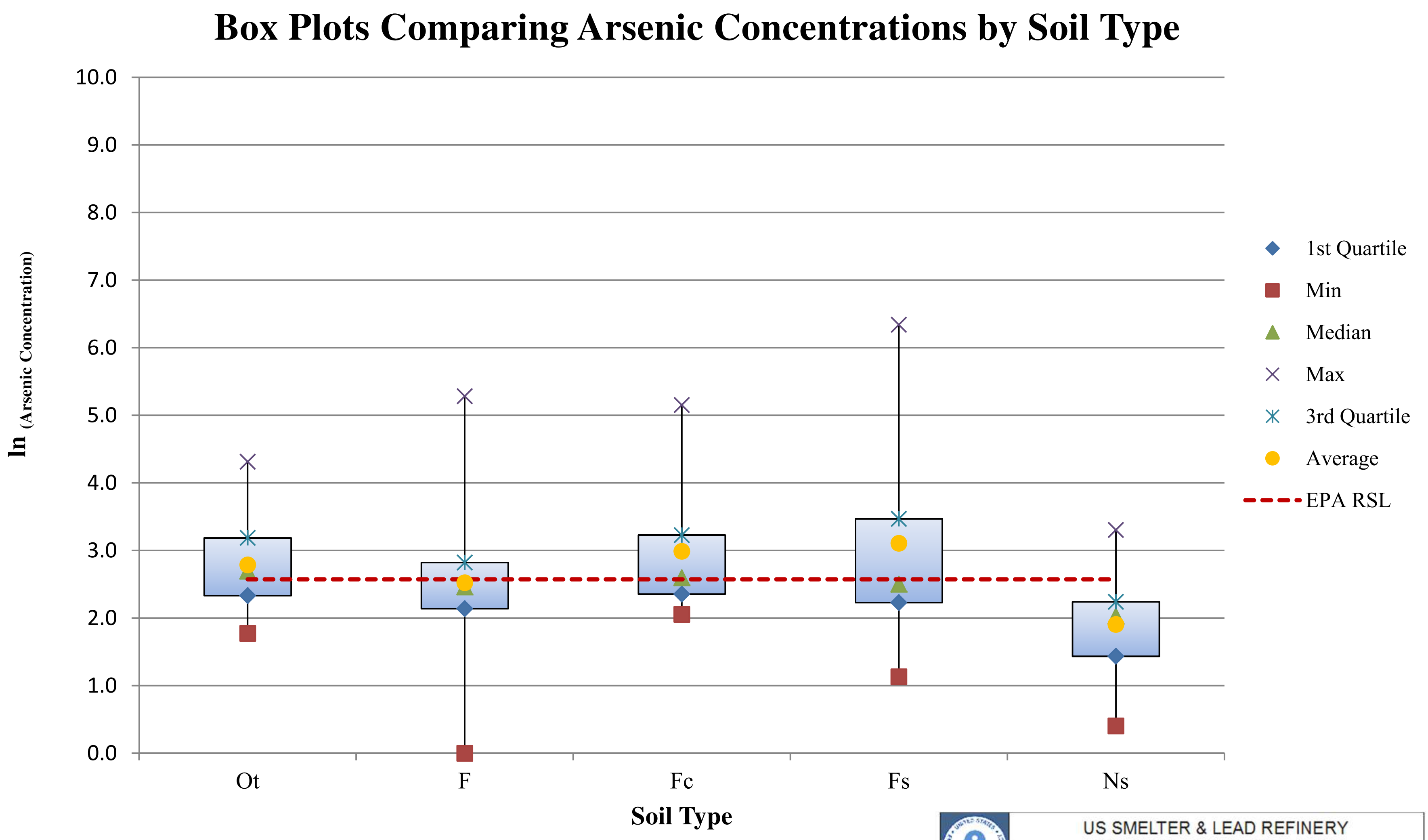
REMEDIAL INVESTIGATION REPORT

FIGURE 5-23

Box Plots Comparing Lead Concentrations by Soil Type

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

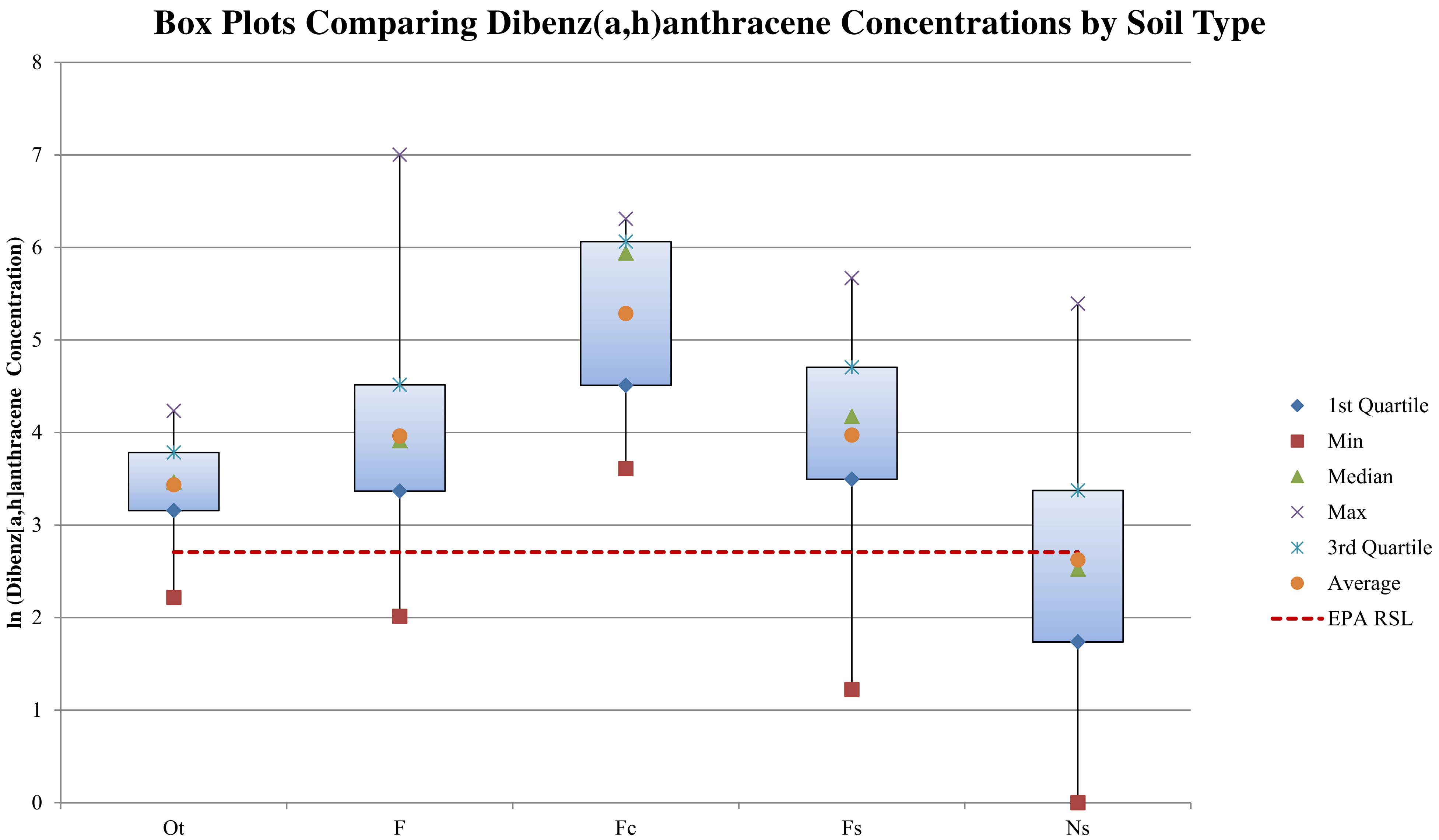
REMEDIAL INVESTIGATION REPORT

FIGURE 5-24

Box Plots Comparing Arsenic Concentrations by Soil Type

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

FIGURE 5-25

Box Plots Comparing Dibenz(a,h)anthracene
Concentrations by Soil Type

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC

TABLES

Table 5-1
Site Screening Levels for Metals
USS Lead Site, East Chicago, Indiana

Analyte Group	Chemical	Background Samples		IDEM Soil Direct Contact [b] (mg/kg)	Residential RSL (mg/kg)	Site Screening Level (SSL) (mg/kg)
		Depth Interval (inches bgs)[a]	Background Threshold Value			
Metals	Aluminum	0-12	6,910	N/A	77,000	77,000
	Antimony	0-12	8.30	140	31	31
	Arsenic	0-6	14.1	3.9	0.39	14.1
		6-12	13.2	3.9	0.39	13.2
	Barium	0-12	89.0	63,000	15,000	15,000
	Beryllium	0-12	1.20	680	160	160
	Cadmium	0-6	1.57	12	70	12
		6-12	0.89	12	70	12
	Calcium	0-12	28,900	N/A	N/A	N/A
	Chromium, Total [c]	0-12	19.8	520,000	120,000	120,000
	Cobalt	0-12	7.70	N/A	23	23
	Copper	0-6	31.3	14,000	3,100	3,100
		6-12	33.1	14,000	3,100	3,100
	Iron	0-12	17,618	N/A	55,000	55,000
	Lead	0-6	112	400	400	400
		6-12	56.6	400	400	400
	Magnesium	0-12	15,406	N/A	N/A	N/A
	Manganese	0-12	478	N/A	1,800	1,800
	Mercury	0-12	0.16	100	5.6	5.6
	Nickel	0-12	20.2	6,900	1,500	1,500
	Potassium	0-12	1,186	N/A	N/A	N/A
	Selenium	0-12	6.40	1,700	390	390
	Silver	0-12	1.40	1,700	390	390
	Sodium	0-12	901	N/A	N/A	N/A
	Thallium	0-12	3.50	24	N/A	24
	Vanadium	0-12	25.2	N/A	390	390
	Zinc	0-12	195	100,000	23,000	23,000

Notes:

a BTVs for arsenic, cadium, copper, and lead are different for surface and subsurface samples.
All other analytes have a single BTV for the entire depth interval analyzed.

b IDEM's Risk Integrated System of Closure (RISC) Default Closure Table (DCT) "Soil Direct" contact levels (IDEM 2009).

c Using values for trivalent chromium (Cr[III])

--	Not tested or no calculation performed
bgs	Below ground surface
DCL	Default closure level
IDEM	Indiana Department of Environmental Management
mg/kg	Milligrams per kilogram
N/A	Not applicable
RISC	Risk integrated system of closure
RSL	Regional screening level

Table 5-2
Site Screening Levels for Polycyclic Aromatic Hydrocarbons
USS Lead Site, East Chicago, Indiana

Analyte Group	Chemical	Background Samples		IDEM Soil Direct Contact [b] (µg/kg)	Residential RSL (µg/kg)	Site Screening Level (SSL) (µg/kg)
		Depth Interval (inches bgs)	Background Threshold Value[a]			
Polycyclic Aromatic Hydrocarbons	2-Methylnaphthalene	0-6	39.0	630,000	N/A	630,000
		6-12	36.6	630,000	N/A	630,000
	Acenaphthene	0-6	3.80	950,000	3,400,000	950,000
		6-12	1.90	950,000	3,400,000	950,000
	Acenaphthylene	0-6	3.70	N/A	N/A	N/A
		6-12	3.72	N/A	N/A	N/A
	Anthracene	0-6	13.0	47,000,000	17,000,000	17,000,000
		6-12	5.64	47,000,000	17,000,000	17,000,000
	Benzo(a)anthracene	0-6	91.0	5,000	150	150
		6-12	62.1	5,000	150	150
	Benzo(a)pyrene	0-6	97.0	500	15	97
		6-12	39.0	500	15	39
	Benzo(b)fluoranthene	0-6	160	5,000	150	160
		6-12	63.0	5,000	150	150
	Benzo(g,h,i)perylene	0-6	75.0	N/A	N/A	N/A
		6-12	33.0	N/A	N/A	N/A
	Benzo(k)fluoranthene	0-6	48.0	50,000	1,500	1,500
		6-12	16.0	50,000	1,500	1,500
	Chrysene	0-6	130	500,000	15,000	15,000
		6-12	68.0	500,000	15,000	15,000
	Dibenz(a,h)anthracene	0-6	26.0	500	15	26
		6-12	9.40	500	15	15
	Fluoranthene	0-6	170	6,300,000	2,300,000	2,300,000
		6-12	90.6	6,300,000	2,300,000	2,300,000
	Fluorene	0-6	4.00	6,300,000	2,300,000	2,300,000
		6-12	3.92	6,300,000	2,300,000	2,300,000
	Indeno(1,2,3-CD)pyrene	0-6	80.0	5,000	150	150
		6-12	32.0	5,000	150	150
	Naphthalene	0-6	25.0	3,200,000	3,600	3,600
		6-12	26.3	3,200,000	3,600	3,600
	Phenanthrene	0-6	110	N/A	N/A	N/A
		6-12	54.9	N/A	N/A	N/A
	Pyrene	0-6	160	4,700,000	1,700,000	1,700,000
		6-12	104	4,700,000	1,700,000	1,700,000

Notes:

[a] BTVs for benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene are different for surface and subsurface samples. All other analytes have a single BTV for the entire depth interval analyzed.

[b] IDEM's Risk Integrated System of Closure (RISC) Default Closure Table (DCT) "Soil Direct" contact levels (IDEM 2009).

--	Not tested or no calculation performed
µg/kg	Micrograms per kilogram
bgs	Below ground surface
BTV	Background threshold value
DCT	Default closure table
IDEM	Indiana Department of Environmental Management
N/A	Not applicable
RISC	Risk integrated system of closure
RSL	Regional screening level
SSL	Site screening level

Table 5-3
Site Screening Levels for Volatile Organic Compounds
USS Lead Site, East Chicago, Indiana

Analyte Group	Chemical	Background Sample Results	IDEM Soil Direct Contact [a] (µg/kg)	Residential RSL (µg/kg)	Site Screening Level (SSL) (µg/kg)
Volatile Organic Compounds	1,1,1-Trichloroethane	--	5,000,000	8,700,000	5,000,000
	1,1,2,2-Tetrachloroethane	--	5,000	560	560
	1,1,2-Trichloro-1,2,2-Triflu	--	N/A	43,000,000	43,000,000
	1,1,2-Trichloroethane	--	9,400	1,100	1,100
	1,1-Dichloroethane	--	1,300,000	3,300	3,300
	1,1-Dichloroethylene	--	310,000	240,000	240,000
	1,2,3-Trichlorobenzene	--	N/A	49,000	49,000
	1,2,4-Trichlorobenzene	--	1,800,000	22,000	22,000
	1,2-Dibromo-3-chloropropa	--	N/A	5.4	5.4
	1,2-Dibromoethane	--	300	34	34
	1,2-Dichlorobenzene	--	2,800,000	1,900,000	1,900,000
	1,2-Dichloroethane	--	3,700	430	430
	1,2-Dichloropropane	--	4,500	890	890
	1,3-Dichlorobenzene	--	420,000	N/A	420,000
	1,4-Dichlorobenzene	--	42,000	2,400	2,400
	2-Butanone	--	44,000,000	28,000,000	28,000,000
	2-Hexanone	--	NA	210,000	210,000
	4-Methyl-2-pentanone	--	12,000,000	5,300,000	5,300,000
	Acetone	--	35,000,000	61,000,000	35,000,000
	Benzene	--	8,400	1,100	1,100
	Bromochloromethane	--	N/A	N/A	N/A
	Bromodichloromethane	--	10,000	270	270
	Bromoform	--	280,000	61,000	61,000
	Bromomethane	--	9,900	7,300	7,300
	Carbon disulfide	--	900,000	820,000	820,000
	Carbon tetrachloride	--	3,300	250	250
	Chlorobenzene	--	380,000	290,000	290,000
	Chloroethane	--	80,000	15,000,000	80,000
	Chloroform	--	3,000	290	290
	Chloromethane	--	N/A	120,000	120,000
	cis-1,2-Dichloroethene	--	110,000	780,000	110,000
	cis-1,3-Dichloropropene	--	N/A	N/A	N/A
	Cyclohexane	--	7,200,000	7,000,000	7,000,000
	Dibromochloromethane	--	N/A	680	680
	Dichlorodifluoromethane	--	N/A	180,000	180,000
	Ethylbenzene	--	4,600,000	5,400	5,400
	Isopropylbenzene	--	1,400,000	2,100,000	1,400,000
	m,p-Xylene	--	690,000	630,000	630,000
	Methyl Acetate	--	N/A	78,000,000	78,000,000
	Methylcyclohexane	--	N/A	N/A	N/A
	Methylene chloride	--	120,000	11,000	11,000
	o-Xylene	--	NA	3,800,000	3,800,000
	Styrene	--	11,000,000	6,300,000	6,300,000
	Tert-Butyl Methyl Ether	--	350,000	43,000	43,000
	Tetrachloroethene	--	9,900	550	550
	Toluene	--	8,800,000	5,000,000	5,000,000
	trans-1,2-Dichloroethene	--	180,000	150,000	150,000
	trans-1,3-Dichloropropene	--	N/A	N/A	N/A
	Trichloroethene	--	4,900	2,800	2,800
	Trichlorofluoromethane	--	980,000	790,000	790,000
	Vinyl chloride	--	1,500	60	60

Notes:

[a] IDEM's Risk Integrated System of Closure (RISC) Default Closure Table (DCT) "Soil Direct" contact levels (IDEM 2009).

--	Not tested or no calculation performed
µg/kg	Micrograms per kilogram
DCT	Default closure table
IDEM	Indiana Department of Environmental Management
N/A	Not applicable
RISC	Risk integrated system of closure
RSL	Regional screening level
SSL	Site screening level

Table 5-4
Site Screening Levels for Polychlorinated Biphenyls and Pesticides
USS Lead Site, East Chicago, Indiana

Analyte Group	Chemical	Background Sample Results	IDEM Soil Direct Contact [a] (µg/kg)	Residential RSL (µg/kg)	Site Screening Level (SSL) (µg/kg)
PCBs and Pesticides	Aroclor 1016	--	1,800	3,900	1,800
	Aroclor 1221	--	1,800	140	140
	Aroclor 1232	--	1800	140	140
	Aroclor 1242	--	1,800	220	220
	Aroclor 1248	--	1,800	220	220
	Aroclor 1254	--	1,800	220	220
	Aroclor 1260	--	1,800	220	220
	Aroclor 1262	--	1,800	NA	1,800
	Aroclor 1268	--	1,800	NA	1,800
	4,4'-DDE	--	20,000	1,400	1,400
	Aldrin	--	250	29	29
	alpha-BHC	--	990	77	77
	alpha-Chlordane	--	N/A	N/A	N/A
	alpha-Endosulfan	--	N/A	N/A	N/A
	beta-BHC	--	3300	270	270
	beta-Endosulfan	--	N/A	N/A	N/A
	delta-BHC	--	N/A	N/A	N/A
	Dieldrin	--	270	30	30
	Endosulfan sulfate	--	N/A	N/A	N/A
	Endrin	--	55,000	18,000	18,000
	Endrin aldehyde	--	N/A	N/A	N/A
	Endrin ketone	--	N/A	N/A	N/A
	gamma-BHC	--	4800	520	520
	gamma-Chlordane	--	N/A	N/A	N/A
	Heptachlor	--	930	110	110
	Heptachlor epoxide	--	470	53	53
	Methoxychlor	--	910,000	310,000	310,000
	p,p'-DDD	--	28,000	2,000	2,000
	p,p'-DDT	--	20,000	1,700	1,700
	Toxaphene	--	3900	440	440

Notes:

[a] IDEM’s Risk Integrated System of Closure (RISC) Default Closure Table (DCT) "Soil Direct" contact levels (IDEM 2009).

--	Not tested or no calculation performed
µg/kg	Micrograms per kilogram
bgs	Below ground surface
DCT	Default closure table
IDEM	Indiana Department of Environmental Management
N/A	Not applicable
PCB	Polychlorinated biphenyls
RISC	Risk integrated system of closure
RSL	Regional screening level
SSL	Site screening level

Table 5-5 COIs in OU1 Yards – Surface Soil

REDACTED

Table 5-6 COIs in OU1 Yards – Subsurface Soil

REDACTED

Table 5-7 COIs in OU1 Recreational Quadrants – Surface Soil

REDACTED

Table 5-8 COIs in OU1 Recreational Quadrants – Subsurface Soil

REDACTED

Table 5-12 Graphical Summary of Lead Results from OU1 Yards and Drip Lines

REDACTED

Table 5-13 Graphical Summary of XRF Lead Results from OU1 Gardens

REDACTED

Table 5-14 Graphical Summary of XRF Lead Results from OU1 Play Areas

REDACTED

6.0 CONTAMINANT FATE AND TRANSPORT

The following sections discuss the conceptual site model (CSM) for OU1 (Section 6.1), the physicochemical properties affecting contaminant fate and transport such as water solubility, adsorption, and soil chemistry (Section 6.2), chemical persistence (Section 6.3), expected fate and transport (Section 6.4), and potential migration routes (Section 6.5).

Relevant chemical terms are defined in Sections 6.2 and 6.3, followed by general descriptions of the site COIs and how chemistry influences their expected fate and transport in Section 6.4. Section 6.5 gives the potential migration pathways specifically as they apply to OU1 at the USS Lead Site.

6.1 CONCEPTUAL SITE MODEL

A CSM is a description of how contaminants enter a system, how they are transported and distributed within the environment, and how humans and organisms can be exposed to those contaminants. A CSM provides a framework for assessing risk from contaminants, understanding uncertainties, and developing remedial strategies. Key elements required to develop a CSM are the location and form of contaminant sources (e.g., emissions, spills, contaminated fill, etc.), transport and migration factors (contaminant sinks), contaminant fate and transport processes (e.g., degradation rates), exposure mechanisms/pathways, and potential human and ecological receptors. Figure 6-1 shows primary contaminant sources, contaminant release and transport mechanisms, and affected media in OU1. Groundwater is presented as an affected medium; however, groundwater will be investigated separately as part of OU2, and is not discussed further in this section. This section (6.1) discusses the origin of COIs in OU1 and the transport mechanisms that affect their distribution.

The USS Lead CSM (see Figure 6-1) presents four potentially affected media at the USS Lead Site: air, soil, surface water, and groundwater. The CSM shows that the USS Lead Site comprises historical plant/factory areas, the residential area (OU1), and a canal, all within an urban setting. The smelter plants are the primary source of contamination, because during plant operations both airborne emissions were generated from plant stacks, and leaks and spills were likely. The fill materials that were used to raise the ground level in OU1 when homes were built at the site are a second major potential source of contaminants. About 2 feet of fill overlie native sands throughout OU1. Metals and PAHs are the main COIs associated with these sources. The water table lies approximately 8.5 feet bgs, with groundwater flowing towards the south/southwest.

Contaminants were deposited at the site through airborne emissions from the industrial plants and direct deposition of contaminated fill material. These contaminants may be remobilized in OU1 through wind (dust and airborne emissions), surface-water runoff and erosion of soils, leaching and infiltration from surface soils, and filling and excavation activities. Other possible sources of contaminants at OU1 may be from fertilizers and pesticides, which may have been applied to the individual properties. Some fertilizers can "contain measurable levels of heavy metals such as lead, arsenic, and cadmium" (EPA 1997). In addition, as noted in Section 1.3.1 above, the DuPont facility manufactured the pesticide lead arsenate, two ingredients of which are the heavy metals lead and arsenic. Human and ecological receptors can be exposed to these COIs through direct dermal exposure to soil, ingestion, or inhalation of windborne soils, ingestion of soils, or ingestion of produce grown in affected soils. Human exposure routes and receptors are discussed in detail in Section 7.0 below and Appendix E of this RI report, and are not discussed further in this section.

6.2 PHYSICOCHEMICAL FACTORS AFFECTING CONTAMINANT FATE AND TRANSPORT

There are several physical and chemical (physicochemical) factors that affect the likely fate and transport of chemical compounds in the environment at the USS Lead Site. These physicochemical factors are complex; they are dictated by a variety of processes that may occur to varying degrees and oftentimes concomitantly, including: water solubility, vapor pressure and Henry's Law constant, carbon and water partition coefficients, and distribution coefficient.

At OU1, the focus of the RI is surface soils, which will also be the focus of the following descriptions of physicochemical factors affecting contaminant fate and transport. Surface water will only be discussed as it pertains to surface soil (e.g., runoff, percolation).

The primary COI at OU1 is lead. Other COIs at OU1 include arsenic and the six PAHs [chrysene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] that exceeded the initial SSLs. Note that PAHs are not considered to be site-related. They are included here for completeness and will be discussed further in Section 8. All COIs have been detected above site SSLs (see Section 5.0 above). Relevant transport factors for these COIs are summarized in Table 6-1 and discussed below.

6.2.1 Aqueous Solubility

Aqueous solubility is a critical property affecting the environmental transport of a chemical. Aqueous solubility is defined as the maximum concentration of a chemical that can dissolve in pure water at a given temperature and pH (Montgomery and Welkom 1989). Solubility is expressed as the mass of a chemical that can dissolve in a given quantity of water, typically milligrams per liter (mg/L). Chemicals with high solubility dissolve easily and have high saturated concentrations. Therefore, chemicals with high solubility can be easily leached from contaminated soils and are typically mobile in groundwater. Inorganic compounds, such as lead, lead oxides, and lead sulfates have low aqueous solubilities and are therefore relatively immobile in soil. PAHs present in OU1 also have very low aqueous solubilities (see Table 6-1) and are expected to be relatively immobile in soils.

6.2.2 Vapor Pressure and Henry's Law Constant

Vapor pressure and Henry's Law constant (K_H) are indications of how readily a compound will volatilize and influence whether a contaminant is more likely to be present in a liquid or gaseous phase. Compounds with low K_H values tend to remain in solution versus volatilizing into the air. Compounds with low vapor pressure tend to have low volatility and little tendency to vaporize. The available vapor pressure and Henry's Law constants for site COIs are listed in Table 6-1. These constants are very low for the primary COIs in OU1, indicating that vaporization of these compounds is not a likely mechanism that will reduce contaminant concentrations in soil.

6.2.3 Adsorption / Partitioning

Adsorption or partitioning is the tendency of a chemical to bind to the surface of soil particles as a result of reactions that occur between the chemical and soil particle surface. The aqueous concentration of chemicals in soils can be substantially influenced by adsorption reactions to the soil matrix.

Adsorption is a function of the chemical- and site-specific soil properties, and is quantified by the distribution coefficient (K_d). K_d is a measure of the ratio of chemical mass that partitions to the solid and liquid phases under equilibrium conditions (see Table 6-1). Chemicals with higher K_d values are more likely to sorb to soils and sediments, while chemicals with lower K_d values are less likely to sorb and may be mobilized to groundwater or surface waters.

The site-specific K_d values listed in Table 6-1 are conservatively estimated by assuming that 0.2% of soil at the site is composed of organic carbon (IDEM 2007):

$$K_d = 0.63 * f_{OC} * K_{OW}$$

where

K_d = distribution coefficient (mL/g)
f_{OC} = fraction of organic carbon (unitless)
K_{OW} = octanol-water coefficient (mL/g), described in Section 6.2.3.2 below

Soils in OU1 have significantly higher organic carbon content based on field observations, so the K_d values listed in Table 6-1 are likely to be significantly lower than those in OU1. Accordingly, the COIs in OU1 are considered very likely to adsorb tightly to soil, except for arsenic, which has a higher aqueous solubility and is expected to have somewhat higher mobility.

6.2.3.1 Inorganic Partitioning

Inorganic compounds are commonly bound to soils through a number of processes that are commonly referred to as *inorganic partitioning* (also "soil binding"). Inorganic partitioning includes electrostatic binding of an inorganic compound to soil particles, precipitation of the inorganic compound with other ions to form an insoluble mineral, or both. For example, an inorganic compound may be immobilized through electrostatic binding followed by precipitation around the sorbed species, resulting in a reduction of (re)mobilization potential for that inorganic compound. Table 6-2 provides a summary of the potential aqueous or soluble forms in the environment, major immobilization/partitioning processes, and geochemical conditions for the inorganic COIs at the USS Lead Site.

Inorganic compounds are commonly bound to soil particles as a result of electrostatic interactions. For example, the mineral hydrous ferric oxide (FeOOH) is a dominant sorbent for many inorganic compounds (e.g., arsenic) at a range of pH values owing to its common presence on soil particle surfaces, amphoteric character, and large surface area. Site-specific K_d values for inorganic compounds may also be correlated to the concentration of hydrous ferric oxide in the soil matrix.

Precipitation is a major immobilization/partitioning processes for most inorganic compounds. Under reducing conditions, the precipitation of immobile metal-sulfide complexes has been noted for arsenic. Similarly, inorganic cations, such as lead, precipitate as relatively immobile metal-carbonate complexes. Therefore, overall mobility of inorganic compounds is highly dependent upon the soil and/or surface water or soil/pore-water chemical conditions. Under neutral pH conditions, inorganics typically have low mobility.

6.2.3.2 Organic Partitioning

The organic carbon partition coefficient (K_{OC}) is often used to estimate the extent to which a chemical will partition between organic matter and water, also known as *organic partitioning*. Organic compounds are often non-polar and tend to interact with the organic matter commonly found within soil matrices. The K_{OC} value is a measure of the tendency of an organic chemical to be adsorbed by soil.

The K_{OC} value is the ratio of the mass of an adsorbed organic chemical per unit mass of organic carbon in the soil to the aqueous solute concentration at equilibrium (Montgomery and Welkom 1990). Lower K_{OC} values (< 10 mL/g) correspond with higher mobility, whereas chemicals with high K_{OC} values tend to adsorb onto the soil matrix.

The *n*-octanol/water partition coefficient (K_{OW}) expresses the distribution of an organic compound between water (a polar solvent) and *n*-octanol (a non-polar solvent). The higher the K_{OW} value, the more hydrophobic the compound, and therefore, the less likely the compound is to remain in solution in water. Both K_{OC} and K_{OW} may be used to predict the degree of sorption to organics in soil and particulate matter, and therefore, their chemical mobility. The organic COIs present in OU1 have relatively high K_{OW} values, indicating a strong tendency to sorb to organics in soil and low mobility (Table 6-1).

6.2.4 Sorption / Retardation

Migration rates of dissolved contaminants range widely for different chemicals because of their degree of adsorption. As a conservative first estimate, they will move at the rate of groundwater flow, or by advection. However, contaminants typically do not move as rapidly as the groundwater because of adsorption to the geologic media. For each contaminant detected, it is possible to calculate a retardation coefficient (also known as the “retardation factor”), which is an estimate of the degree to which the dissolved contaminant is slowed by adsorption in relation to the groundwater flow velocity (Fetter 2001). The retardation coefficient is calculated using the equation (Fetter 2001)

$$R = 1 + \rho_b \times {}^{K_d}/_{n_e}$$

where:

R = retardation coefficient (dimensionless)

ρ_b = bulk density of the soil (g/cm^3)

K_d = distribution coefficient of the contaminant (mL/g)

n_e = effective porosity

The effect of retardation is estimated by dividing the groundwater flow velocity by R, which provides a value of migration that is either equal to the flow rate (in the case of no retardation, $R = 1$) or less than the flow rate (in the presence of retardation, $R > 1$).

Soil density was not measured during the RI. The NRCS Web Soil Survey estimates the bulk density of soil at the USS Lead Site to be approximately 1.6 grams per cubic centimeter (g/cm^3) (USDA 2010). Potential contaminant mobility at OU1 will be discussed further in Section 6.4 below.

6.2.5 Soil Chemistry

Surface soil chemistry conditions, such as pH, presence of other cations/anions, and saturated/ unsaturated conditions, are important factors that influence the fate and transport of contaminants. Soil pH typically drives the dominant ionic form of a metal contaminant and by extension whether the metal will be present in a soluble or insoluble form. The pH also dictates the stability and number of cation and anion sorption sites on clay and other soil minerals. For inorganics present as cations (e.g., lead), sorption is greatest in soils ranging from neutral to alkaline pHs because clays, metal oxides, and hydroxides have more negatively charged sites to bind the positively charged cations. Conversely, at more acidic pH ranges, these soil minerals have more positively charged sites that can sorb inorganics that are commonly present as anions (e.g., arsenate).

Soil pH was measured during the initial sample extraction for SVOC analyses for 192 soil samples analyzed at an off-site laboratory during the RI. Overall, the soil pH (regardless of depth or location within OU1) ranges from neutral to slightly alkaline. The NRCS Web Soil Survey database publishes data regarding the soil pH in Lake County, Indiana, in OU1 (USDA 2010). NRCS provided data only for the two small parts of OU1 that were mapped as having **OkB** soils. NRCS does not report values for the 92% of OU1 that NRCS classifies as **Ur**. Table 6-3 summarizes the minimum, maximum, average (mean), and median soil pH values obtained from these sources. For inorganics present as cations (e.g., lead), sorption is greatest in these types of soils. The NRCS survey data presented show that the **OkB** soils (see Figure 4-1) have a neutral to slightly acidic pH. However, measured soils collected from these areas showed a neutral pH.

The presence or absence of other cations and anions may impact the speciation of the contaminant and/or may compete with a contaminant (e.g., phosphate competition with arsenic) for sorption sites and thus increase contaminant mobility. Conversely, many of these same cations and anions may precipitate out with metals, reducing their solubility/mobility.

Saturated or unsaturated soil conditions create anoxic or oxic environments, which may catalyze geochemical reactions, potentially affecting the dominant contaminant species present for mobilization. In addition to affecting the potential metal speciation, redox conditions may play an important role in sorption/desorption and precipitation/dissolution reactions. If soil becomes anoxic, iron minerals that may be currently sorbing inorganic COIs may be reduced, which could release the previously sorbed cation or anion. Reducing conditions are also required to immobilize several metals (e.g., arsenic and lead) through the precipitation of stable metal sulfide minerals. If a previously reduced soil becomes oxidized (for example, turnover of surface soils as in gardening), previously present metal sulfide minerals may undergo oxidative dissolution where the metal is released, sulfide is oxidized to sulfate, and the soil becomes more acidic.

6.2.6 Physical Transport Factors

The primary expected mechanism of contaminant transport in OU1 is physical relocation of contaminated soils by wind, water, or excavation. Potential physical transport factors are fugitive dust mobilized by wind; erosion and/or solution by wind or by overland surface water flow; percolation (also known as "leaching") of surface water; and soil excavation and filling activities.

Contaminants already adsorbed to surface soil particles can be blown into the atmosphere and eventually redeposited by wind. Erosion of exposed surface soils by winds is potentially an important physical transport factor at the USS Lead Site, but is mitigated by extensive vegetative cover (lawns), which binds soils and reduces erosion.

Substances dissolved in surface water can partition out of the dissolved phase to a solid phase or adsorb onto particles suspended in the water or onto bottom sediment. Conversely, chemicals may desorb from sediment back into the water. Contaminants may also be transported into subsurface drainageways such as city sewers via surface-water runoff and, to a lesser extent, via percolation downward in the soil column to open, exposed, or fractured sewers.

Surface soil excavation and filling activities can potentially re-suspend contaminated fugitive dust/ particles or bring in additional soils with contamination if the soils are from the polluted source. Site-specific conditions that affect potential physical transport factors will be further evaluated in Section 6.5.

6.3 CHEMICAL PERSISTENCE

Chemical persistence is the resistance of a chemical to degradation or other transformations in the environment. Factors affecting chemical persistence, volatilization, degradation, transformation, and bioaccumulation, are discussed below.

6.3.1 Volatilization

Volatilization occurs when a chemical changes from a liquid to a gaseous phase. With respect to soil, this process typically results in a decrease in the amount of a chemical in soil as the chemical volatilizes to soil gas and discharges to the atmosphere. Overall, a reduction in chemical concentrations in soil through volatilization occurs over time. Volatilization reactions are most significant in surface soils.

Chemical volatility is typically quantified by the Henry's Law constant (Table 6-1). Compounds with K_H values higher than 10^{-3} atm-m^3/mol are expected to volatilize readily from water to air, whereas those with lower K_H values are relatively nonvolatile. Inorganic compounds persist in soil and do not readily dissolve in groundwater or volatilize into air. COIs in OU1 have low Henry's Law constants (Table 6-1); thus volatilization is not expected to substantially influence the fate of most site-specific compounds.

6.3.2 Degradation

Degradation is the transformation of one chemical into another by such processes as hydrolysis, photodegradation, and biodegradation. It is commonly expressed as a half-life that composites the degradation with whatever processes may be operating or occurring simultaneously.

Photodegradation and hydrolysis are common abiotic reactions. Photodegradation is the chemical decomposition induced by light or other radiant energy and is most significant in surface soils. Hydrolysis is the reaction of a chemical with water (e.g., hydroxyl and hydronium ions) and is most significant in saturated environments.

Degradation processes are unlikely to influence the inorganic contaminant of concern concentrations at the USS Lead Site, as metal compounds are not significantly influenced by degradation processes such as hydrolysis, photodegradation, and biodegradation. Moreover, organic compounds are typically highly stable under most environmental conditions, and the predominant degradation mechanism affecting their fate is photodegradation. Photodegradation is limited to the uppermost surface soils. At the USS Lead Site, PAHs may have a potential for photodegradation. Potential contaminant mobility at OU1 will be discussed further in Section 6.4.

6.3.3 Transformation

Transformation occurs when inorganics are increased in valence state by oxidation or reduced in valence state by reduction. Transformation can be caused by changes in oxidation-reduction potential or pH, and by microbial or abiotic processes. Transformation may have a significant effect on the mobility of an inorganic compound. Potential contaminant mobility at OU1 will be discussed further in Section 6.4.

6.3.4 Bioaccumulation

Bioaccumulation is the process of chemicals adsorbing to and accumulating in plants and the organ tissue of animals. Inorganics generally have higher K_{OC} values and may bioaccumulate more readily. Potential contaminant mobility at OU1 will be discussed further in Section 6.4.

6.4 EXPECTED FATE AND TRANSPORT

The expected fate and transport for each of the primary COIs present in OU1 are discussed below. Table 6-2 summarizes the potential chemical forms, immobilization mechanisms, and mobilization mechanisms of the inorganic COIs. This section provides a description of the general behavior of the COIs identified at the USS Lead Site.

This section is a discussion of the fate and transport of COIs in OU1. The primary COI at the Site is lead; however, since arsenic and PAHs were also detected in soil they are included in all analytical discussions regarding fate and transport. The investigation methods and prescribed remedy for lead are based on the guidance provided in the Handbook; hence, lead does not require as much discussion as arsenic and PAHs. Despite the additional text discussing arsenic and PAHs at the Site, lead is the primary COI and is the COI driving the remedy.

6.4.1 Lead

The expected fate and transport of lead at OU1 are primarily driven by sorption of lead onto soil particles. Lead was detected at concentrations above SSLs in surface soil samples throughout OU1. In general, high lead concentrations are limited to fill soils, and concentrations in native soils decrease sharply with depth.

The pH and redox conditions of soils are the most important factors affecting lead mobility. Acidic conditions favor lead solubility and bioavailability. Neutral pH conditions favor the adsorption of lead to oxides and oxyhydroxides of iron, manganese, and aluminum, as well as to clay minerals and organic matter. Furthermore, the formation of soluble lead carbonates and phosphates under these conditions limits lead mobility. Under very alkaline conditions, which dissolve organic matter, and/or the presence of natural organic acids (e.g., humic and fulvic acids), lead solubility will increase due to the formation of mobile metal-organic complexes. Even at neutral pHs, if no particles are available for sorption, lead will likely precipitate out of solution as $PbCO_3$ (partitioning to the solid phase instead of liquid phase owing to the high K_d of lead). Furthermore, a low redox potential may result in the dissolution of iron hydroxides, which would result in increased lead mobility, but it may also favor the formation of insoluble lead sulfides (e.g., galena).

At the USS Lead Site, low solubility, very high K_d (see Table 6-1), and neutral pH (see Table 6-2) strongly indicate that lead will adsorb to soil particles and remain fairly immobile.

6.4.2 Arsenic

The expected fate and transport of arsenic at OU1 are primarily driven by sorption of arsenic onto soil particles. Arsenic was detected at concentrations above SSLs in surface soils throughout OU1 at the USS Lead Site. Arsenic in soil may be transported as fugitive dust by wind, in runoff, or may leach into the subsurface soil or groundwater. However, because many arsenic compounds partition to soil under oxidizing conditions, leaching usually does not transport arsenic to any great depth (Moore, et al. 1988; Pantsar-Kallio and Manninen 1997; Welch, et al. 1988). Arsenic is largely immobile in agricultural soils; therefore, it tends to concentrate and remain in the upper soil layers indefinitely. Downward migration has been shown to be greater in a sandy soil than in a clay loam (Sanok, et al. 1995). Additionally, site surface soils generally were described as being either organic topsoil (silty sand) or some variation of fill with a sand component. Typically, a native sand layer is encountered at a depth of 18 to 22 inches bgs. Data presented in Section 5.3.1.2 generally suggest that arsenic is not mobile in the native sand layer at OU1 due to lack of arsenic data detected above the SSL.

Transport and partitioning of arsenic depends upon the chemical form of the arsenic and on interactions with other materials present. Soluble forms move with the water, and may be carried long distances (EPA 1979). However, arsenic may be adsorbed from water onto soils, especially clays, iron oxides, aluminum hydroxides, manganese compounds, and organic material (EPA 1979; Welch, et al. 1988). Arsenic adsorption in soil is positively influenced by the iron content of the soil (Janssen, et al. 1997). Analytical results show that OU1 soils contain abundant iron. Under oxidizing and mildly reducing conditions, surface-water arsenic concentrations are usually controlled by adsorption rather than by mineral precipitation. In acidic and neutral waters, As(V) is extensively adsorbed, while As(III) is relatively weakly adsorbed. Dissolved phosphate competes with arsenic for adsorption sites, thus suppressing arsenic adsorption and enhancing the mobility of arsenic. However, dissolved-phosphate concentrations are expected to be low and should not play a significant role in competing with arsenic for sorption sites.

Both biotic and abiotic reduction by sulfides may play an important role in arsenic redox chemistry (Rochette, et al. 2000). Microbial reduction of arsenate occurs through the respiration and detoxification mechanisms of *E. coli* and *Staphylococcus* bacteria (Jones, et al. 2000). Under highly reducing conditions, sulfide (as H_2S and HS^-) is capable of reducing As(V) to As(III) without microbial mediation; however, the reduction rate is highly pH-dependent. The reaction kinetics of arsenate reduction by sulfides are slow at neutral pH, whereas a pH of 4 can increase the reduction rate by 300-fold (Rochette, et al. 2000). In such environments, dissolved As-S complexes may represent a large fraction of the available arsenic. Once As(V) is reduced to As(III), it may form several different soluble and insoluble phases with sulfur (Rochette, et al. 2000). These phases may provide an important sink for arsenic in the environment via the formation of surface precipitates similar to arsenopyrite (Bostick and Fendorf 2003).

These site-specific characteristics indicate that, with neutral pH, the presence of iron and sulfates, and even with a low K_d, the actual distribution of arsenic is found to be more prevalent in the solid phase. Arsenic will tend to be bound to soil and clay particles at the USS Lead Site and will be only slightly more mobile than lead.

6.4.3 Organics

As stated in Section 5.1, although SVOCs (including PAHs) are discussed below, there is no reasonable expectation that consistent releases of these compounds into the OU1 area are associated with a metals smelting facility (USS Lead). Rather, as discussed further in Section 8, detections for these compounds are associated with other anthropogenic sources typical of a metropolitan industrial area and results discussed herein are intended for completeness of the RI report only.

PAHs are the organic COIs present in OU1. The key factors that influence the fate and transport of SVOCs are their water solubility, volatility, affinity for organic carbon (K_{OC}) or water (K_{OW}), and potential for adsorption (K_d). This section provides a description of the general behavior of SVOCs. The six PAHs detected above SSLs at the site include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

PAHs are composed of hydrogen and carbon arranged molecularly in two or more fused benzene rings without heteroatoms or substituents (Fetzer 2000). Often, low molecular weight PAHs (e.g., 128.16 for naphthalene) are more mobile in the environment as compared to the high molecular weight PAHs (e.g., 252.3 for benzo(a)pyrene). Higher molecular weight PAHs are relatively immobile because of their large molecular volumes and their low volatility and solubility. The PAH COIs at the USS Lead Site all have molecular weights of ≥ 228.0 g/mol. These six COIs, as well as a few others, are also known for their carcinogenic, mutagenic, and teratogenic properties (Luch 2005).

In soils, PAHs do not readily volatilize, and are typically adsorbed strongly to soil and soil organic matter. PAHs are therefore expected to remain adsorbed to soil at the site. Concentrations of PAHs in soil typically tend to decrease over time as a result of natural attenuation from processes such as degradation and dispersion. PAHs undergo biodegradation in both soil and water; however, they tend to bioaccumulate in plant and animal tissue.

PAHs are lipophilic, and PAHs tend to sorb to soils, suspended particles, or sediments rather than dissolve/mix in water. In general, the high number of aromatic rings and molecular weight of PAHs result in low water solubility and high K_{OC} (see Table 6-1). High K_{OC} values indicate a strong tendency for the compounds to partition in the organic matter in soil, resulting in lower mobility. With most K_d values ranging from 501 to 8,717, even the most water-soluble PAHs would not be readily mobile in the dissolved phase. Therefore, PAHs are not expected to be mobile in groundwater or surface waters. One exception, for example, is naphthalene, which is soluble in water and has lower K_{OC} and K_d values. At the USS Lead Site, naphthalene did not exceed the SSLs for any depth in OU1.

In aquatic systems, the degree of sorption depends on the organic carbon content and particle size (ATSDR 1997). Sorption of PAHs to particulates increases with increasing organic carbon content of the particles and increasing molecular weight of the PAHs. Low and medium molecular weight PAHs are more likely to be transported through sediments by leaching or being resuspended into the water column. At low humic acid concentrations (below 0.1 percent), hydrocarbons are adsorbed onto the hydrophobic portions of humic particles (Eisler 1987). This sorption increases as humic acid concentration increases.

Above humic concentrations of 0.1 percent, solubilization of PAHs into humic acid aggregates sharply increases. This solubility is also pH-dependent. At a humic acid concentration of 0.05 percent, higher pH levels favor PAH solubilization. Approximately 33 percent of PAHs do, however, remain dissolved in the water column (Eisler 1987). These PAHs are expected to degrade rapidly through photodegradation (if exposed to sunlight).

6.5 POTENTIAL MIGRATION ROUTES

Potential migration routes for contaminants at the USS Lead Site were assessed according to the contaminants' properties and fate-and-transport processes. The COIs detected in soil samples at concentrations above SSLs included:

- Arsenic
- Lead
- Benzo(a)anthracene
- Benzo(b)pyrene
- Benzo(b)fluoranthene
- Chrysene
- Dibenzo(a, h)anthracene
- Indeno(1, 2, 3-cd)pyrene

Potential migration pathways for the listed COIs to be released, deposited, or redistributed in surface soils include:

- particulate erosion and redeposition by wind
- runoff, particulate erosion, and redeposition by surface water
- surface-water percolation
- surface soil filling and excavation activities

Chemicals with high carbon/water partition coefficients and distribution coefficients, such as lead and arsenic, are more likely to sorb to soil particles and thus to be transported along with those particles via wind and surface water. Because some surface soils within OU1 are exposed, it is likely that lead and arsenic are transported as particulates or dust originating from these surface soils.

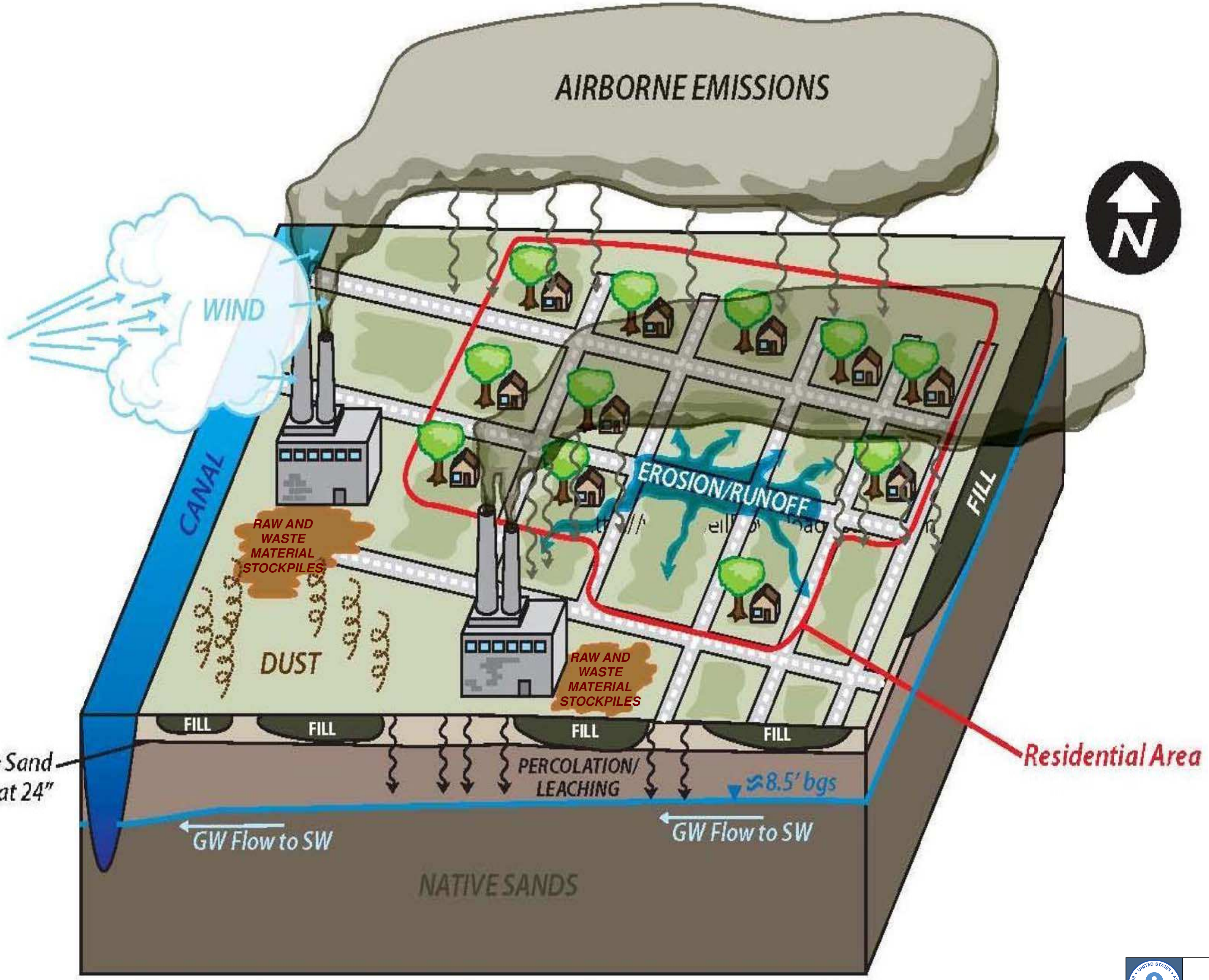
Contaminants may migrate in air via two distinct mechanisms: entrainment of contaminated particles by the wind and volatilization, primarily of organic compounds. Windborne dust is the primary pathway for site COIs to be released to the atmosphere due to their strong tendency to adsorb to soil particles. The most likely transport mechanism for inorganic and PAH COIs is by wind-borne transport of contaminated, eroded soil and dust. Volatilization is not considered a potential migration pathway because lead, arsenic, and PAHs have very low volatility and will not volatilize to any significant degree under current site conditions. Because OU1 is flat lying and served by a municipal sewer system, redeposition in low-lying areas is not expected to be of major significance at the site.

Surface runoff water is another significant pathway that can erode surface soils and transport particles via overland flow, resulting in redeposition at lower elevations at the USS Lead Site. Due to low solubility and high K_{OC} values, both the inorganic and organic COIs do not dissolve or leach easily into surface water, but rather stay sorbed onto any particle initially sorbed to. However, surface water can transport particles and COIs laterally through runoff or downward through percolation. Specifically, during storm events, contaminants present on particles in the upper surface soils may be transported via preferential runoff routes. If the stormwater runoff flow is sufficient, contaminated soil particulates may be entrained in the surface runoff and be transported across properties that are not paved and/or vegetated. Depending on the topography of the specific property, surface runoff may flow towards the city sewer system or the Indiana Harbor Canal.

Excavation and filling activities are other migration pathways. Particularly at the USS Lead Site, there has been documentation of such activities. Excavation potentially exposes the subsurface to fugitive dust deposition. Filling activities result in top soils that are not as compact as native soils, which may result in faster percolation and/or erosion rates. There is also a possibility that amended fill materials may be contaminated, particularly if they originate from a nearby source of contamination.

The potential for contaminant mobility and the risk to human health (discussed in Section 7.0 below) at OU1 is a driver for future site remedial actions, which will be addressed during the future feasibility study and remedial design phase.

FIGURES



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

FIGURE 6-1

CONCEPTUAL SITE MODEL

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC

TABLES

Table 6-1
Physical Properties for Chemicals of Interest
USS Lead Site East Chicago, Indiana

Contaminant of Concern	Water solubility (mg/L water)	Vapor Pressure (mm Hg)	Henry's Law Constant, K_h (atm-m^3/mol)	Organic Carbon Partition Coefficient, log(K_{oc}) (mL/g)	Octanol-Water Partition Coeffecient log(K_{ow}) (mL/g)	Distribution Coefficient, Kd (1) (mL/g)	S.G. (unitless)	Molecular Weight (g/mol)
SVOCs								
Benzo(a)anthracene	1.40E-02	5.0E-9 @ 20° C	1.16E-06	6.14	5.60	501	1.30	228.0
Benzo(a)pyrene	1.20E-03	5.60E-09	1.55E-06	6.74	6.06	1,449	1.24	252.3
Benzo(b)fluoranthene	1.20E-03	5.0E-7 @ 20° C	1.22E-05	5.74	6.12	1,661	1.29	252.3
Chrysene	1.80E-03	6.30E-09	1.05E-06	5.3	5.61	513	1.27	228.2
Dibenzo(a, h)anthracene	5.0E-4 @ 25 °C	1E-10 @ 20° C	7.30E-08	6.52	6.84	8,717	1.28	278.4
Indeno(1, 2, 3-cd)pyrene	6.20E-02	1.0E-6 @ 20° C	6.95E-08	6.20	6.58	4,790	1.38	276.3
Metals								
Arsenic As(V) (Na_2HAsO_4) As (III) ($NaAsO_2$)	6.1E6 @ 15 °C Soluble	N/A	N/A	N/A	N/A	2 (2)	1.87	312.01 129.9
Lead Pb(II) ($PbCO_3$)	Insoluble	N/A	N/A	N/A	N/A	1,950 - 10,760 (3)	6.14	267.2

Notes:

Data Sources: (EPA 1990), (Verschueren 2001), (ATDSR 2008)

(1) K_d values calculated assuming 0.2% fraction of organic carbon (f_{oc}) in soil (IDEM 2007): $K_d = 0.63 * f_{oc} * K_{ow}$

(2) K_d values taken from *Understanding Variation in Partition Coefficient (Kd) Values, Volume III, EPA 402-R-04-002C, 2004.* Actual reported values ranged from 0.28 to 6.46.

(3) K_d values taken from *Understanding Variation in Partition Coefficient (Kd) Values, Volume II, EPA 402-R-99-004B, 1999* . Soil pH assumed to be bewteen 6.4 and 8.7. Aqueous concentrations assumed to be <10 ppb.

atm	atmosphere
g	gram
Hg	mercury
K_d	distribution coefficient
K_h	Henry's Law constant
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol-water partition coefficient
mL	milliliter
mm	millimeter
mol	mole

Table 6-2
Potential Forms, Immobilization and Mobilization Mechanisms for Inorganic COIs
USS Lead Site East Chicago, Indiana

Inorganic Consituent	Potential Aqueous/Soluble Forms in the Environment	Immobilization Mechanism(s)	Mobilization Mechanisms/ Pathways
Arsenic	Reduced Form: $H_3AsO_3^0$ Oxidized Form: H_2AsO_4, $HAsO_4{}^{2-}$	Sorption to iron (Fe) and aluminum hydroxides ($Al(OH)_3$), noncrystalline aluminosilicates (Al_2SiO_5), Fe and calcium (Ca) precipitates; formation of sulfides (AsS, As_2S_3 , As_4S_4)	Low pH destabilizes iron hydroxides (eg. FeO, Fe_3O_4, Fe_2O_3). Low Eh dissolves iron hydroxides. Phosphates and in some cases elevated sulfate ($SO^{2-}{}_4$) levels may outcompete As for sorption sites in soil. As may be mobilized if sulfides (e.g. H_2S, HS^- and S^{2-}) are oxidized.
Lead	Pb^{2+}, $PbCO_3$	Sorption to iron hydroxides , organic matter, noncrystalline Al_2SiO_5, carbonate ($CO_3{}^{2-}$)minerals; formation of sparingly soluble lead complexes suchs as carbonates (e.g. $PbCO_3$), sulfides (e.g. PbS), sulfates (e.g. $PbSO_4$), phosphates (e.g. $Pb_3(PO_4)_2$).	Low pH destabilizes $CO_3{}^{2-}$ and iron hydroxides. Commingled organic acids and chelates (e.g. EDTA) may decrease sorption. Low Eh dissolves iron hydroxides but favors PbS formation.

Notes:

Sources: Brady et al. 1998), (Brady et al. 1999), (Rai et al. 1984), (McBride 1994), (Smith et al. 1995)

As	Arsenic
C	Carbon
EDTA	Ethylenediaminetetraacetic acid
Eh	Reduction potential
H	Hydrogen
O	Oxygen
Pb	Lead
pH	A measure of the acidity or basicity of an aqueous solution
S	Sulfur

Table 6-3 pH values for USS Lead Site, East Chicago, Indiana

pH Method	*Number of Samples*	*Minimum pH*	*Maximum pH*	*Mean pH*	*Median pH*
December 2009 lab analysis (all depths)	**8**	**7.1**	**9.6**	**7.7**	**7.5**
0-6 inches bgs	3	7.1	7.5	7.4	7.5
6-12 inches bgs	3	7.1	7.5	7.4	7.5
12-18 inches bgs	1	--	--	7.5	--
18-24 inches bgs	1	--	--	9.6	--
August 2010 lab analysis (all depths)	**184**	**6.8**	**8.3**	**7.3**	**7.0**
0-6 inches bgs	62	6.8	8.3	7.1	7.0
6-12 inches bgs	47	6.8	8.3	7.3	7.0
12-18 inches bgs	39	6.8	8.3	7.4	7.1
18-24 inches bgs	36	6.8	8.3	7.5	7.5
NRCS Web Soil Survey database[a]	**--**	**--**	**--**	**--**	**--**
0-6 inches bgs	--	--	--	--	6.3[b]
6-12 inches bgs	--	--	--	--	6.5[b]
12-18 inches bgs	--	--	--	--	6.5[b]
18-24 inches bgs	--	--	--	--	6.5[b]

Notes:

a Data from NRCS Web Soil Survey Database are from Version 11 September 22, 1020. Only values for soil type OKb are given in database. No pHs for soil type Ur were in the NRCS database.

b For each soil layer, pH is recorded as three separate values in the NRCS database. Typically, a low value and a high value indicate the pH range for the soil component and a third “representative” value indicates the expected pH value. For USS Lead Site area, only the “representative” was given from the NRCS website/database.

bgs below ground surface

NRCS Natural Resources Conservation Service Web Soil Survey

7.0 HUMAN HEALTH RISK ASSESSMENT

The draft Human Health Risk Assessment for the USS Lead Site is presented in Appendix E. The HHRA is limited to a characterization of the risks and hazards posed to human receptors associated with potential exposure to site-related contaminants in soil within OU1. The technical approach used to prepare the HHRA accords with the EPA and IDEM risk assessment guidance, including primarily EPA's "Risk Assessment Guidance for Superfund" (RAGS) (EPA 1989) as well as IDEM's RISC (IDEM 2001). This summary is organized to match the major sections of the HHRA.

The HHRA summarized below utilizes all data obtained during the RI to assess potential risks to site users. The risk evaluation of lead differs from other constituents because of its unique toxicological properties. Lead exposure can have systemic (i.e., non-carcinogenic) effects, but does not appear to have a threshold exposure level like other non-carcinogens. Therefore, the HHRA defines three types of risk: cancer risk, non-cancer risk, and risk from lead. Each type of risk is significant and will be considered independently for future risk-management decisions.

7.1 DATA EVALUATION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

The HHRA focuses on potential exposure to contaminants in soil based on analytical data for soil samples collected at various residential, recreational, school, and industrial/commercial properties at the USS Lead Site. As discussed in Section 3.0 and Section 5.0 above, analytical data have been obtained and evaluated as part of numerous historical investigations, as well as Phases I and II of the current RI. In order to best characterize current conditions at the USS Lead Site, the HHRA considered analytical results only from samples collected in Phases I and II of the current RI. This section summarizes data acquisition (Section 7.1.1), data evaluation (Section 7.1.2), and selection of chemicals of potential concern (COPC) (Section 7.1.3).

7.1.1 Data Acquisition

Phase I and II RI sampling is summarized in Section 3.1 and Section 3.2, respectively. USS Lead Site properties sampled during Phases I and II are identified on Figure 3-1. As discussed in Section 3.0, soil samples of various types were collected at a series of depths and locations at each property. In summary, up to three different types of samples were collected at each property:

- Five-point composites at discrete 6-inch intervals at 0 to 6, 6 to 12, 12 to 18, and 18 to 24 inches bgs. **Note:** In a small number of cases, the deepest interval extended several inches deeper than

24 inches bgs in front and back yards on properties where soil removal occurred as part of City of East Chicago activities.

- Discrete grab samples at the same 6-inch intervals from the center of any play areas, gardens, and flower beds at a property.
- Four-point drip line composites around buildings. At homes with gutters, samples were collected at each downspout discharge. If a single downspout was present, a grab sample was collected. If multiple downspouts were present, grab samples were collected at each downspout and composited.

For the purposes of the HHRA, all three types of soil samples were considered together because potential receptors are assumed to move freely throughout each property, and because including all sample results was believed appropriate for maximizing health protectiveness. Specifically, soil samples were grouped in two ways. Soil samples collected from 0 to 6 inches bgs at each property were grouped and referred to as "surface soil" under current land use conditions. Soil samples collected from 0 to 2 feet bgs (or slightly deeper at a limited number of locations) were grouped and referred to as "subsurface soil" under current land use conditions. (**Note:** Soil 0 to 6 inches bgs was included as part of subsurface soil because receptors [utility and construction workers] cannot be exposed to soil deeper than 6 inches bgs without going through and contacting soil from 0 to 6 inches bgs.) However, under future land use conditions, soil at depths from 6 inches to 2 feet bgs may become mixed with soil from 0 to 6 inches bgs due to various excavation, grading, and construction activities. Therefore, under future land use conditions, soil from 0 to 2 feet bgs is defined as both surface and subsurface soil.

7.1.2 Data Evaluation

Data were evaluated based on completeness, holding times, initial and continuing calibrations, surrogate recoveries, internal standards, compound identification, laboratory and field quality assurance/quality control (QA/QC) procedures and results, reporting limits (RL), documentation practices, and application of validation qualifiers (EPA 1992a). Analytical data collected as part of Phase I and II RI sampling were considered to be acceptable for use in the HHRA. Data were reduced based on consideration of essential nutrient and duplicate status as described below.

- Calcium, magnesium, potassium, and sodium are classified as essential nutrients and, therefore, were eliminated from further quantitative evaluation (EPA 1989).
- Duplicate pairs were reduced to a single value based on an evaluation of the RPD between the paired results.

7.1.3 Selection of COPCs

Consistent with EPA's approach for selecting chemical constituents for quantitative evaluation, maximum detected concentrations of constituents were compared to conservative screening levels, and background levels if appropriate, to identify COPCs (EPA 1989). (**Note:** Consistent with EPA guidance, the average concentration of lead in soil was compared to the appropriate receptor-specific screening level). As noted in Section 5.0, the nature and extent discussion compares the COIs to the SSLs, which are independent of the conservative screening levels used in the HHRA. Each of these steps is summarized below in Sections 7.1.3.1 and 7.1.3.2, respectively.

7.1.3.1 Screening Levels

If the maximum detected constituent concentration was less than its conservative screening level, the constituent was eliminated as a COPC because the constituent would not contribute significantly to overall risk (EPA 1993). Exceedances of screening levels do not in themselves indicate that an unacceptable risk exists. Rather, the exceedance of a screening level indicates need for further evaluation in the risk assessment. Soil screening levels for protection of human health for different land use types are summarized as follows:

- **Residential, recreational, and school properties**: EPA's RSLs for residential soil (EPA 2010c), based on the lower of an excess cancer risk of $1\text{x}10^{-6}$ or a hazard index (HI) of 0.1 for non-cancer effects. All three of these property types are open and available to the general public. Default soil screening levels are not available for recreational and school properties. Therefore, the most conservative, unlimited access RSLs for residential soil were used for all three soil types.
- **Industrial/Commercial properties**: EPA's RSLs for industrial soil (EPA 2010c). (**Note:** For the purposes of the RI, only two industrial/commercial properties were sampled – a gas station on Kennedy Avenue and a beauty shop on Euclid Avenue.)

Primary screening levels were not available for a limited number of constituents detected at the USS Lead Site. For these constituents, surrogate screening values were selected and documented based on structural similarities, potential toxicity, and health endpoints. Uses of surrogates are documented in the appropriate screening tables in the HHRA.

7.1.3.2 Background Screening

After the comparison of maximum detected concentrations to the applicable screening levels, secondary screening of detected constituents (metals and PAHs) was performed using regional background concentrations if available. Screening against background concentrations ensured that constituents that may naturally occur at levels above the regulatory screening levels would not be included as COPCs in the HHRA. The approach for developing background data sets and conducting background screening of site results is presented in Appendix B of the attached Risk Assessment (see Appendix E), and summarized below.

Background soil samples were collected on August 9, 2010, from two public parks (Pulaski Park and Harrison Park) and one cemetery (Elmwood Cemetery) in Lake County, Indiana (see Figure 3-2). These are the same locations that START used to collect background samples in September 2007 (STN 2007). Pulaski Park and Harrison Park are located about 1.75 miles west-northwest and west-southwest, respectively, from the USS Lead Site. Elmwood Cemetery is located about 1.5 miles south-southwest of the USS Lead Site. At each park, grab samples were collected at three locations and at each cemetery, grab samples were collected at two locations. At each location, grab samples were collected at two separate intervals: 0 to 6 inches bgs and 6 to 12 inches bgs. The grab samples were sent to EPA's CLP for TAL metals and PAHs.

Both graphical and statistical methods were used to provide initial exploratory analysis of the raw results for metals and PAHs in surface (0 to 6 inches bgs) and subsurface (6 to 12 in bgs) soil. Qualitative evaluation and comparisons of central tendency Wilcoxon Rank Sum (WRS) test results from the initial exploratory analysis were used to evaluate whether background concentrations should be pooled across depths or evaluated separately for individual chemicals. As appropriate, outlier values were removed from the background data set. Based on the modified background data set, estimators for an upper threshold or plausible upper bound (sometimes referred to as a concentration limit, although BTV is the term used in EPA [2010d]) of the background distribution for individual chemicals were calculated. Single-point threshold limits are commonly used to conduct background screening at areas of concern; however, their use should generally be restricted to cases where sample sizes in a particular area of concern are too small to permit the use of two-population statistical tests, or where the goal is to perform preliminary or rapid screens of site results.

The maximum detected concentrations of metals and PAHs at each property whose samples were retained at the soil-screening level stage were compared to their respective BTVs. Metals and PAHs that exceeded their BTVs were retained as COPCs.

As discussed further in Section 8.4.3, the concentrations of PAHs in site soil were further evaluated. Based on multiple lines of evidence, including comparison to the concentration of PAHs in soil from the Chicago, IL metropolitan area (USGS 2003), it was concluded that PAHs from most USS Lead Site properties can be considered ambient and are not from site-related aerial deposition, even though concentrations exceed BTVs. Nonetheless, for the purposes of the HHRA, PAHs were retained as COPCs based on comparison to screening levels (Section 2.2.1) and the site-related background screening presented in Appendix B.

7.2 EXPOSURE ASSESSMENT

Exposure assessment is the process of measuring or estimating the intensity, frequency, and duration of human exposure to a chemical in the environment. The exposure setting at and surrounding the USS Lead Site has been described in Section 4.0. The remainder of this section summarizes the site-specific CSM used as the foundation of the exposure assessment (Section 7.2.1) and the methods used to quantify receptor-specific exposures (Section 7.2.2).

7.2.1 Conceptual Site Model

The CSM links potential or actual contaminant releases to potential human exposures. As discussed in Section 4.0, OU1 is a mixed residential and commercial/industrial area north of the former USS Lead industrial facility. The mixed use area includes (1) numerous residences, including single and multi-family units some of which are public housing, in the southwest corner of the area, (2) various generally small commercial/industrial operations, (3) various municipal and community offices and operations, (4) two schools (the Carrie Gosch Elementary School and the Carmelite School for Girls), (5) four parks, and (6) numerous places of worship (see Figure 3-1). Residences, schools, and public parks constitute the large majority of properties and acreage within the USS Lead Site. These properties are unlikely to be redeveloped and replaced by alternate property types. Therefore, for the purpose of the risk assessment, future land uses of all properties are assumed to be the same as current land uses. In addition to the primary types of receptors associated with each property (for example, adult and child residents at residences, and students, faculty, and staff at schools, etc.), the risk assessment also considers potential exposures of workers involved in utility installation and repair and construction activities at each property.

Because no COPCs were identified on industrial/commercial and municipal and community properties, receptors were not identified for these property types. Vacant lots were assumed to be developed as residential properties. Therefore, for the purposes of the HHRA, vacant properties were treated as residential properties. Thus, the HHRA evaluated the following three property types:

- Residential (Note: Because the girls, as well as teachers and staff, live at the school, the Carmelite School for Girls was treated as a residence with adolescent (6 to 18 years of age) students and adult staff).
- Schools – a single school, the Carrie Gosch Elementary School, was considered in the HHRA.
- Recreational – four parks were considered in the HHRA: Riley Park, Goodman Park, Kennedy Gardens Park, and Melville Avenue Park.

Receptors considered at each of these property types are summarized below.

- Residential
    - Child residents (0 to 6 years of age)
    - Adult residents
    - Adult utility workers
    - Adult construction workers.
- Schools
    - Students (6 to 12 years of age)
    - Adult indoor teachers and staff (spending all or the majority of their work days indoors, for example, most teachers, staff, and administrators)
    - Adult outdoor teachers and staff (spending a significant portion of their work days outdoors, for example, physical education teachers, custodial staff, and landscaping workers)
    - Adult utility workers
    - Adult construction workers
- Recreational
    - Child recreationalists (0 to 6 years of age)
    - Adolescent recreationalists (6 to 16 years of age)
    - Adult recreationalists
    - Adult indoor park workers (spending all or most of their work days indoors, for example, most staff and administrators). Note: indoor workers were not evaluated for either Melville or Kennedy Gardens Park, as park buildings are not present at either of these parks.
    - Adult outdoor park workers (spending a significant portion of their work days outdoors, for example, staff directing or supervising outdoor recreational activities and programs, custodial workers, and landscaping workers). **Note:** Outdoor park workers were not evaluated at Kennedy Gardens Park; this park is used as a public space and not a location for organized recreational activities.

In general, all the receptors identified above were assumed exposed to surface (current land use conditions) and subsurface soil (future land use conditions), respectively, via incidental ingestion, dermal contact, and inhalation of particulates in ambient air. (**Note:** Utility and construction workers were assumed to be exposed to subsurface soil under both current and future land use conditions). Additionally, residents were also assumed exposed through ingestion of homegrown produce.

7.2.2 Exposure Quantification

Exposure assessment is the process of measuring or estimating the intensity, frequency, and duration of human exposure to a chemical in the environment. Exposures were estimated under both Reasonable Maximum Exposure (RME) and Central Tendency Exposure (CTE) scenarios to provide a range of exposures (and ultimately risks and hazards) for use by risk managers. The RME is estimated by selecting values for exposure variables such that the combination of all variables results in the maximum, reasonably expected exposure. The CTE is estimated by selecting values such that the combination results in the typical (average) exposure that could occur at a site (EPA 1993).

An exposure can occur over a period of time. The total exposure can be divided by the time period to calculate an average exposure per unit of time. An average exposure can be expressed in terms of body weight. Most exposures quantified in the HHRA are normalized for time and body weight, are presented in units of milligrams of chemical per kilogram of body weight per day (mg/kg-day), and are termed "doses." The equation below is a generic equation for calculating chemical doses (EPA 1989).

$$D = \frac{(C \times CR \times EF \times ED)}{(BW \times AT)}$$

where

D = **Dose:** the amount of chemical at the exchange boundary (mg/kg-day); to evaluate exposure to non-carcinogenic chemicals, the dose is referred to as the average daily dose (ADD); to evaluate exposure to carcinogenic chemicals, the dose is referred to as the lifetime average daily dose (LADD)

C = **Chemical concentration:** the average concentration (referred to as the exposure point concentration [EPC]) contacted over the exposure period (for example, mg/kg for soil)

CR = **Contact rate:** the amount of contaminated medium contacted per unit of time (for example, mg/day for soil)

EF = **Exposure frequency:** how often the exposure occurs (days/year)

ED = **Exposure duration:** how long the exposure occurs (years)

BW = **Body weight:** the average body weight of the receptor over the exposure period (kilograms [kg])

AT = **Averaging time:** the period over which exposure is averaged (days); for carcinogens, the averaging time is 25,550 days based on a lifetime exposure of 70 years; for non-carcinogens, the averaging time is calculated as ED (years) × 365 days/year

(**Note:** Intakes via inhalation were formerly calculated in this same manner. However, in accordance with EPA's RAGS Part F [EPA 2009a], inhalation exposures are now calculated in a different manner, as discussed in Section 3.3.2 of the HHRA).

Variations of the Dose equation above were used to calculate pathway-specific receptor exposures to COPCs. The equations and parameter values used for each exposure pathway are presented in Tables A4.1.RME through A4.14.CTE in the Risk Assessment (see Appendix A of Appendix E).

EPCs were calculated following methods and recommendations provided in EPA (2010d) and Helsel (2005). Modeling was used to generate medium-specific EPCs for media not sampled directly. Specifically, modeling was used to estimate EPCs for blood lead, outdoor air (from soil), and homegrown produce, as summarized below.

- EPA's IEUBK Model and the Adult Lead Model (ALM) were used to estimate soil concentrations that correspond to acceptable blood-lead concentrations for residents and non-residents, respectively (EPA 2003a; 2009c, d). Appendix C of the HHRA (Appendix E to this RI report) presents the methodology based on the IEUBK and ALM models used to calculate acceptable receptor-specific soil lead concentrations (referred to as PRGs). The lead PRGs were compared to the lead EPCs (average lead concentrations) to evaluate whether adverse effects could result from exposure to lead in soil.
- Concentrations of non-volatile constituents from soil in ambient air were estimated using constituent- and site-specific particulate emission factors (PEF) as presented in the Regional Screening Level User's Guide (EPA 2010b).
- The uptake of COPCs from soil into homegrown produce was evaluated for current and future residents at the USS Lead Site using COPC-specific uptake factors. Uptakes into aboveground and belowground produce were evaluated separately. COPC-specific uptake factors were obtained from or calculated consistent with EPA's "Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities" (EPA 2005).

7.3 TOXICITY ASSESSMENT

The toxicity assessment provides a description of the relationship between a dose of a chemical and the potential likelihood of an adverse health effect. In the context of the regulatory risk assessment process, potential effects of chemicals are separated into two categories: carcinogenic (cancer) and non-carcinogenic (non-cancer, referred to as hazards) effects. This division relates to current EPA policy that the mechanisms of action for these endpoints differ. The EPA generally assumes conservatively that carcinogenic chemicals do not exhibit a response threshold[1] (EPA 1986, 2005a), while non-carcinogenic effects are universally recognized as threshold phenomena. However, chemicals classified as carcinogenic may also be capable of producing non-cancer health effects. Potential health risks for COPCs are evaluated for both carcinogenic and non-carcinogenic risks. The risk assessment used the default toxicity values presented in the EPA RSL tables (EPA 2010c).

As noted in Section 7.2.2, exposures to lead were evaluated using EPA's IEUBK and ALM models.

7.4 RISK CHARACTERIZATION

In the risk characterization, the toxicity factors (RfD/RfCs and SFs/URFs) were integrated with COPC concentrations and intake assumptions to estimate potential cancer risks (risks) and non-carcinogenic hazards. Risks and hazards were calculated using standard risk assessment methodologies (EPA 1989). Risks were compared to EPA's risk range of $1x10^{-6}$ (one cancer per one million exposed receptors) to $1x10^{-4}$ (one cancer per ten thousand exposed receptors). Risks less than $1x10^{-6}$ are considered insignificant. Risks within the range are remediated at the discretion of risk managers, while risks greater than $1x10^{-4}$ typically require remediation (EPA 1991b). Hazards are compared to a target hazard index of 1 (EPA 1989). Risks posed by lead in soil were evaluated by comparing average lead concentrations in soil at each property to receptor-specific lead PRGs.

EPA's IEUBK model was used to develop soil-lead PRGs for child and adolescent receptors, including child residents, adolescent school children, and child recreationalists. For the remaining receptors considered in the USS Lead HHRA, EPA's ALM was used to develop soil lead PRGs. For residential child receptors, the average lead concentration in soil at each property was compared to the EPA residential soil RSL of 400 mg/kg. The 400 mg/kg RSL was calculated using EPA's IEUBK model and default exposure assumptions. Insufficient site-specific information (for example, localized concentrations of lead in air, water, and foodstuffs) was available to warrant calculation of a site-specific residential soil PRG. Available site specific information were below regulatory levels such as the municipal lead result for drinking water (3.6 µg/l), blood lead concentrations in school children, and low bioavailability of lead in soil at the site. Therefore, residential properties with average lead concentrations in soil greater than 400 mg/kg were identified as presenting potential lead risks to residential receptors.

---

[1] A threshold indicates that a minimum amount of drug or chemical agent is required to elicit an effect. For example, certain metals such as iron and selenium are toxic above a threshold dose but safe and, in fact, required dietary components at lower doses. For carcinogens, EPA assumes that no threshold exists and that there is some increased risk at every dose level.

PRGs for lead in soil for both adolescent school children and child recreationalists were calculated in accordance with EPA's "Assessing Intermittent or Variable Exposures at Lead Sites" (EPA-540-R-03-008), assuming that the overall average concentration of lead in soil to which these receptors could be safely exposed was the residential soil PRG of 400 mg/kg. For each receptor, three inputs were identified: (1) the average concentration to which the receptor would be exposed at home, (2) the fraction of time the receptor would spend at home, and (3) the fraction of time the receptor would spend at the alternate exposure point (for an adolescent school child, this would be the school; for a child recreationalist, this would be a park). Using these inputs and the target acceptable overall average lead concentration of 400 mg/kg, receptor-specific soil-lead PRGs (the acceptable concentration of lead in soil at the alternate location) were calculated using the equations presented in Appendix E.

The calculated soil-lead PRG for an adolescent school child is 583 mg/kg under both RME and CTE conditions. The calculated soil-lead PRGs for a child recreationalist are 693 mg/kg and 1,050 mg/kg under RME and CTE conditions, respectively. School and park properties with average lead concentrations in soil greater than these receptor-specific PRGs were identified as presenting potential lead risks.

Risk characterization results are discussed by property and receptor type in the following order: residential, school, and recreational properties, followed by utility and construction workers assumed to be potentially exposed at all properties. The HHRA evaluated exposures and characterized risks and hazards under both RME and CTE conditions. RME conditions are designed to represent the maximum exposures that can reasonably occur. In contrast, CTE conditions are intended to represent typical (average) exposures. The presentation of both RME and CTE results provides risk managers with a range of risks and hazards to help clarify the need for and extent of remedial options at the site. This section considers only the RME results with the exception of a general summary and conclusions regarding similarities and differences between RME and CTE results. Summary and conclusions are arranged by property type and receptor.

Residential Properties

The risk and hazard status of the 80 residential properties is evaluated in terms of the following four categories:

- Acceptable risks and HI (soil lead EPCs less than receptor-specific lead soil PRGs and total risk $\leq 1x10^{-6}$ and total HI ≤ 1)
- Risk from lead only (soil lead EPCs > at least one receptor-specific lead soil PRG and total risk $\leq 1x10^{-6}$ and total HI ≤ 1)

- Risks and HI from lead and other COPCs (soil lead EPCs > at least one receptor-specific lead soil PRG and total risk $\geq 1 \times 10^{-6}$ and/or total HI ≥ 1)
- Risks and HI from other COPCs only (lead EPCs less than receptor-specific lead soil PRGs and total risk $\geq 1 \times 10^{-6}$ and/or total HI ≥ 1).

Current Land Use Conditions

Under current land use conditions, the 80 residential properties are distributed among the four categories as follows (see Figure 7-1):

- Category 1: Acceptable risks and HI – 28 properties (35 percent)
- Category 2: Risk from lead only – 12 properties (15 percent)
- Category 3: Risks and HI from lead and other COPCs – 31 properties (39 percent)
- Category 4: Risks and HI from other COPCs only – 9 properties (11 percent).

The primary risk drivers are arsenic and carcinogenic PAHs. The primary hazard drivers are arsenic, antimony, manganese, and mercury, as well as a series of other metals at a small number of properties. Risks and hazards are driven by ingestion of homegrown produce and incidental ingestion of soil.

Properties in Category 1 are located primarily in the eastern one-third of the Site. A sizeable portion (about 40 percent) of these properties were sampled only for lead. Sampling of these properties for TAL metals and PAHs could result in a change of risk category.

Properties in Category 2 are divided into two groups: (1) about one-half are clustered in the area of public housing at the southwest corner of the Site, and (2) the remaining properties are scattered primarily in the eastern one-third of the site.

Properties in Category 3 are distributed primarily in the middle one-third of the Site.

The majority of Category 4 properties are located in the eastern one-third of the Site.

Twenty-seven properties have total current risks greater than 1×10^{-4}, the upper end of EPA's risk range of 1×10^{-6} to 1×10^{-4} (EPA 1990). The total risks at these properties range from 2×10^{-4} (multiple properties) to 5×10^{-3} (Alexander Ave.) (see Table RA-3 and Figure RA-6).

Future Land Use Conditions

Under future land use conditions, the risk and hazard status of the 80 residential properties is distributed among the four risk categories as follows (see Figure 7-2):

- Category 1: Acceptable risks and HI – 28 properties (35 percent)
- Category 2: Risk from lead only – 1 property (1 percent)
- Category 3: Risks and HI from lead and other COPCs – 23 properties (29 percent)
- Category 4: Risks and HI from other COPCs only – 28 properties (35 percent).

Risk and hazard drivers (both COPCs and exposure pathways) are as described under current land use conditions.

Category 1 properties are distributed much as described under current land use conditions. There is only one property in Category 2 (Gladiola Ave.). The remaining properties in this category under current land use conditions moved under future land use conditions to either Category 3 (primarily because risks and hazards from other COPCs were added when considering subsurface, rather than surface, soil) or Category 4 (lead concentrations decreased below a level of concern, and risks and hazards from other COPCs were added when considering subsurface soil rather than surface soil).

Category 3 properties are distributed in two primary groups: (1) about 75 percent are in the eastern two-thirds of the Site and (2) seven properties are clustered in the areas of public housing at the southwest corner of the Site.

Category 4 properties are primarily located east of the Carrie Gosch Elementary School and the area of public housing.

Thirty-six properties have total future risks greater than $1x10^{-4}$, the upper end of EPA's risk range of $1x10^{-6}$ to $1x10^{-4}$ (EPA 1990). The total risks at these properties range from $2x10^{-4}$ (multiple properties) to $5x10^{-3}$ (Aster Ave.) (see Table RA-3 and Figure RA-6).

<u>Carmelite School for Girls</u>

Under both current (C) and future (F) land use conditions, total risks for adolescent students ($5x10^{-5}$ [C] and $7x10^{-5}$ [F])) and adult teachers and staff ($4x10-^{5}$ [C] and $1x10^{-4}$ [F])) are within EPA's risk range of $1x10^{-6}$ to $1x10^{-4}$ (EPA 1990). These risks are driven by potential exposure to PAHs through ingestion of homegrown produce and incidental ingestion of soil. Hazards for both receptor groups are less than 1 and considered insignificant. Finally, lead does not pose a risk to either adolescent students or adult teachers and staff.

Carrie Gosch Elementary School

Under both current and future land use conditions, total risks for adolescent students, indoor teachers and staff, and outdoor teachers and staff are less than or equal to 1×10^{-5} and within EPA's risk range of 1×10^{-6} to 1×10^{-4} (EPA 1990). These risks are driven by potential exposure to PAHs through incidental ingestion of and dermal contact with soil. Hazards are less than 1 and considered insignificant for all receptors. Finally, lead does not pose a risk to any receptors.

Recreational Properties

Under current land use conditions, total risks to child, adolescent, and adult recreationalists; indoor park workers; and outdoor park workers at Riley Park, Goodman Park, and Kennedy Gardens Park are within EPA's risk range of 1×10^{-6} to 1×10^{-4} (EPA 1990); maximum risk is 3×10^{-5} for the outdoor park worker at Goodman Park. These risks are driven by potential exposure to arsenic and PAHs through incidental ingestion of and dermal contact with soil. Total hazards at all three parks are less than 1 and considered insignificant for all receptors.

Lead poses the following risks at each park:

- Riley Park – lead does not pose a risk to any receptors.
- Goodman Park – lead poses a risk to child recreationalists, indoor park workers, and outdoor park workers.
- Kennedy Gardens Park – lead poses a risk to all recreational receptors.

It should be noted that indoor and outdoor workers are not currently present at Kennedy Gardens Park. Therefore, risks termed "current" at this park should be interpreted as occurring in the future, with exposure to surface soil only.

Under future land use conditions, the risks increase slightly for all receptors, but remain within EPA's risk range. The risk drivers remain as discussed under current land use conditions. Hazards remain insignificant and the risks from lead remain similar to those described under current land use conditions.

Utility Worker

Under current and future land use conditions, total risks are less than 1×10^{-6} and considered insignificant at three properties on Euclid Ave., Ivy St., and. 151st St. (see Figure 7-3). Total risks for the remaining 63 properties are within EPA's risk range of 1×10^{-6} to 1×10^{-4} (maximum risk of 9×10^{-5} on Aster Ave.) (EPA 1990). Risks are driven by potential exposure to arsenic and carcinogenic PAHs primarily through incidental ingestion of soil. Hazards are less than 1 and insignificant at all properties. Lead poses a risk to utility workers at three properties on 150th Place, Aster Ave., and Aster Ave.

Construction Worker

Under current and future land use conditions, total risks are within EPA's risk range of 1×10^{-6} to 1×10^{-4} at seven properties (see Figure 7-4). Five of these properties are in the public housing area at the southwest corner of the Site. Total risks at the remaining 59 properties are less than 1×10^{-6} and considered insignificant. Risks are driven by potential exposure to arsenic through incidental ingestion of and dermal contact with soil. Hazards exceed 1 at 11 properties. Finally, lead poses a risk at 16 properties, the majority of which are clustered in the area of public housing.

RME *vs.* CTE Conditions

Overall conclusions based on RME conditions remain when considering CTE conditions. However, the absolute magnitude of the total risks and hazards decrease. Specific conclusions for particular land uses or receptor types are as follows:

- Residential properties – All conclusions regarding lead based on CTE conditions remain identical to those based on RME conditions. However, the number of residential properties with total risks greater than 1×10^{-4}, the upper end of EPA's risk range, is reduced as follows: from under RME conditions, 29 (current land use conditions) and 36 (future land use conditions) to under CTE conditions, 7 (current land use conditions) and 12 (future land use conditions).
- Carmelite School for Girls – RME conclusions hold for CTE; total risks and hazards are lower.
- Carrie Gosch Elementary School – The total risks for indoor and outdoor teachers and staff are less than 1×10^{-6} and considered insignificant under future land use and CTE conditions.
- Recreational properties – Generally, RME conclusions hold under CTE conditions. However, total risks for adolescent and adult recreationalists are less than 1×10^{-6} and considered insignificant under current land use conditions; they are less than 1×10^{-6} for adolescent recreationalists under future land use conditions.
- Utility workers – RME conclusions hold for CTE; total risks and hazards are lower.
- Construction workers – Under CTE conditions, total risks are less than 1×10^{-6} and insignificant at all properties. Hazards are greater than 1 at three properties on Euclid Ave. (1.1), Aster Ave. (2.4), and Gladiola Ave. (1.6). Lead risks are similar to those described under RME conditions.

However, the number of properties with exceedances is reduced from 16 to 8; the majority remain in the public housing area.

7.5 UNCERTAINTIES

Uncertainties are inherent in the process of quantitative risk assessment due to the use of environmental sampling results, assumptions regarding exposure, and the quantitative representation of chemical toxicity. Analysis of the critical areas of uncertainty in risk assessment provides a better understanding of the quantitative results through the identification of the uncertainties that most significantly affect the results.

EPA guidance stresses the importance of providing an in-depth analysis of uncertainties so that risk managers are better informed when evaluating risk assessment conclusions (EPA 1989). Potentially significant sources of uncertainty for this assessment are discussed in the HHRA and include analytical data, exposure estimates, toxicity estimates, and background conditions. The uncertainties associated with analytical data are summarized below, as these represent the most truly site-specific uncertainties. The reader is directed to Section 6 of the HHRA for a discussion of the other sources of uncertainty identified above.

Laboratory analysis of environmental samples is subject to a number of technical difficulties; however, the magnitude of uncertainty is generally small compared to other sources. At the USS Lead Site, there are four primary sources of uncertainty with regard to the analytical data used in the HHRA: (1) the depth of surface soil samples, (2) the use of XRF data, (3) the limited number of soil samples analyzed for constituents other than lead, and (4) a limited number of samples at each property. Each of these sources of uncertainty is summarized below.

- Surface soil samples were collected from 0 to 6 inches bgs. However, EPA guidance suggests that concentrations of some constituents, particularly lead, may be highest in the uppermost few centimeters (1 inch) (EPA 2003b). Therefore, collection of surface soil samples from 0 to 6 inches bgs may result in a dilution of lead concentrations in surface soil samples. However, the EPA Region 5 FIELDS group evaluated the concentration of lead in soil samples collected by EPA Region 5 START in 2007 at the USS Lead Site. The FIELDS group concluded that concentrations of lead measured in soil samples collected from 0 to 1 inch bgs did not differ from measured lead concentrations in samples collected from 1 to 6 inches bgs at the same location (EPA 2007).
- Field-based analytical methods have been found acceptable for use in investigating hazardous waste sites if a particular method (in this case XRF) is generally accepted and performed in accordance with QA/QC protocols and procedures (Howe and Lynch 2005). The XRF technique – well established and routinely used in site investigations, including those characterized using the Triad approach (EPA 2008b) – was performed using an established analytical method

(Method 6200). Therefore, for this site, EPA Region 5 concluded that XRF data (obtained by EPA's FIELDS group) are acceptable for use in the RI and HHRA for the USS Lead Site. Further, all XRF data used in the HHRA were first adjusted based on a correlation developed between samples analyzed using both XRF and laboratory analysis.

- All soil samples collected in Phases I and II were analyzed for lead, either by XRF (and later adjusted as described above) or by an off-site laboratory. However, only 20 percent of the Phase I soil samples were sent to an off-site laboratory for total metals analysis. (**Note:** All Phase II soil samples were sent offsite for total metals analysis). Also, only eight Phase I soil samples were sent offsite for VOC, SVOC (including PAHs), PCB, and pesticide analyses. VOCs, non-PAH SVOCs, PCBs, and pesticides were not detected in any of these eight samples; therefore, these were not analytes in Phase II sampling. This means that the EPCs (and in turn risks and hazards) for non-lead COPCs, particularly arsenic and PAHs, are subject to a moderate to large amount of uncertainty.

7.6 SUMMARY AND CONCLUSIONS OF HHRA

This section summarizes the risks and hazards under current and future land use and RME conditions. Risks associated with lead are present throughout the study area. The HHRA found that risks and hazards associated with other compounds exist under both current and future land use conditions for between 30 and 40 percent of residential properties. The discussion is organized by property type. The section concludes with a brief statement comparing RME and CTE results.

Residential Properties

- Under both current and future land use conditions, about 35 percent of the properties sampled have acceptable risks and HIs (i.e., soil lead EPCs less than soil PRGs, risk estimates less than $1x10^{-6}$, and HIs below 1.0). These properties are located primarily in the eastern one-third of the site.
- Under current and future land use conditions, between 36 and 45 percent of the properties have total carcinogenic risks greater than $1x10^{-4}$ (the upper end of EPA's risk range). These total risks are driven by potential exposure to arsenic and PAHs through ingestion of homegrown produce and incidental ingestion of soil.
- Hazards greater than 1 are driven by potential exposure to arsenic, antimony, manganese, and mercury, as well as a number of other metals at a small number of properties through the same exposure pathways as for risks.
- As noted above, residential properties throughout the OU1 study area have soil concentrations above 400 mg/kg and thus have hazards associated with them. In the eastern area of OU1, roughly 30% of the residential properties have soil concentrations greater than 400 mg/kg. In the southwestern area of OU1, roughly 66% of the residential properties have soil concentrations greater than 400 mg/kg. In the northwestern area of OU1, roughly 50% of the residential properties have soil concentrations greater than 400 mg/kg.

Carmelite School for Girls

- Under both current and future land use conditions, total risks for both adolescent students and adult teachers and staff are within EPA's risk range of $1x10^{-6}$ to $1x10^{-4}$. Total risks are driven by potential exposure to PAHs through ingestion of homegrown produce and incidental soil ingestion.

- Under both current and future land use conditions, all HIs are less than 1 and insignificant, and there are no identified risks from lead.

Carrie Gosch Elementary School

- Under both current and future land use conditions, total risks to adolescent students and adult teachers and staff (both indoor and outdoor) are within EPA's risk range of 1×10^{-6} to 1×10^{-4}. Total risks are driven by potential exposure to PAHs through incidental ingestion of and dermal contact with soil.
- Under both current and future land use conditions, all HIs are less than 1 and insignificant and there are no identified risks from lead.

Recreational

- Under both current and future land use conditions there are no unacceptable risks and hazards and no identified risks from lead at the Melville Avenue Park.
- Under both current and future land use conditions, total risks for all recreational receptors (child, adolescent, and adult recreationalists and adult indoor and outdoor workers) are within EPA's risk range of 1×10^{-6} to 1×10^{-4} for the other three parks: Goodman Park, Riley Park, and Kennedy Gardens Park. Total risks are driven by potential exposure to arsenic and PAHs through incidental ingestion of and dermal contact with soil.
- Under both current and future land use conditions, there are no Under both current and future land use conditions, total risks for all recreational receptors (child, adolescent, and adult recreationalists and adult indoor and outdoor workers) are within EPA's risk range of 1×10^{-6} to 1×10^{-4} for the other three parks: Goodman Park, Riley Park, and Kennedy Gardens Park. Total risks are driven by potential exposure to arsenic and PAHs through incidental ingestion of and dermal contact with soil.
- Under both current and future land use conditions, there are no identified unacceptable hazards at any of the three parks.
- Under both current and future land use conditions, there are no identified lead risks at Riley Park; at Goodman Park, lead presents a risk to the child recreationalist, the indoor worker, and the outdoor worker; and at Kennedy Gardens Park, lead presents a risk to all potential recreational receptors. (**Note:** Both indoor and outdoor workers do not currently exist at Kennedy Gardens Park. Risks to these receptors are entirely theoretical and would occur in the future only.)

Utility Workers

- At three properties (one on Euclid Avenue, one on Ivy Street, and one on East 151st Street), total risks are less than 1×10^{-6} and insignificant. At 13 additional properties, no carcinogenic COPCs were identified.
- At the remaining 77 properties (residential, recreational, and school), total risks are within EPA's risk range of 1×10^{-6} to 1×10^{-4}. Total risks are driven by potential exposure to arsenic and PAHs through incidental ingestion of soil.
- Under both current and future land use conditions, HIs are less than 1 and insignificant at all but one of the properties. The HI at a property on Aster Ave. is 1.2; all COPC-specific hazards are

less than 1. Lead poses a risk to utility workers at three properties: one on East 150th Place, and two on Aster Avenue.

Construction Workers

- Total risks at seven properties (5 within the public housing area) are within EPA's risk range of $1x10^{-6}$ to $1x10^{-4}$ and are driven by potential exposure to arsenic through incidental ingestion of and dermal contact with soil.
- Total risks at the remaining 59 properties are less than $1x10^{-6}$ and insignificant.
- HIs exceed 1 at 11 properties.
- Lead risks were unacceptable at 16 properties, the majority of which are at or near the area of public housing.

RME *vs.* CTE Conditions

The overall conclusions based on RME conditions remain when considering CTE conditions. However, the absolute magnitude of the total risks and hazards decreases.

FIGURES

FIGURES 7-1 TO 7-4: RISK CHARACTERIZATION MAPS

HAVE BEEN REDACTED – FOUR PAGES

CONTAINS POTENTIAL PERSONALLY-IDENTIFYING INFORMATION

8.0 SUMMARY AND CONCLUSIONS

This section provides a brief summary of the major findings of the RI and presents conclusions regarding data limitations and recommended future work. Specifically, the following sections summarize the nature and extent of contamination (Section 8.1), fate and transport (Section 8.2), the HHRA (Section 8.3), and conclusions of the RI (Section 8.4).

8.1 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION

SulTRAC collected surface and subsurface soil samples during the RI from a total of 88 properties, consisting of 232 distinct "yards" (including drip zone samples and quadrants from larger properties such as parks and schools), in order to define the nature and extent of COIs in and around OU1. These 232 separate "yards" included 75 front yards, 70 back yards, 27 quadrants, and 60 drip zones. The drip zones were considered as separate "yards" because they covered a geographic area that was not confined to a front yard, back yard, or quadrant. All soil samples were analyzed for lead. In addition, a subset of samples was analyzed for various combinations of total metals, VOCs, SVOCs, PAHs, PCBs, and pesticides to provide a basis for more fully assessing contamination in shallow soils in OU1. Results from the RI soil investigation include:

- Ten metal analytes and 6 PAH analytes were identified as COIs
- 123/232 yards (53%) exceeded the SSL for lead in surface and/or subsurface soil
- 75/136 yards (55%) exceeded the SSL for arsenic in surface and/or subsurface soil
- 50/53 yards (94%) exceeded one or more SSLs for PAHs in surface and/or subsurface soil

Lead is the primary COI at OU1. In addition to testing for metals, a small percentage (22%) of the yards sampled during the RI were analyzed for PAHs; however, PAHs were the COIs that exceeded the SSLs in the highest proportion of samples. 191 of the 196 samples analyzed for PAHs (97%) exceeded SSLs. Data analysis indicated that lead and PAHs on similar properties were not correlated and, as discussed later in Section 8.4.3, PAHs are not considered to be site-related contaminants. The SSL exceedances for lead and arsenic on similar properties were generally correlated. It is unlikely that soils will exceed the arsenic SSL unless they also exceed the lead SSL.

The lateral extent of lead-impacted soil covered the entire area of OU1. The area west of Huish Avenue contained a higher frequency of exceedances for lead in both surface and subsurface soil samples than the eastern half of OU1. Lead concentrations in the front yard, back yard, and/or drip zone in all nine properties sampled in the East Chicago Housing Authority complex exceeded the SSL for lead. The highest arsenic and lead concentrations in all of OU1 were also found in the East Chicago Housing Authority complex and may be attributed to the historical operations at the Anaconda Copper Company facility. The distribution of arsenic suggests that the primary source of arsenic in OU1 is likely to have been the placement of impacted fill and not aerial deposition.

An analysis of front and back yards reveals that there is an approximately 75% chance that COIs in one yard will indicate that the other yard also contains COI concentrations in excess of SSLs. In addition, based on the observed vertical distributions of lead, arsenic, and PAHs, there is a 15% chance that sampling only the upper depth intervals (0-6 inches bgs) would miss contamination in subsurface soils (6-24 inches bgs). A comparison of soil type to COI concentration concluded that soil type is not a reliable indicator of the presence or absence of COIs, except that the native sands are generally free of contamination.

8.2 SUMMARY OF CONTAMINANT FATE AND TRANSPORT

The USS Lead CSM (Figure 6-1) presents four potentially affected media at the USS Lead Site: air, soil, surface water, and groundwater. The CSM shows that the USS Lead Site comprises historical plant/factory areas, a current residential area (OU1), and a canal, all within an urban setting. The two historical factory/plant buildings are the most likely primary sources of contamination because airborne emissions were generated from plant stacks, and leaks and spills were likely during plant operations. In this CSM, metals and PAHs are the main COIs associated with these sources. OU1 sits atop fill and top soils that overlie native sands at approximately 2 feet bgs. The water table is approximately 8.5 feet bgs with groundwater flowing toward the south/southwest. Contaminants are mainly transported around the site through wind (dust and airborne emissions), surface-water runoff and erosion of soils, surface-water percolation/leaching and infiltration, and filling and excavation activities.

Potential migration routes for COIs at the USS Lead Site were assessed according to the properties of the contaminants and fate-and-transport processes. Potential migration pathways for COIs to be released, deposited, or redistributed in surface soils include:

- particulate erosion and redeposition by wind
- runoff, particulate erosion, and redeposition by surface water
- surface water percolation
- surface soil filling and excavation activities

Contaminants may migrate into air via two distinct emission mechanisms: entrainment of contaminated particles by the wind and volatilization, primarily of organic compounds. Wind and the concomitant release of dust is the primary pathway for site COIs to be released to the atmosphere due to their strong tendency to adsorb to soil particles. The most likely transport mechanism for inorganic and PAH COIs is by windborne transport of contaminated dust and soil erosion. This potential is mitigated by the extensive vegetative cover of soils throughout OU1.

Surface-water runoff is another pathway that can erode surface soils and transport particles via overland flow, resulting in redeposition at lower elevations at the USS Lead Site. Because OU1 is flat lying and served by a municipal sewer system, redeposition in low-lying areas is not expected to be of major significance at the site.

Excavation and filling activities are other migration pathways, and there has been documentation of such activities at the USS Lead Site. Excavation potentially exposes the subsurface to fugitive dust erosion and deposition. Filling activities result in top soils that are not as compact as native soils, which may result in faster percolation and/or erosion rates. There is also a possibility that amended fill materials may be contaminated, particularly if used from the nearby, contaminated, source.

8.3 SUMMARY OF HUMAN HEALTH RISK ASSESSMENT

This section summarizes the risks and hazards presented in the HHRA (Section 7.0 above and Appendix E) under current and future land use RME and CTE conditions. Risks associated with lead are present throughout the study area. The HHRA found that risks and hazards associated with other compounds exist under both current and future land use conditions for between 30 and 40 percent of residential properties. This discussion is organized by property type and concludes with a brief statement comparing RME and CTE results.

Residential Properties

- Under both current and future land use conditions, about 35 percent of the properties sampled have acceptable risks and HIs (i.e., soil lead EPCs less than soil PRGs, risk estimates less than 1×10^{-6}, and HIs below 1.0). These properties are located primarily in the eastern one-third of the site.
- Under current and future land use conditions, between 36 and 45 percent of the properties have total carcinogenic risks greater than 1×10^{-4} (the upper end of EPA's risk range). These total risks are driven by potential exposure to arsenic and PAHs through ingestion of homegrown produce and incidental ingestion of soil.

- Hazards greater than 1 are driven by potential exposure to arsenic, antimony, manganese, and mercury, as well as a number of other metals at a small number of properties through the same exposure pathways as for risks.
- As noted above, residential properties throughout the OU1 study area have soil concentrations above 400 mg/kg and thus have hazards associated with them. In the eastern area of OU1, roughly 30% of the residential properties have soil concentrations greater than 400 mg/kg. In the southwestern area of OU1, roughly 66% of the residential properties have soil concentrations greater than 400 mg/kg. In the northwestern area of OU1, roughly 50% of the residential properties have soil concentrations greater than 400 mg/kg.

Carmelite School for Girls

- Under both current and future land use conditions, total risks for both adolescent students and adult teachers and staff are within EPA's risk range of $1\text{x}10^{-6}$ to $1\text{x}10^{-4}$. Total risks are driven by potential exposure to PAHs through ingestion of homegrown produce and incidental soil ingestion.
- Under both current and future land use conditions, all HIs are less than 1 and insignificant, and there are no identified risks from lead.

Carrie Gosch Elementary School

- Under both current and future land use conditions, total risks to adolescent students and adult teachers and staff (both indoor and outdoor) are within EPA's risk range of $1\text{x}10^{-6}$ to $1\text{x}10^{-4}$. Total risks are driven by potential exposure to PAHs through incidental ingestion of and dermal contact with soil.
- Under both current and future land use conditions, all HIs are less than 1 and insignificant and there are no identified risks from lead.

Recreational

- Under both current and future land use conditions there are no unacceptable risks and hazards and no identified risks from lead at the Melville Avenue Park.
- Under both current and future land use conditions, there were no unacceptable hazards identified at any of the three parks.
- Under both current and future land use conditions, there are no identified lead risks at Riley Park; at Goodman Park, lead presents a risk to the child recreationalist, the indoor worker, and the outdoor worker; and at Kennedy Gardens Park, lead presents a risk to all potential recreational receptors. (**Note:** Both indoor and outdoor workers do not currently exist at Kennedy Gardens Park. Risks to these receptors are entirely theoretical and might occur in the future only.)

Utility Workers

- At three properties (one on Euclid Avenue, one on Ivy Street, and one on East 151st Street), total risks are less than $1\text{x}10^{-6}$ and insignificant. At 13 additional properties, no carcinogenic COPCs were identified.
- At the remaining 77 properties (residential, recreational, and school), total risks are within EPA's risk range of $1\text{x}10^{-6}$ to $1\text{x}10^{-4}$. Total risks are driven by potential exposure to arsenic and PAHs through incidental ingestion of soil.

- Under both current and future land use conditions, HIs are less than 1 and insignificant at all but one of the properties. The HI at a property on Aster Ave. is 1.2; all COPC-specific hazards are less than 1. Lead poses a risk to utility workers at three properties: one on East 150th Place, and two on Aster Avenue.

Construction Workers

- Total risks at seven properties (5 in the area of public housing) are within EPA's risk range of $1x10^{-6}$ to $1x10^{-4}$ and are driven by potential exposure to arsenic through incidental ingestion of and dermal contact with soil.
- Total risks at the remaining 59 properties are less than $1x10^{-6}$ and insignificant.
- HIs exceed 1 at 11 properties.
- Lead risks were unacceptable at 16 properties, the majority of which are at or near the area of public housing.

RME *vs.* CTE Conditions

The overall conclusions based on RME conditions remain when considering CTE conditions. However, the absolute magnitude of the total risks and hazards decreases.

8.4 RECOMMENDATIONS

The purpose of the RI at OU1 was to evaluate the nature and extent of contamination in soil and to assess the associated human health risks. The total number of properties in OU1 based on tax records (property ownership records) is 1,271. In order to provide a more meaningful evaluation of the extent of contamination at OU1, the residential area was divided into three sections, based on similarities of observed contaminant distribution. The three sections that comprise OU1 are:

- **The eastern area** (east of Huish Avenue). The eastern area includes 490 residential properties, 16 commercial/recreational properties, including Riley Park and the Carmelite Home for Girls, and 11 former railroad right-of-way properties;

- **The southwestern area** (west of Huish Avenue, south of 149th Street and south of Carrie Gosch Elementary School property). The southwestern area includes 345 residential properties (including the public housing area), 16 commercial/recreational properties, including Kennedy Park and Goodman Park, and 2 easements; and

- **The northwestern area** (west of Huish Avenue, north of 149th Street, including Carrie Gosch Elementary School). The northwestern area includes 339 residential properties, 48 commercial/ recreational properties, including Martin Luther King Park and Carrie Gosch Elementary School, and 4 easements.

Based on the HHRA discussion in Section 7.0 of this report and Section 8.3 above, the COIs at OU1 are lead, arsenic, and PAHs. Each COI is discussed separately below.

8.4.1 Lead

The following presents a brief summary of the lead results observed at OU1 and the recommendations for future work.

8.4.1.1 Lead Summary

Lead is the primary COI at OU1. The *Superfund Lead-Contaminated Residential Sites Handbook* (EPA 2003c), EPA RSLs (EPA 2010c), and the State of Indiana's *Risk Integrated System of Closure (RISC) Technical Resource Guidance Document* (IDEM 2009) set RALs for lead at 400 mg/kg for residential areas and 800 mg/kg for industrial areas. As discussed in Section 7.0 and Section 8.3 above, 16 percent of the residential properties exhibited risk for lead only and 38 percent of residential properties exhibited risk for lead and other COIs.

Multiple evaluations were performed regarding lead concentrations at OU1, as discussed in Section 5.0. The results of the evaluations of nature and extent of contamination are summarized below:

A consistent distribution of lead in soil was not found in the eastern area or the northwestern area of OU1. Also, lead concentrations in soil were found to be dissimilar between yards on the same property. Further work at OU1 will need to consider each property individually and each yard on each property separately.

Some drip zone results showed elevated lead concentrations while the rest of the property did not. While this result is consistent with aerial deposition of lead, this result was not found across the OU1 area. However, it is clear that aerial deposition and the placement of contaminated fill materials are both contributing factors to lead concentrations at OU1.

Elevated lead concentrations were found in the fill material across the OU1 area. The native sand material generally encountered at a depth of 18 to 24 inches bgs was found to be free of elevated lead concentrations. Therefore, native sands in the OU1 project site define the lower boundary of impacted soil, and any removal of soil will be considered complete once native sand is reached with confirmation via XRF.

It was not practical to "count" the number of yards in the residential properties of OU1, because some properties only had a front or back yard, not both. Some residential properties also had paved front and/or back yards. It is possible to estimate the number of yards in each of the three sections of OU1 by assuming that each residential property consists of three "yards" (front, back yard, and drip zone) and that each park, commercial property, or school can be divided into four quadrants (called "yards" in the table below). Based on these assumptions, estimates of the number of properties and yards in each of the three areas can be made as listed in Table 8-1.

Table 8-1: Total Estimated Number of Yards and Quadrants at OU1

	Properties	Yards/Drip Zones/ Quadrants
Eastern Area		
Residential	490	1470
Commercial/Industrial	16	64
Right-of-Way/Easement	11	44
Southwestern Area		
Residential	345	1035
Commercial/Industrial	16	64
Right-of-Way/Easement	2	8
Northwestern Area		
Residential	339	1017
Commercial/Industrial	48	192
Right-of-Way/Easement	4	16

A summary of the number of yards, drip zones, and quadrants actually sampled during the RI effort along with a frequency of "yards" with a lead concentration above 400 mg/kg is summarized in Table 8-2. Only one property (on Carey Street) was noted as having a drip zone sample above 400 mg/kg without a corresponding exceedance in the front or back yard. Five properties had exceedances in the front and/or back yard with no exceedance in the drip zone sample.

Table 8-2: Frequency of Lead Exceedances at OU1 Yards

	Number Sampled	Soil Lead Results Above 400 mg/kg	Frequency
Eastern Area			
Yards (front and back)	90	27	30%
Drip Zones	34	12	35.3%
Quadrants	12	7	58%
Southwestern Area			
Yards (front and back)	58	38	65.5%
Drip Zones	13	13	100%
Quadrants	10	10	100%
Northwestern Area			
Yards (front and back)	57	29	50.1%
Drip Zones	13	10	76%
Quadrants	14	2	14.3%

Three TCLP samples were collected to assess the total lead concentration levels that might require disposal as RCRA hazardous waste as part of remedial actions involving soil removal at OU1. Three properties were selected for testing based on the lead analytical data from December 2009. The properties selected represent the breadth of total lead concentrations, ranging from just above the residential clean-up level of 400 mg/kg to near the maximum concentration measured.

An exponential regression was performed to generate a "best fit" curve for the data. When the TCLP limit of 5 mg/L is inserted into the best-fit equation, the resulting total lead concentration in soil is predicted to be 2,400 mg/kg. It is estimated that soil sample results containing total lead concentrations above 2,400 mg/kg may exhibit characteristics of hazardous waste and may require disposal as hazardous waste or pretreatment, based on preliminary extrapolation of TCLP results for these three samples. A total of sixteen "yards" (including 2 quadrants and 3 drip zones) had soil lead concentrations above 2,400 mg/kg. Sixteen yards represent approximately 7 percent of the total yards sampled. Land disposal restrictions will require treatment of soils exceeding the TCLP limit for lead before disposal, and treatment and disposal costs for these soils will likely be a significant factor affecting total cost of cleanup that should be evaluated in the feasibility study (FS). Based on this estimate of the total number of yards and the percentage of yards with soil lead concentrations above 2,400 mg/kg, it is estimated that 274 yards will require treatment for lead before disposal.

8.4.1.2 Recommendations for Lead

Based on lead concentrations observed during this RI, lead-contaminated soils at the USS Lead Site are likely to require remedial action to address unacceptable risks. Because of the inconsistent distribution of lead contamination in OU1, it is suggested that soils from each property where access can be obtained be sampled for lead.

8.4.2 Arsenic

The following presents a brief summary of the arsenic results observed at OU1 and the recommendations for future work.

8.4.2.1 Arsenic Summary

Although lead was found to be the most widespread contaminant at OU1, arsenic was also present at some locations within the residential area. The background soil concentration for arsenic at OU1 was calculated to be 14.1 mg/kg. Site-specific background soil concentrations for arsenic were collected from the top 12 inches (0-6 and 6-12 inches bgs) of soil samples from background locations. Comparison of the EPA RSL (EPA 2010c) for arsenic (0.39 mg/kg) to site-specific background concentrations indicates the presence of naturally occurring arsenic at the site. The Illinois EPA has calculated background metropolitan arsenic concentrations in soil to be 13.0 mg/kg (IPCB 2007). Although the USS Lead Site is not within Illinois, it is approximately 5 miles from the City of Chicago and the Illinois-Indiana state border. Use of the site-specific background level of 14.1 mg/kg was considered acceptable, based on the similarity between the metropolitan area background levels and those measured at OU1.

As shown in Figure 8-1, arsenic concentrations in soil samples collected within the OU1 area are distributed around both the site-specific background concentration of 14.1 mg/kg and the Illinois EPA metropolitan background concentration of 13.0 mg/kg. Because of the similarity between the bulk soil concentrations for arsenic at OU1 and the background concentrations discussed above, it is appropriate to calculate an Upper Tolerance Limit (UTL) for arsenic concentrations in soil to distinguish between soil concentrations that are distributed among the naturally occurring values at the site and those that may be impacted by activities in and around the site.

The EPA statistical program ProUCL, version 4.1.01, was used to test for data outliers and for normal or lognormal distribution of the data. Arsenic concentrations contained in this set of "outliers" are associated with impacted samples that are not part of the naturally occurring soil distribution and are thus excluded from the UTL calculation. Twenty-five individual data points ranging in concentration from 46.2 to 414 mg/kg were considered to be outliers and were excluded from the UTL analysis. The reduced data set had a calculated mean of 13.16 mg/kg, similar to the background values above, and did not exhibit a normal distribution around the mean (Lilliefors Test Statistic = 0.159, Lilliefors Critical Value at 5% = 0.0499). Figure 8-2 illustrates that the data set for arsenic at OU1 approaches a lognormal distribution; however, the test for lognormality of the data rejects this hypothesis at the 5% significance level (Lilliefors Test Statistic = 0.0566, Lilliefors Critical Value at 5% = 0.0499). Because the data were distributed neither normally nor lognormally, no clear-cut approach to statistical treatment of the data set is apparent. The data were assumed to be lognormally distributed because the data more closely approached a lognormal distribution and it was felt that the UTL calculated from the non-parametric test was too close to the 10^{-4} risk level. A 95% UTL of 26.36 mg/kg was calculated using the log-transformed data. The 95% UTL value of 26 mg/kg was taken as the upper bound of the naturally occurring arsenic at OU1, and the preliminary RAL for the site was set equal to the UTL.

The soil concentration for arsenic that corresponds to a risk level of 1x10^{-4} (based on the risk assessment discussed in Section 7), is 12.5 mg/kg. The 12.5 mg/kg soil concentration is driven by the ingestion pathway for home grown produce and the assumption that all produce consumed at a residence is grown on the property. If the home grown produce ingestion pathway is removed from the calculation, the soil concentration that corresponds to the 1x10^{-4} risk level is 39 mg/kg. The dosing assumptions included with the default exposure to home grown produce are very conservative, so two different scenarios were evaluated to estimate a more realistic exposure. The first scenario involved replacing the RME home grown produce assumptions with the CTE home grown produce assumptions. The calculated soil concentration (using the RME assumptions for Ingestion, Dermal and Inhalation exposure, with the CTE assumptions for produce) is 27 mg/kg for the 1x10^{-4} risk level. However, it is important to note that the CTE assumptions include 9 years of exposure while the other exposure pathways in the RME conditions assume 30 years. Consequently, in the second scenario, the RME home grown produce assumptions over 30 years were used, but it was assumed that only ¼ (25%) of the produce consumed came from gardens located on the property where the risk assessment was being performed. The calculated soil concentration associated with the 1x10^{-4} risk level for this second scenario was 26 mg/kg. The only assumptions changed from the nominal risk assessment process were to change the assumption that produce consumption at a given property only comes from a garden on the property. The net effects of using the CTE exposure for produce (9 years vs. 30 years) or 25% of the RME exposure for produce (recognizing home grown produce is not the only source of produce to residents at OU1) are essentially the same.

A summary of the number of yards, drip zones, and quadrants sampled during the RI along with a frequency of "yards" with an arsenic concentration above 26 mg/kg where lead concentrations did not exceed 400 mg/kg is presented as Table 8-3. Four properties had at least one soil sample where the arsenic concentration exceeded 26 mg/kg but the lead concentration did not exceed 400 mg/kg.

Table 8-3: Frequency of Arsenic Exceedances at OU1 in Yards without a Lead Exceedance

	Number Sampled	Soil Arsenic Results above 26 mg/kg	Frequency
Eastern Area			
Yards (front and back)	47	1	2.1%
Drip Zones	10	2	20%
Quadrants	3	1	25%
Southwestern Area			
Yards (front and back)	25	0	0%
Drip Zones	5	0	0%
Quadrants	8	0	0%
Northwestern Area			
Yards (front and back)	25	0	0%
Drip Zones	5	0	0%
Quadrants	7	0	0%

8.4.2.2 Recommendations for Arsenic

It is recommended that soils at each property at OU1 where access can be obtained be sampled for arsenic in conjunction with the lead testing recommended above. The recommendation to sample each property is based on the inconsistent distribution of soil arsenic across OU1, as discussed above.

8.4.3 Polycyclic Aromatic Hydrocarbons

The following presents a brief summary of the PAH results observed at OU1 and the recommendations for future work.

8.4.3.1 PAH Summary

PAHs have been found to be ubiquitous in urban environments (USGS 2003; Mauro, et al. 2006; MassDEP 2002). Coupled with the widespread distribution of anthropogenic PAHs are the low EPA RSLs, which are risk-based screening levels. Consequently, PAH RSL exceedances were noted during the RI investigation. However, there was no discernible pattern of highly impacted PAH concentrations that would indicate that these compounds are of concern at OU1.

During the RI sampling efforts conducted in December 2009 and August 2010, 175 soil samples and 21 field duplicate samples were analyzed for PAHs. Concentrations of PAHs in soils exceeded EPA RSLs (EPA 2010c) in 190 of the 196 total samples tested for PAHs. Site-specific background levels of PAHs in close proximity to OU1 were assessed. However, the results of background PAH measurements were not consistent with similar studies conducted in the Chicago metropolitan area (USGS 2003; 35 IAC Part 742) or other metropolitan areas (Mauro, et al. 2006; MassDEP 2002).

PAH background concentrations in urban soils in the Midwest and northeastern U.S. are significantly higher than the site-specific BTVs derived for OU1. Soil types at the cemetery and park locations used to derive the site-specific BTVs (native soils) are not consistent with the soil types seen at OU1 (urban fill soils). It is reasonable to conclude that the site-specific background concentrations for native soil in the parks and cemeteries are not representative of the urban fill soils at OU1. The site-specific BTVs derived for the cemeteries and parks appear to represent ambient PAH concentrations associated with airborne deposition in native soils rather than ambient PAH concentrations in urban fill soils. Furthermore, evaluation of the OU1 PAH data versus the USGS Chicago metropolitan area PAH data indicates that there is no statistical difference between the data sets.

As a result, the Illinois Tiered Approach to Corrective Action Objectives (TACO) criteria for metropolitan areas are considered as more appropriate SSLs for PAHs than the site-specific background values when the risk-based RSL is below the metropolitan background value. Although Illinois TACO criteria do not apply to sites located outside Illinois, the TACO criteria for metropolitan areas appear to be the most appropriate criteria for OU1 because East Chicago lies within the Chicago metropolitan statistical area (MSA), but not within the City of Chicago. Using the EPA RSLs and Illinois TACO PAH background concentrations for MSAs where appropriate allows for reasonably achievable and practical SSLs to be established for OU1 PAHs, as shown in Table 8-4.

Table 8-4: Site Screening Levels for PAHs at OU1

Analyte Name	Units	EPA RSL (Residential)	TACO PAH Background	OU1 SSL	Reference
2-Methylnaphthalene	µg/kg	31,000	140	31,000	RSL
Acenaphthene	µg/kg	340,000	130	340,000	RSL
Acenaphthylene	µg/kg	340,000	70	340,000	RSL
Anthracene	µg/kg	1,700,000	400	1,700,000	RSL
Benzo(a)anthracene	µg/kg	150	1,800	1,800	TACO
Benzo(a)pyrene	µg/kg	15	2,100	2,100	TACO
Benzo(b)fluoranthene	µg/kg	150	2,100	2,100	TACO
Benzo(g,h,i)perylene	µg/kg	170,000	1,700	170,000	RSL
Benzo(k)fluoranthene	µg/kg	1,500	1,700	1,700	TACO
Chrysene	µg/kg	15,000	2,700	15,000	RSL
Dibenz(a,h)anthracene	µg/kg	15	420	420	TACO
Fluoranthene	µg/kg	230,000	4,100	230,000	RSL
Fluorene	µg/kg	230,000	180	230,000	RSL
Indeno(1,2,3-CD)pyrene	µg/kg	150	1,600	1,600	TACO
Naphthalene	µg/kg	3,600	200	3,600	RSL
Phenanthrene	µg/kg	230,000	2,500	230,000	RSL
Pyrene	µg/kg	170,000	3,000	170,000	RSL

Notes:

µg/kg	Microgram per kilogram

A summary of the number of yards, drip zones, and quadrants actually sampled during the RI effort, together with a frequency of "yards" with soil PAH concentrations above SSLs and no exceedances for lead and/or arsenic, is presented in Table 8-5.

Table 8-5: Frequency of PAH Exceedances at OU1 in Yards without a Lead Exceedance

	Number Sampled	Soil PAH Results above SSLs	Frequency
Eastern Area			
Yards (front and back)	13	1	7.7%
Drip Zones	6	0	0%
Quadrants	5	0	0%
Southwestern Area			
Yards (front and back)	4	0	0%
Drip Zones	0	0	0%
Quadrants	8	0	0%
Northwestern Area			
Yards (front and back)	12	0	0%
Drip Zones	3	0	0%
Quadrants	5	1	20%

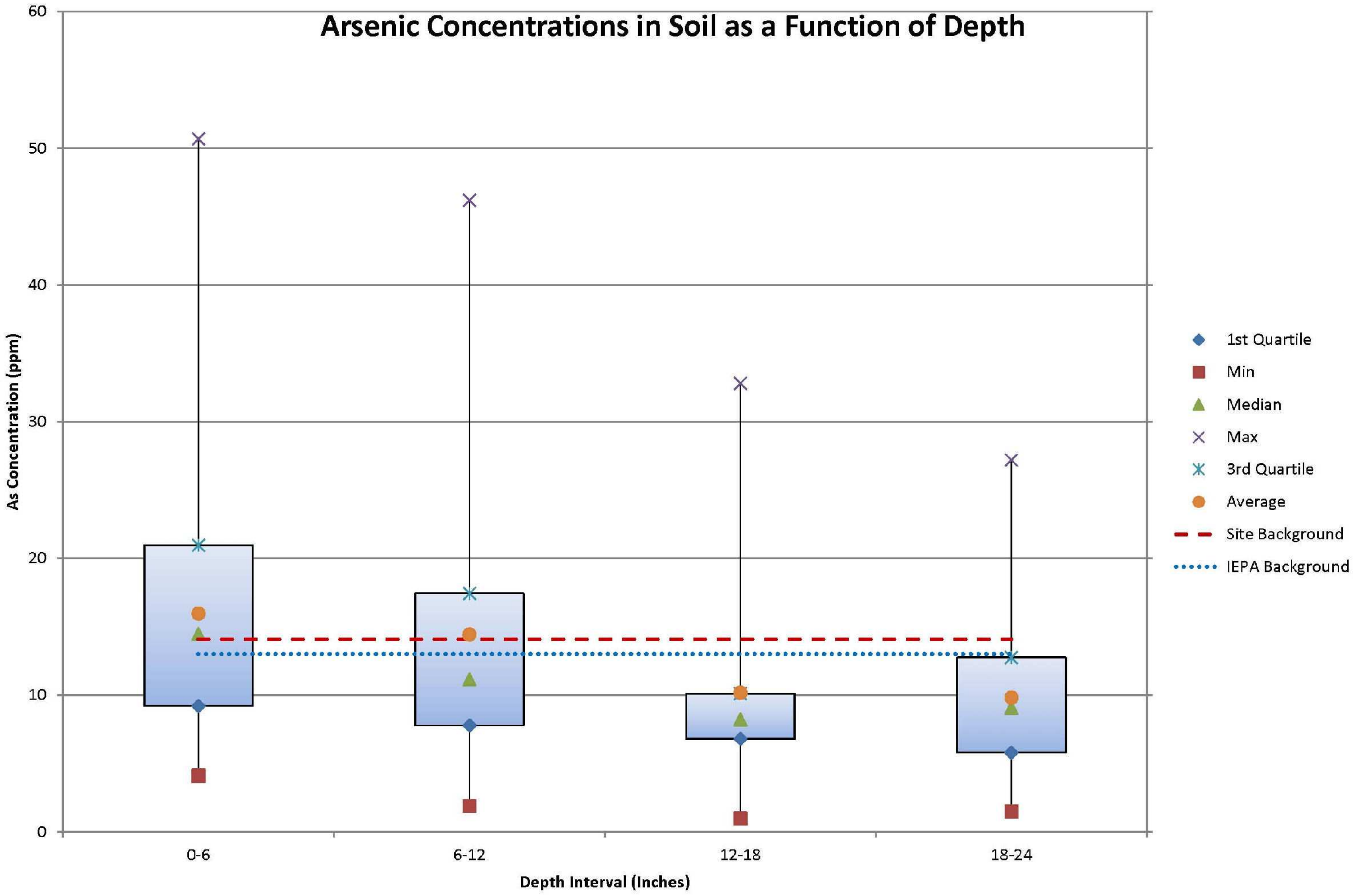
8.4.3.2 Recommendations for PAHs

It is not recommended to further evaluate PAHs in soil during future work at the site, as it has not been demonstrated that soil PAH concentrations exist at OU1 above the levels that would normally be expected in urban soils in the Chicago MSA. There is also no reasonable expectation that PAHs were generated and released as part of activities conducted at the USS Lead (OU2) facility.

8.5 CONCLUSIONS

In summary, of the 1,271 properties in OU1, 53 percent or 672 properties are likely to require remedial action to address risk associated with lead and 4 percent or 51 properties are likely to require remediation to address risks associated with arsenic only. Appropriate remedial actions to address these risks will be considered in a Feasibility Study. Based on the analytical data collected during this RI, levels of VOCs, SVOCs (including PAHs), PCBs, and pesticides do not require further evaluation.

FIGURES



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

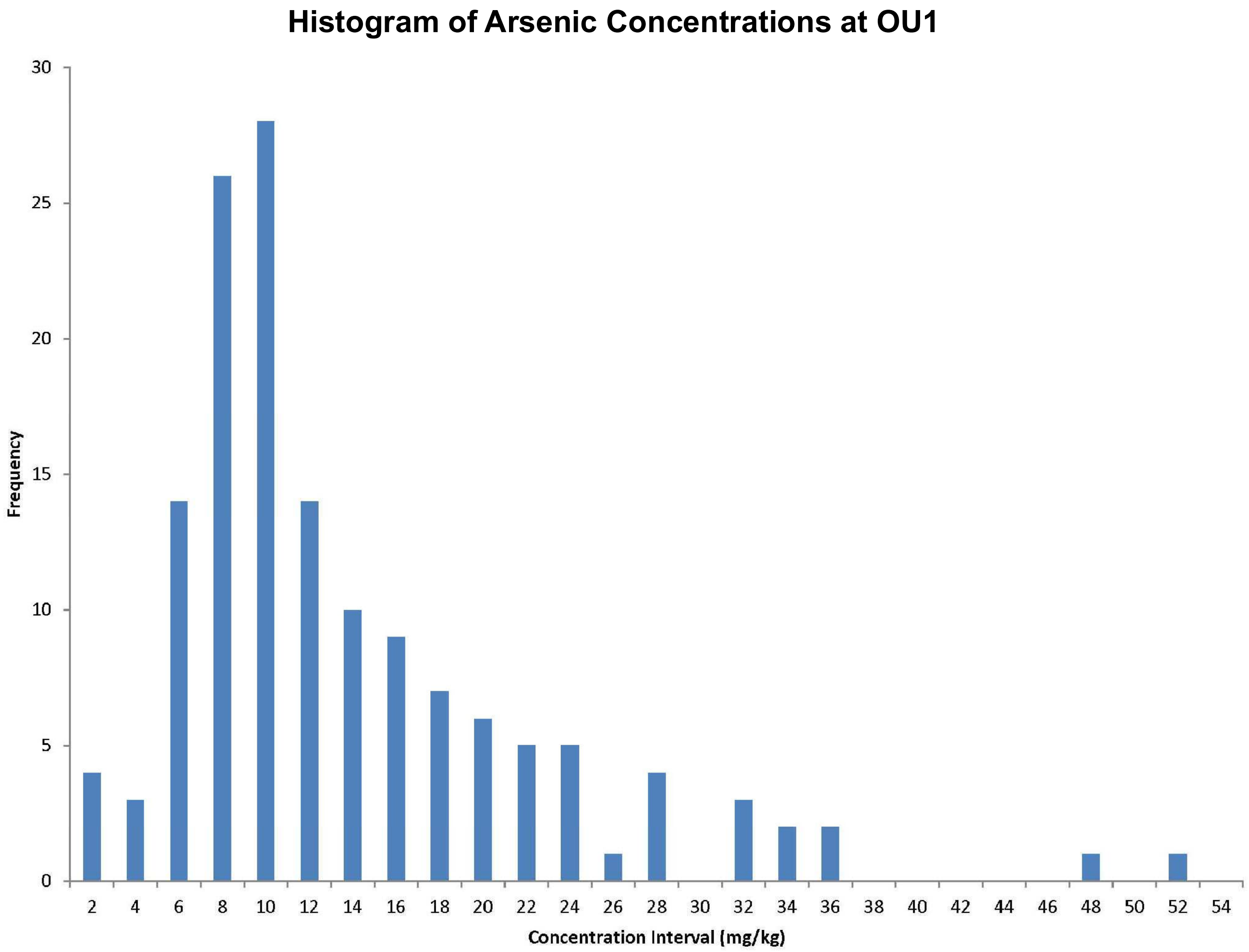
REMEDIAL INVESTIGATION REPORT

FIGURE 8-1

ARSENIC CONCENTRATIONS IN SOIL AS A FUNCTION OF DEPTH

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC



US SMELTER & LEAD REFINERY
LAKE COUNTY, EAST CHICAGO, INDIANA

REMEDIAL INVESTIGATION REPORT

FIGURE 8-2

HISTOGRAM OF ARSENIC
CONCENTRATIONS AT OU1

EPA REGION 5 RAC 2 | REVISION 0 | JUNE 2012

ST SulTRAC

9.0 REFERENCES

35 IAC Part 742. Title 35 Illinois Administrative Code Part 742 "Tiered Approach to Corrective Action Objectives."

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. "Public Health Statement: Polycyclic Aromatic Hydrocarbons." Accessed on line at: http://www.atsdr.cdc.gov/PHS/PHS.asp?id=120&tid=25. August.

ATSDR. 1997. Toxicological Profile for Polycyclic Aromatic Hydrocarbons. U.S.

ATSDR. 2007a. "Public Health Statement: Arsenic." August.

ATSDR. 2007b. "Public Health Statement: Lead." August.

Bostick, B.C. and Fendorf, S. 2003. Arsenite sorption on troilite (FeS) and pyrite (FeS_2).

City-Data. 2011. East Chicago, Indiana (IN 46312) profile. Accessed online at: http://www.city-data.com/city/East-Chicago-Indiana.html on February 10, 2011.

DAI Environmental, Inc. (DAI). 2004a. "Off-Site Soil Excavation, Howard Industries (HI Triangle Area), USS Lead Refinery, Inc., 5300 Kennedy Avenue, East Chicago, Indiana." February 13.

DAI. 2004b. "Off-Site Soil Excavation, Indiana Harbor Belt Railroad (Triangle Area), USS Lead Refinery, Inc., 5300 Kennedy Avenue, East Chicago, Indiana." February 13.

DAI. 2004c. "Off-Site Soil Excavation, Kennedy Avenue (Eastern Off-Site Area), USS Lead Refinery, Inc., 5300 Kennedy Avenue, East Chicago, Indiana." February 13.

DAI. 2004d. "On-Site Soil Excavation (Wetlands Area), USS Lead Refinery, Inc., 5300 Kennedy Avenue, East Chicago, Indiana." February 25.

East Chicago. 2011. "City of East Chicago Facts." Accessed online at: http://www.eastchicago.com/resource_center/quick_facts/ on February 10, 2011.

Eisler, R. 1987. Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report 85 (1.11). Contaminant Hazard Reviews Report No. 11.

FedStats. 2009. "MapStats: East Chicago, Indiana." Accessed online at: http://www.fedstats.gov/qf/states/18/1819486

Fetzer, J.C. 2000. The Chemistry and Analysis of the Large Polycyclic Aromatic Hydrocarbons. *Polycyclic Aromatic Compounds* (New York: Wiley) 27:143. ISBN 0471363545.Geochemical Solutions. 2001a. "Site-Wide Sampling and Analysis Report." July 24.

Geochemical Solutions. 2001b. "USS Lead – MRFI Addendum Off-Site Sampling and Analysis Report." October 15.

Geochemical Solutions. 2004. "Draft Final USS Lead Modified RCRA Facility Investigation (MRFI) Report." March 1.

Gray, Henry H., Ault, Curtis H., and Keller, Stanley J. 1987. Bedrock geologic map of Indiana: Dept. of Natural Resources, Indiana Geological Survey, Miscellaneous Map 48, scale = 1:500,000, http://igs.indiana.edu/arcims/statewide/download.html

Hansel, A.K., Mickelson, D.M., Schneider, A.E., and Larsen, C.E. 1985. "Late Wisconsinan and Holocene history of the Lake Michigan basin." In: Karrow, P. F. and Calkin, P. E. (eds.), *Quaternary Evolution of the Great Lakes*, pp. 40-53. Geological Association of Canada, Special Paper 30.

Hammond Lead Products (Hammond). About Us. Retrieved from: http://www.hammondleadproducts.com/about%20us.html. 2005.

Helsel, D. 2005. *Nondetects and Data Analysis: Statistics for Censored Environmental Data.* John Wiley & Sons, Inc. New York, New York. 250 pp.

Howe, R. and K. Lynch. 2005. "Legal and Technical Defensibility of Data and the Triad Approach." *Remediation.* Volume 15, Issue 2. Spring. Pages 35 through 52.

Indiana Department of Environmental Management (IDEM). 2001. "Risk Integrated System of Closure (RISC) Technical Guide." February.

Determining the fraction of organic carbon. [Web]. Retrieved from http://www.in.gov/idem/Foc_Guidance_070925_Final.pdf

IDEM. 2009. "Risk Integrated System of Closure (RISC) Technical Resource Guidance Document." Final dated February 15, 2001. Revised September 9.

Illinois State Geological Survey (ISGS). 1975. "Handbook of Illinois Stratigraphy." Bulletin 95. 261 pages.

Janssen, R.P.T., W.J.G.M. Peijnenburg, L. Posthuma, et al. 1997. Equilibrium partitioning of heavy metals in Dutch field soils: I. Relationship between metal partition coefficients and soil characteristics. Environ Toxicol Chem 16(12):2470-2478.

Jones, C.A., et al. 2000. Rates of microbial mediated arsenate reduction and solubilization. Soil Science Society of America Journal 64(2):600-608. April.

Law Engineering & Environmental Services (LAW). 2000. Draft Independent Assessment of the Impacts of Historical Lead Air Emissions in East Chicago, Indiana. November.

Luch, Andreas. 2005. "The Carcinogenic Effects of Polycyclic Aromatic Hydrocarbons." London: Imperial College Press. ISBN 1-86094-417-5.

Massachusetts Department of Environmental Protection (MassDEP). 2002. "Technical Update: Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil." Table 1. MassDEP Identified Background Levels in Soil. May.

Mauro, D., P. DeClercq, R. Siegener, and A. Coleman (Mauro, et al). 2006. "Survey of the distribution and sources of PAHs in urban surface soils." Land Contamination & Reclamation, Vol. 14, No. 2, pp. 513-524.

Montgomery, J. H. and L. Welkom. 1989. *Groundwater Chemicals Desk Reference*. Lewis Publishers. Chelsea, MI.

Moore, J.N., W.H. Ficklin, C. Johns. 1988. Partitioning of arsenic and metals in reducing sulfidic sediments. Environ Sci Technol 22:432-437.

National Parks Service (NPS). 2006. "Indiana Dunes, Nature and Science." Accessed online at: http://www.nps.gov/indu/naturescience/index.htm on February 10, 2011.

National Weather Service (NWS2010). "Climate Summary." Accessed online at: http://www.crh.noaa.gov/lot/?n=climate on February 10, 2011.

Pantsar-Kallio, M. and P.K.G. Manninen. 1997. Speciation of mobile arsenic in soil samples as a function of pH. Sci Total Environ 204(2):193-200.

Resource Consultants, Inc. (RCI). 1990. Site Assessment Plan, U.S.S. Lead Refinery, Inc., East Chicago, Indiana, RCI Project No. 1-3214.00. August 3.

Rochette, E. A., B. C. Bostick, G. Li, and S. Fendorf. 2000. Kinetics of arsenate reduction by dissolved sulfide: Environmental Science and Technology, v. 34, pp. 4714-4720.

Sanok, W.J., Ebel, J.G., Jr., Manzell, K.L., et al. 1995. Residues of arsenic and lead in potato soils on Long Island. Chemosphere 30(4):803-806.

STN Environmental JV (STN). 2007. "Draft Site Assessment Letter Report, USS Lead Site, East Chicago/Hammond, Lake County, Indiana, Technical Direction Document No. S05-0708-002, Contract No. EP-S5-06-03." November 8.

SulTRAC. 2009a. "Work Plan – Remedial Investigation/Feasibility Study for USS Lead Superfund Site, East Chicago, Lake County, Indiana." August 6.

SulTRAC. 2009b. "Field Sampling Plan, USS Lead Superfund Site, East Chicago, Lake County, Indiana." October 26.

SulTRAC. 2009c. "Remedial Investigation/Feasibility Study, Quality Assurance Project Plan, USS Lead Superfund Site, East Chicago, Lake County, Indiana." October 26.

SulTRAC. 2010a. "Amended Field Sampling Plan, USS Lead Superfund Site, East Chicago, Lake County, Indiana." July 6.

SulTRAC. 2010b. "Amended Quality Assurance Project Plan, USS Lead Superfund Site, East Chicago, Indiana." July 6.

SulTRAC. 2010c. "USS Lead Residential Area, 407 Vernon Ave. Soil Removal Oversight, October 12, 2010, Remedial Action Contract (RAC) 2 No. EP-S5-06-02, Work Assignment No. 054-RICO-053J." October 18.

TechLaw, Inc. (TechLaw). 2002. Air Dispersion Modeling and Historical Aerial Photography Review. April 5.

TechLaw. 2004a. "Draft Characterization of Lead and Other Metals in Soil in the Vicinity of the USS Lead Site, East Chicago, Indiana." April 20.

TechLaw. 2004b. "Figure 1. Ecological Wetland Habitats, Screening Level Risk Evaluation, USS Lead, East Chicago, Indiana." August 25.

U.S. Department of Agriculture (USDA). 2010. "Natural Resources Conservation Service Web Soil Survey." Accessed on January 26, 2011. On-line Address: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

U.S. Environmental Protection Agency (EPA). 1979. "Water-related environmental fate of 129 priority pollutants: Vol. I. Introduction and technical background, metals and inorganics, pesticides and PCBs." Washington, DC: U.S. Environmental Protection Agency, Office of Water Planning and Standard. EPA440479029a.

EPA. 1985. "Inspection Report of Hammond Lead and USS Lead Refining Soil Survey, Hammond and East Chicago, Indiana." October 15.

EPA. 1986. Guidelines for Carcinogenic Risk Assessment. Risk Assessment Forum. Washington, DC. September. EPA/630/R-00-004.

EPA. 1989. *Risk Assessment Guidance for Superfund (RAGS). Volume I. Human Health Evaluation Manual (Part A).* Interim Final. Office of Emergency and Remedial Response (OERR). EPA/540/1-89/002. December.

EPA. 1990. "National Oil and Hazardous Substances Pollutant Contingency Plan (NCP)." *Federal Register*. Volume 55, No. 46. April 9.

EPA. 1991. "RAGS Supplemental Guidance, Standard Default Exposure Factors." Interim Final. Office of Solid Waste and Emergency Response (OSWER) Directive 9285.6-03. March 25.

EPA. 1992. Site Analysis, U.S. Smelter and Lead Refinery, Inc., East Chicago, Indiana, TS-PIC-92075. August.

EPA. 1992a. "Guidance for Data Usability in Risk Assessment (Part A)." Final. OERR. Publication 9285.7-09A. April.

EPA. 1993. "Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure." Preliminary Review. May.

EPA. 1997. "Environmental Fact Sheet, Waste-Derived Fertilizers." Solid Waste and Emergency Response. EPA530-F-97-053. December. On-Line Address: http://www.epa.gov/osw/hazard/recycling/fertiliz/fertiliz.pdf

EPA. 2003a. "Recommendations of the Technical Review Workgroup for Lead for an Interim Approach for Assessing Risks Associated with Adult Exposures to Lead in Soil." Technical Review Workgroup for Lead. January. Final (December 1996). EPA-540-R-03-001. January. On-Line Address: http://www.epa.gov/superfund/lead/products/adultpb.pdf

EPA. 2003b. *Superfund Lead-Contaminated Residential Sites Handbook.* August.

EPA. 2003c. "Superfund Lead-Contaminated Residential Sites Handbook." Office of Emergency and Remedial Response, OSWER Publication No. 9285.7-50. August.

EPA. 2005. "Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities." OSWER. EPA530-R-05-006. September. On-Line Address: http://www.epa.gov/epawaste/hazard/tsk/td/combust/riskvol.hum#volume1

EPA. 2006. "Supplemental Risk Assessment of Potential Air Emissions from the Confined Disposal Facility for the Indiana Harbor and Shipping Canal Sediment Dredging and Disposal Project." December.

EPA. 2007. "USS Lead Soil Contamination Site: Do Lead Concentrations Differ at Depth?" Presentation by EPA FIELDS Team, Chicago, IL. March 5.

EPA. 2008a. Hazardous Ranking System Documentation Record. US Smelter and Lead Refinery. April.

EPA. 2008b. Demonstrations of Method Applicability under a Triad Approach for Site Assessment and Cleanup – Technology Bulletin. OSWER. EPA 542-F-08-006. August.

EPA. 2009a. *RAGS, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).* Office of Superfund Remediation and Technology Innovation. EPA-540-R-070-002. OSWER 9285.7-82. January.

EPA. 2009b. "RAC II Region 5 Statement of Work For Remedial Investigation/Feasibility Study (RI/FS), USS Lead Superfund Site, Lake County, Indiana." June 19.

EPA. 2009c. ALM Spreadsheet (MS Excel). June 21. On-Line Address: http://www.epa.gov/superfund/lead/products/ALM_2009.xls

EPA. 2009d. Integrated Exposure Uptake Biokinetic Model for Lead in Children. Windows Version. (IEUBKwin. Version 1.1 Build 9). June. On-Line Address: http://www.epa.gov/superfund/lead/products.htm

EPA. 2010a. "USS Lead Superfund Site, Linear Regression results for Lead in Residential Soil." Prepared by John Bing-Canar, FIELDS Group, US EPA, Region V. March.

EPA. 2010b. Regional Screening Level User's Guide (November 2010). On-Line Address: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm

EPA. 2010c. "Regional Screening Level (RSL) Summary Table, November 2010." Accessed online at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_NOVEMBER2010.pdf

EPA. 2010d. "ProUCL Version 4.00.05 Technical Guide (Draft)." EPA/600/R-07/038. Prepared by A. Singh, N. Armbya, and A.K. Singh. Office of Research and Development, Washington, DC. May.

EPA. 2011a. “Great Lakes Areas of Concern, Grand Calumet River Area of Concern.” Accessed online at: http://www.epa.gov/glnpo/aoc/grandcal.html. January.

EPA. 2011b. “Community Involvement Plan, USS Lead Superfund Site, East Chicago, Indiana.” U.S. Environmental Protection Agency, Region 5. April.

EPA. 2011c. “Pollution/Situation Report, USS LEAD-2, Removal Polrep, Initial Removal Polrep,” U.S. Environmental Protection Agency, Region 5. November 1.

EPA. 2011d. “Pollution/Situation Report, USS LEAD-2, Removal Polrep,” U.S. Environmental Protection Agency, Region 5. November 16.

EPA. 2011e. “Pollution/Situation Report, USS LEAD-2, Removal Polrep,” U.S. Environmental Protection Agency, Region 5. December 15.

U.S. Geological Survey (USGS). 2003. “Concentrations of Polynuclear Aromatic Hydrocarbons and Inorganic Constituents in Ambient Surface Soils, Chicago, Illinois: 2001-02.” Water Resources Investigation Report 03-4105.

Watson, L.R.; Shedlock, R.J.; Banaszak, K.J.; Arihood, L.D.; and Doss, P.K. 1989. “Preliminary analysis of the shallow ground-water system in the vicinity of the Grand Calumet River/Indiana Harbor Canal, northwestern Indiana.” U.S. Geological Survey Open-File Report 88–492, 45 pp.

Welch A.H.; Lico, M.S.; Hughes, J.L. 1988. Arsenic in groundwater of the western United States. Ground Water 26(3):333-347.

Weston Solutions, Inc. (Weston). 2009. “Federal On-Scene Coordinator’s Report, Rev. 1 Comprehensive Environmental Response, Compensation, and Liability Act, Removal Action at the USS Lead Site, East Chicago, Lake County, Indiana, Site ID 053J.” August 31.

APPENDIX A
ANALYTICAL SOIL RESULTS:
TABLES A-1 THROUGH A-7 REDACTED

APPENDIX B
FIELD NOTES

REDACTED

APPENDIX C
DATA VALIDATION REPORTS REDACTED

APPENDIX D
XRF REGRESSION REPORT

USS Lead Superfund Site
Linear Regression results for Lead in Residential Soils

Prepared By
John Bing-Canar, FIELDS Group, US EPA, Region V
March 2010

Simple linear regression and regression diagnostics were used to find the "best fitting" linear relationship between XRF measurements of Lead levels in soil and their corresponding laboratory measurements using the SAS® software. This relationship is quantified into a model (equation) of XRF measurements of Lead and its corresponding laboratory measurement. The statistical methods employed were drawn from SAS® literature and three regression texts: Statistical Methods in Water Resources, 1992; and Applied Regression Analysis and Other Multivariate Methods, 1978 and 1988. (See "References" section for a complete list of regression resources.) Simple linear regression was performed for Lead (Pb). The data set used was provided by Cheryl Gorman (Sullivan International), a USEPA Contractor. The name of the data file is: CLP vs XRF Lead.xls.

The steps used to perform simple linear regression were:

1. Plot the data;
2. Computer the least squares regression statistics;
3. Examine adherence to the assumptions of regression using residual plots; and
4. Employ regression diagnostics (Helsel and Hirsch, 1992).

There was a statistically significant linear regression relationship between XRF Lead values and their corresponding Laboratory value in soil (see Figure 1). However, regression diagnostics found that some of the assumptions of regression were violated. These violations included heteroscedasticity (see Figure 2) and a lack of normality for these residuals (results not shown). To overcome these violations, the natural log of the XRF Lead values and their corresponding Laboratory value was taken. Figure 3 shows that there was a statistically significant linear regression relationship between the natural log of the XRF Lead values and their corresponding natural log of the Laboratory value. Figure 4 demonstrates that the assumption of homoscedasticity of residuals was met but