

# Health Consultation

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“EVALUATION OF SURFACE SOIL EXPOSURES”

VILLAGE OF SANDOVAL SITE

SANDOVAL, ILLINOIS

EPA FACILITY ID: ILD053980454

DECEMBER 17, 2018

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Agency for Toxic Substances and Disease Registry  
Division of Community Health Investigations  
Atlanta, Georgia 30333

## **Health Consultation: A Note of Explanation**

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR Toll Free at  
1-800-CDC-INFO  
or

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HEALTH CONSULTATION

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Prepared By:

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## Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
BLL	blood lead level
CDC	Centers for Disease Control and Prevention
CREG	cancer risk evaluation guide
CV	comparison value
DHHS	Department of Health and Human Services
EMEG	environmental media evaluation guide
ESI	Expanded Site Inspection
IARC	International Agency for Research on Cancer
IDPH	Illinois Department of Public Health
IEUBK	Integrated Exposure Uptake Bio-kinetic Model
Illinois EPA	Illinois Environmental Protection Agency
LOAEL	lowest-observed-adverse-effect-level
µg/dL	micrograms per deciliter
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
MRL	minimal risk level
NPL	National Priorities List
NOAEL	no-observed-adverse-effect-level
PHC	public health consultation
ppm	parts per million
RBA	relative bioavailability
RfD	reference dose
RMEG	reference dose media evaluation guides
TCL	Target Compound List
U.S. EPA	U.S. Environmental Protection Agency
XRF	X-ray fluorescence spectrometer





## 1. Executive Summary

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### Introduction

The Agency for Toxic Substances and Disease Registry's (ATSDR) purpose is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent people from coming into contact with harmful toxic substances. ATSDR has a congressional mandate to evaluate sites that the United States Environmental Protection Agency (U.S. EPA) adds to the Superfund National Priorities List (NPL). The Sandoval Zinc Superfund site was placed on the NPL in September of 2011.

In August 2016, the U.S. EPA Region 5 requested that ATSDR assess potential health implications from residential exposures to metals in Sandoval emitted from the former Sandoval Zinc smelter. The "site" includes the former smelter property as well as public and residential properties in the Village of Sandoval, Illinois. U.S. EPA requested that ATSDR focus its evaluation on metals found in the soil on properties within the community. In general, the community is concerned about whether lead is present at concentrations that could be harmful.

For this assessment, ATSDR evaluated soil data for 93 parcels of property (89 residential; 3 schools; 1 public park) collected in 2009 by the Illinois Environmental Protection Agency (Illinois EPA) and in 2010 and 2017 by the U.S. EPA. To address concerns about child exposures to lead, one daycare, a grade school with pre-K childcare facility, and a high school property were sampled in July 2017. Results from these properties prompted ATSDR to recommend that U.S. EPA consider expedited remediation, which also included the remediation of 7 residential locations, in the fall of 2017 [TetraTech, 2018]. The total number of remediated properties to date is 18 properties including 15 residences<sup>1</sup>, and the three preschool/schools mentioned previously [TetraTech, 2018]. As part of the Remedial Investigation (RI), U.S. EPA plans to sample the soil of over 600 residential properties in the Village of Sandoval.

ATSDR reviewed Illinois Department of Public Health (IDPH) blood lead data for children aged six and younger in Sandoval and compared the results from children of the same age group in Marion County and across the state of Illinois. These data were collected between 1997 and 2015 (the most recent year available as of the writing of this document).

The purpose of this public health consultation (PHC) is to evaluate the public health significance of exposures to contaminants in the soil on properties within the Village of Sandoval and provide recommendations

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<sup>1</sup> [https://response.epa.gov/site/sitrep\\_profile.aspx?site\\_id=7423&counter=17576](https://response.epa.gov/site/sitrep_profile.aspx?site_id=7423&counter=17576)

	to protect health. This evaluation also includes the review of blood lead data and other sources of lead in the community.
<b>Conclusions</b>	Following its review of the U.S. EPA, Illinois EPA, and the IDPH data, ATSDR reached four overarching health-based conclusions.
<b>Conclusion 1</b>	Unborn babies exposed to lead from maternal contact with contaminated soil and young children who accidentally ingest soil and dust containing lead while playing in yards in the Sandoval community are at a higher risk of harmful health effects from lead exposures. Concentrations of lead in some school and residential properties pose a public health hazard for these populations.
<b>Basis for Decision</b>	<ul style="list-style-type: none"> <li>▪ Levels of lead in eight residential properties that have not undergone soil clean-up are above U.S. EPA’s priority action level of 1,200 parts per million (ppm).</li> <li>▪ Forty-one properties of the 93 sampled to date had lead measured above the U.S. EPA remedial action level of 400 ppm remaining in soil.</li> <li>▪ Young children exposed to lead may be at risk for long-term health problems such as slower growth and development, decreased hearing and attention, learning and behavioral problems.</li> <li>▪ Too much lead in a pregnant woman’s body can put her at risk for miscarriage, cause her baby to be born too early or too small, and harm her baby’s brain, kidneys, and nervous system.</li> </ul>
<b>Conclusion 2</b>	Though 93 properties have been sampled to date, the extent and magnitude of soil contamination has not been adequately characterized in the community, as there are over 600 residential properties in the Village of Sandoval. Additional sampling is recommended for all properties within Sandoval that have not been previously sampled.
<b>Basis for Decision</b>	Concentrations of lead in residential soils do not follow a deposition pattern of historical releases from the former Sandoval Zinc property, and it appears that most contamination has occurred from the use of smelter waste as fill. Smelter waste containing high levels of lead and other metals was made available to Sandoval residents for fill in surface roadways, driveways, sidewalks, and parking lots as well as for filling low areas on individual residential properties. There are no records of who removed material from the site or what areas of Sandoval received the waste. To identify contaminated properties, comprehensive residential sampling is warranted.
<b>Conclusion 3</b>	ATSDR reviewed the IDPH blood lead data for children aged six and younger in Sandoval and compared the results from children of the same age group in Marion County and across the state of Illinois collected between 1997 and 2015. Blood leads in Sandoval are similar to Marion County or the State of Illinois.
<b>Basis for Decision</b>	Children aged six years and younger with blood lead levels 10 µg/dL or greater in Sandoval, Marion County, and the State of Illinois show a consistent decline over time (See Figure 3 in section 6.2 and Appendix B,

	<p>Table 1). Children tested in Sandoval with blood lead levels 5 to less than 10 µg/dL were slightly elevated in 2012 when compared to the county and state levels, but were at or below the county and state levels from 2013 to 2015 (Appendix B, Table 1). No zip codes in Marion County, including the ones for the Village of Sandoval, are high risk according to the Illinois State Lead Program [IDPH, 2016; IDPH, 2017].</p>
<b>Conclusion 4</b>	<p>Concentrations of metals other than lead in the soil at Sandoval properties sampled are not likely to harm people’s health.</p>
<b>Basis for Decision</b>	<p>Concentrations of antimony, arsenic, copper, iron, and manganese exceeded health based comparison values in a limited number of properties. Further evaluation of exposure to these metals indicates that harmful effects are unlikely. All other metals found in the soil were present at or below background concentrations for the state of Illinois [USGS, 2017].</p>
<b>Next Steps</b>	<p>Because no level of lead in children’s blood has been proven safe, ATSDR and CDC recommend reducing lead exposure wherever possible. ATSDR recommends that parents:</p> <ol style="list-style-type: none"> <li>1. Discuss lead exposure with your child’s pediatrician and consider having your children’s blood lead tested if you are concerned about your child’s exposure.</li> <li>2. Take measures to reduce exposure to lead from soil and other possible sources to children and pregnant women:             <ul style="list-style-type: none"> <li>▪ After working or playing in the yard                 <ul style="list-style-type: none"> <li>○ take shoes off before entering your home</li> <li>○ use a damp cloth or damp/wet mop to remove dust and dirt from your home</li> <li>○ wash hands, wash toys, and wash pets.</li> </ul> </li> <li>▪ Create a raised bed and fill with clean soil for gardening to reduce exposures from gardening and digging. Rinse produce well to remove garden soil.</li> <li>▪ Eat a diet rich in iron, calcium, vitamins C&amp;D, and zinc (found in dairy, green vegetables, and lean meat) because they keep the body from absorbing lead. These minerals are especially important in the diets of pregnant women and young children.</li> </ul> </li> <li>3. Monitor your children’s behavior while playing outdoors and make every effort to prevent your children from accidentally or deliberately eating soil.</li> <li>4. Allow U.S. EPA to sample your soil to find out if your family is at risk for lead exposure, and whether your property should be considered for cleanup.</li> </ol>

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Following its review of available information, ATSDR recommends that U.S. EPA:

1. Continue timely soil remediation to protect public health.
2. Continue timely soil sampling in properties that have not been adequately characterized.

For site related questions, call ATSDR at 1-800-CDC-INFO and ask for information on the Sandoval Zinc site.

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For general information about lead, residents can visit:

<https://www.cdc.gov/nceh/lead/>

**For More  
Information**

For information about children's exposure to lead, parents can visit:

<https://www.cdc.gov/nceh/lead/parents.htm>

## 2. Statement of Issues

The U.S. EPA Region 5 requested that the ATSDR provide technical public health assistance to assess potential health implications from residential exposures to metals in soil contaminated with ore and slag from the former Sandoval Zinc smelter. In 2009, 2010, and 2017, the Illinois EPA and U.S. EPA analyzed soil from 93 properties for metals. Lead, arsenic, and other metals were found in surface soil at levels that exceeded regulatory action levels.

The purpose of this PHC is to evaluate the public health significance of exposures to contaminants in the soil on properties within the Village of Sandoval and provide recommendations to protect health. This evaluation also includes the review of blood lead data and other sources of lead in the community.

## 3. Background

### 3.1. Site Description

The Sandoval Zinc site occupies about 14 acres east of Sandoval in Marion County, Illinois (Figure 1, Appendix A). The site is an abandoned zinc smelter which operated between 1898 and 1985 which underwent on-site clean-up efforts completed in 2012. Metal laden cinder and slag cover the site to a depth of between one to ten feet thick over 12 acres. The site is higher than the surrounding areas due to the buildup of slag. Water runs off the site and into adjacent ditches, creeks, a pond, and farm properties. Historically, cinders and slag not used by the facility were placed in piles and made available to the public and Village of Sandoval for constructing roadways, driveways, sidewalks, parking lots and as fill material in yards on properties. The use of this material disseminated smelter material throughout the community. In addition to cinders and slag, ash from the furnaces was released from the smelter stack. The windblown ash was deposited primarily on the site and areas immediately adjacent to the site. This ash contained high concentrations of metals [Illinois EPA, 2010].

The site is surrounded by agricultural land to north, east and south, a wooded area directly west with two newer homes to the southwest. The nearest residence is approximately 550 feet away. The most densely populated residential area of Sandoval is located west of US Highway 51, which is approximately ¼ mile from the western edge of the site [Illinois EPA, 2010]. The Remedial Investigation/Feasibility Study process is ongoing to manage onsite contamination and additional offsite soil characterization is planned.

### 3.2. Enforcement History

The Sandoval Zinc Company operated a smelter in the Village of Sandoval until the company went bankrupt in 1985. The Illinois EPA conducted a preliminary site assessment in 1986, a screening site inspection in 1988, and an expanded site inspection (ESI) in 1997, and a site cleanup in 1998. In 2009 the Illinois EPA conducted another ESI to determine if the site would score high enough to be listed on the NPL. NPL listing makes sites eligible for Superfund cleanup [U.S. EPA, 2017a]. As part of the ESI, the Illinois EPA collected soil samples from 27 residential properties around the Village of Sandoval to determine whether contaminants had moved offsite from the smelter and into the community. During this investigation, 10 properties were identified with lead in soil over the U.S. EPA's priority action level of 1200 ppm. These soil sampling results prompted Illinois EPA to refer the site to the U.S. EPA for more extensive sampling of residential areas and time critical removal action.

In 2010, U.S. EPA collected samples to characterize metals in the soil of residential properties around Sandoval. The site was placed on the NPL in September 2011. The U.S. EPA completed soil removal and remediation of residential properties above priority action levels by fall of 2011, and finished property restorations in the spring of 2012. In 2017, the U.S. EPA followed up on the 2010 sampling with soil sampling of properties in Sandoval to evaluate the solubility of the lead for human uptake (“*bioavailability*”) [U.S. EPA, 2012]. The U.S. EPA held a public meeting to discuss ongoing site activities in June 2017. ATSDR attended this meeting to address community concerns and answer questions. Upon completion of the site visit and community meeting, ATSDR provided recommendations to U.S. EPA.

### 3.3. Demographic Statistics

The U.S. Census reported 1,481 people in Sandoval in 2010; 1448 (98%) of residents were white, 10 (0.7%) were black, and 24 (1.6%) were mixed or other race. Only 21 (1.4%) of the population identified as Hispanic or Latino. The population is fairly young, with approximately a third (32%) of residents 19 years or younger with a median age of 34 years [U.S. Census Bureau, 2017]. See Appendix A, Figure 2 for a demographic map of the community. Approximately 159 (11%) of the population is children aged 6 and younger in 2010 (Appendix A, Figure 2).

## 4. Exposure Pathways Evaluation

To determine whether people are 1) currently exposed to contaminants or 2) were exposed in the past, ATSDR examines the path between a contaminant and a person or group of people who could be exposed. For these “exposure pathways” to be considered complete, they must satisfy each of the following requirements:

1. A contamination source (Sandoval Zinc and its contaminated smelter waste): Sandoval Zinc emitted metal particulate via smelting operations as well as slag over the surface of their property. Some of this slag was used as fill by the Village of Sandoval as well as area residents as road fill and fill for low-lying land areas.
2. Movement through air or soil: Heavy metals moved through air as wind-blown particulates landing on the soil. Waste materials were stored onsite, and covered the soil of the facility property. Waste materials were made available to the public for private use offsite and were primarily used as fill material.
3. An exposure point (such as surface soil): Residents could be currently or previously exposed to soil or air with heavy metals from the zinc smelting operations.
4. A route of exposure (eating/drinking, breathing, and touching): Residents could have inhaled emissions during facility operations (past exposure). Residents (particularly children) could contact metals in soil while playing in residential areas with contamination (past and current exposure).
5. People who are or could be exposed: People living, working, or playing on contaminated properties could be exposed. Further, people who lived near the smelter when it was operational could have also had exposure from historical air emissions (past exposure).

Other exposures not related to smelter operations could also exist. Homes built before 1978 may contain lead paint. The U.S. Census Bureau estimated in 2016 that 314 out of 512 housing units in Sandoval were built prior to 1979. Deteriorating lead paint from window frames, the outside of homes, or other surfaces could impact the soil, and are very common sources of lead exposure for young children who may ingest or mouth paint chips from peeling or chipping paint indoors. Lead was also

used in gasoline from the year 1923 until it was banned in 1986 and these emissions contaminated soils, particularly near heavily travelled roadways [Sheets, 2001].

Exposure to contaminants in surface soil can occur from incidental ingestion and skin (also referred to as dermal) contact which are the focus of ATSDR's evaluation. Preschool age children tend to swallow more soil than any other age group through outdoor play and because they put their hands and non-food items in their mouths and sometimes exhibit behavior where they may eat soil. Older children and adults tend to swallow much smaller amounts of soil. The amount of grass or other soil cover in an area, the amount of time spent outdoors, and weather conditions also impact soil exposure. Residents may also be exposed to lead through growing and eating homegrown fruits and vegetables in contaminated soil.

## 5. Available Data

ATSDR evaluated three environmental datasets collected by Illinois EPA and U.S. EPA for metals in soil, and evaluated blood lead data provided by the IDPH. These datasets are described below.

### 5.1. Environmental Data

Between October 2009 and June 2017, Illinois EPA and U.S. EPA have conducted three separate sampling events in residential areas of Sandoval, including:

**2009:** In October 2009, the Illinois EPA sampled the soil at 23 properties in the Village of Sandoval. A total of 27 surface soil samples were collected at depths between 0 to 6 inches. Samples were collected with hand trowels and analyzed for the inorganic portion of the target compound list (TCL). All soil samples were sent to and analyzed in a laboratory, and the data were reported as "composite" samples. A composite sample is typically five individual samples collected on a property and blended together and analyzed as an average.

**2010:** In August 2010, U.S. EPA collected soil samples from 71 properties to further characterize site related contaminants in residential areas. Surface soil locations in each yard were screened for metals using a portable x-ray fluorescence analyzer ("XRF"), including:

- 142 composite surface soil samples from the 71 residences were screened by XRF;
- 13 composite subsurface soil samples were screened by XRF at 13 of the residences; and
- 49 composite soil samples from 39 residences initially screened by XRF were sent to a laboratory for analysis.

The samples were collected from different locations in each yard, including the rain "drip line" of the house, which is often impacted by lead paint from the home's exterior. Five-point composite samples were collected from the top 0 to 6 inches of soil, and subsurface samples were collected from 3-6 inches in depth.

**2017:** In June of 2017, U.S. EPA collected samples from 18 previously sampled properties which included local childcare and school facilities, the village park, and residential properties. The samples were tested individually as sieved or "fine" samples (filtered to collect finer dirt and dust particles) or non-sieved "bulk" samples that could include bits of slag, rocks, mulch, sticks, etc. The samples were analyzed for lead as well as the solubility of the lead. Higher solubility of lead makes it easier for the body to absorb.



The percent of the lead that is bioavailable for human uptake from exposure was also reported by the analytical lab.

## 5.2. Blood Lead Data

ATSDR evaluated blood lead data from the IDPH for children aged six years and younger who had an address in Sandoval at the time of testing. Data from the years 1997 to 2015 were reviewed. Blood lead data for Marion County and the State of Illinois were used for comparison. It is important to note that Sandoval is in a low-risk zip code. IDPH defines high-risk zip codes as having older housing stock and a high percentage of low-income families.<sup>2</sup> The state of Illinois does not require blood lead testing in low risk zip codes unless the child is on public assistance, like Medicaid or Women, Infants and Children (WIC). This requirement is because low income children generally have higher lead exposures.<sup>3</sup> Blood lead testing is not mandatory for all children in Sandoval. Illinois law also requires parents or legal guardians of children on public assistance to provide a statement from a physician or health care provider that the child has been tested or evaluated for lead poisoning before attending a licensed daycare, kindergarten, or school [IDPH, 2015]. Note that ATSDR's assessment of blood lead data reflects a subset of children sampled per year, not all children were sampled. A range of approximately 12% to 36% of children in the community were tested from 1997 to 2015 (Appendix B, Table 1). Those children likely represent those at highest risk for exposure.

## 6. Soil Data Screening

ATSDR's initial step—the screening process—compares measured chemical concentrations with health-based comparison values (CVs). A health-based CV is an estimate of daily human exposure to a chemical that is not likely to result in harmful health effects over a specified exposure duration. CVs allow for health assessors to determine which chemicals measured in samples should be evaluated further for their potential to harm health. Exceeding a CV does not mean that harmful effects are likely, but that a complete review of the site-specific exposures and a careful review of the exposure literature is needed to better understand if harmful effects are likely from exposure. Contaminants exceeding CVs in the screening phase are considered “contaminants of potential concern” and are evaluated further in the Health Implications section.

ATSDR has developed CVs for specific media (e.g., air, water, and soil). ATSDR CVs are generally available for three specified exposure periods: acute (1–14 days), intermediate (15–364 days), and chronic (365 days and longer) [ATSDR 2005]. For this assessment, ATSDR conducted a screening assessment of the available surface soil data.

Some of the CVs and health guidelines ATSDR scientists use include ATSDR's cancer risk evaluation guides (CREGs), reference dose media evaluation guides (RMEGs), environmental media evaluation guides (EMEGs), and minimal risk levels (MRLs). ATSDR uses U.S. EPA risk screening levels (RSLs) if ATSDR does not have CV. Health-based guidelines are conservative levels of protection—they are not “thresholds of toxicity”, or levels that would cause a person to get sick. Although exposures to concentrations at or below a CV represent low or no risk, exposures to concentrations above a CV are not necessarily harmful. To ensure that they will protect even the most sensitive populations (e.g.,

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<sup>2</sup> <http://www.dph.illinois.gov/sites/default/files/publications/preventing-and-testing-for-childhood-lead-poisoning-a-reference-guide-for-physicians-and-healthcare.pdf>

<sup>3</sup> <https://www.cdc.gov/nceh/lead/parents.htm>



children or the elderly), CVs are designed intentionally to be much lower than concentrations that cause health effects in animal or human studies. All ATSDR health-based CVs are non-enforceable—they are for screening purposes and are only used to determine the chemicals that require further evaluation. The CVs ATSDR routinely uses for screening include:

- **ATSDR CREGs** are estimates of the concentrations of a carcinogen at which there is an elevated risk for-one case of cancer in one million people exposed over a lifetime.
- **ATSDR RMEGs** represent concentrations of substances in soil to which humans may be exposed without experiencing adverse health effect. RMEGs apply to chronic exposures. They are based on the EPA Reference doses presented in the EPA Integrated Risk Information System (IRIS) database.
- **ATSDR EMEGs** are estimates of the concentrations of contaminants calculated that anyone could be exposed to without experiencing health effects, based on chronic, intermediate, and acute exposures (those occurring longer than 365 days, from between 14-365 days, and 14 days of exposure or less, respectively.) They are based on the ATSDR Minimal Risk Levels published in its ATSDR Toxicological Profiles.

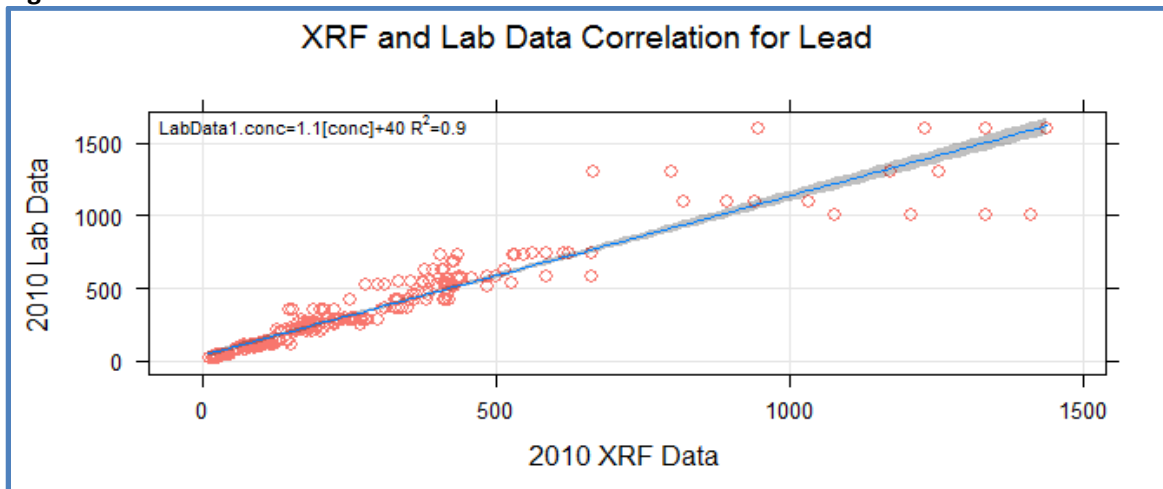
U.S. EPA RSLs are risk-based numbers that are available for multiple exposure pathways and for chemicals with both carcinogenic and non-carcinogenic effects which are based on toxicological information from the EPA Integrated Risk Information System (IRIS) database as well as other sources. The U.S. EPA RSL was used to identify properties with levels of lead in the soil over 400 ppm.

During the initial screening, there were metals identified that exceeded CVs. These pollutants are discussed in greater detail in the remainder of this document.

### 6.1. Representativeness and Limitations of the Data

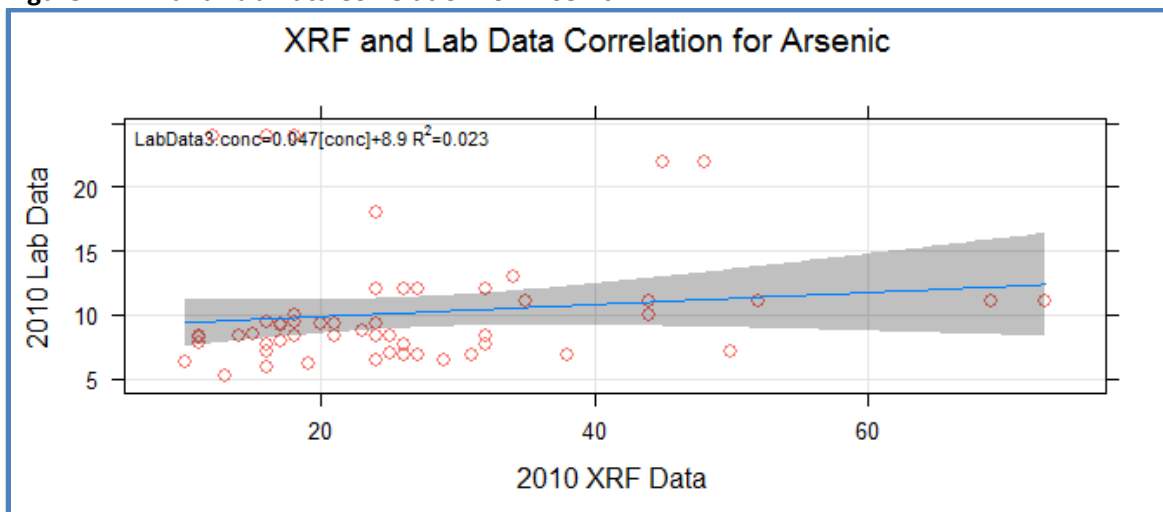
X-ray fluorescence (XRF) analyzers are popular for rapid soil sampling in the field, and do not require laboratory analysis (the industry gold standard for accuracy) to yield immediate results for many heavy metals. XRF analysis is generally recommended as a screening tool to identify properties that require confirmatory lab sampling. Evaluating XRF and corresponding lab data for samples collected by U.S. EPA in 2010, ATSDR determined that the XRF reported contaminant concentrations could be under or overestimated depending on the pollutant being reported. This is a known issue for certain pollutants that can interfere with or *skew* the results for another pollutant if both are present in a sample (e.g., lead and arsenic) [U.S. EPA, 1998]. Compared to the federal reference method (FRM) for laboratory analysis of the data, lead was consistently underreported and arsenic was consistently over reported in the Sandoval XRF data. In Figure 1 below, the correlation between the lead XRF and lab data for individual samples is shown. This analysis indicates that the lead sampling results reported by XRF analysis and traditional laboratory analysis are highly correlated ( $R^2=0.9$ , or 90%). It also suggests that as the XRF lead concentrations increase the XRF tends to underestimate lead concentrations. The plot demonstrates that there is a strong correlation between the XRF and laboratory data for lead, with the XRF concentrations being slightly less (a ten percent underestimation) than the lab results as concentrations begin to exceed approximately 700 ppm.

**Figure 1. XRF and Lab Data Correlation for Lead**



This same assessment of XRF and Lab data for arsenic was conducted. Unlike the strong correlation noted for lead, Figure 2 illustrates the poor correlation of XRF and lab analyzed arsenic levels ( $R^2=2.3\%$ ). Arsenic concentrations were overestimated in the XRF data. This overestimation occurred with other metals analyzed in the data as well, with XRF analyzer reporting higher levels of other metals than the laboratory analysis.

**Figure 2. XRF and Lab Data Correlation for Arsenic**



Since lab analysis reported concentrations significantly lower than what the XRF had reported and since there was poor correlation between the lab and XRF data for all metals except lead, ATSDR chose to base the recommendations and conclusions in this health consultation on the analysis of lab data only for all metals except lead. Since there is a strong correlation between the XRF and lab analysis for lead, ATSDR determined that it was appropriate to analyze all lead samples—lab and XRF—together for the properties sampled to date [U.S. EPA, 2007].

**6.2. Results: Contaminants of Potential Concern (COPCs)**

Ten properties with the highest levels of lead in soil were identified for remediation after the 2009 and 2010 sampling, with 8 permitting access and receiving remediation. Cleanup of the affected properties

commenced in 2011 and was complete by the end of April 2012 [U.S. EPA, 2017b]. These same 10 properties generally had the highest concentrations of other metals as well. Two homeowners denied U.S. EPA access for remediation of their properties. ATSDR excluded soil sampling results from the eight remediated properties in this document, but included the soil sampling results from the two properties that denied access. The soil at these two properties, having the highest lead concentrations of the 85 unremediated properties ATSDR evaluated, poses a present and future risk to occupants.

**Table 1. Summary of data with non-cancer exceedances, excluding remediated properties (ppm)<sup>a</sup>**

	Antimony	Arsenic	Copper	Iron	Lead-Total <sup>b</sup>	Lead-Bulk <sup>b</sup>	Lead-Fine <sup>b</sup>	Lead-Total on Remediated Properties <sup>e</sup>	Manganese
<b>Number of Properties</b>	54	54	54	54	85	18	18	8	54
<b>Number of Samples</b>	65	65	65	65	996	70	70	92	65
<b>Number of Detections</b>	65	65	65	65	996	70	70	92	65
<b>Min</b>	0.3	3.6	11	9,200	10	26.7	21.5	97	80.2
<b>Max</b>	74.4	24	1,850	75,700	1,970	1,380	1,530	49900	3,760
<b>Comparison Value (CV)<sup>c</sup></b>	23	17	570	55,000	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>	2,900
<b>CV source</b>	ATSDR Chronic RMEG	ATSDR Chronic EMEG	ATSDR Int/ Acute EMEG	U.S. EPA Ingestion RSL	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>	ATSDR Chronic RMEG
<b># samples exceeding CVs</b>	3	3	2	1	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>	1
<b># properties exceeding CVs</b>	3	3	2	1	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>	NA <sup>d</sup>	1

<sup>a</sup>All results reported in parts per pollutant per million parts soil (ppm)

<sup>b</sup>The size of the dust particles influences its toxicity in the body; U.S. EPA considers fine particles to represent those most likely to be taken up in the body, thus filters “bulk samples” to 150 μm in size to report “biologically available” lead concentrations in the fine fraction of the soil. Lead-Total is information for properties that were sampled for lead; Lead-Bulk and Lead-Fine is information related only to properties sampled for bioavailability.

<sup>c</sup>The CV listed is the lowest non-cancer CV; cancer risk for arsenic is assessed in the Public Health Evaluation section.

RMEG: Reference Dose Media Evaluation Guide (EMEG): chronic (365+) days of exposure

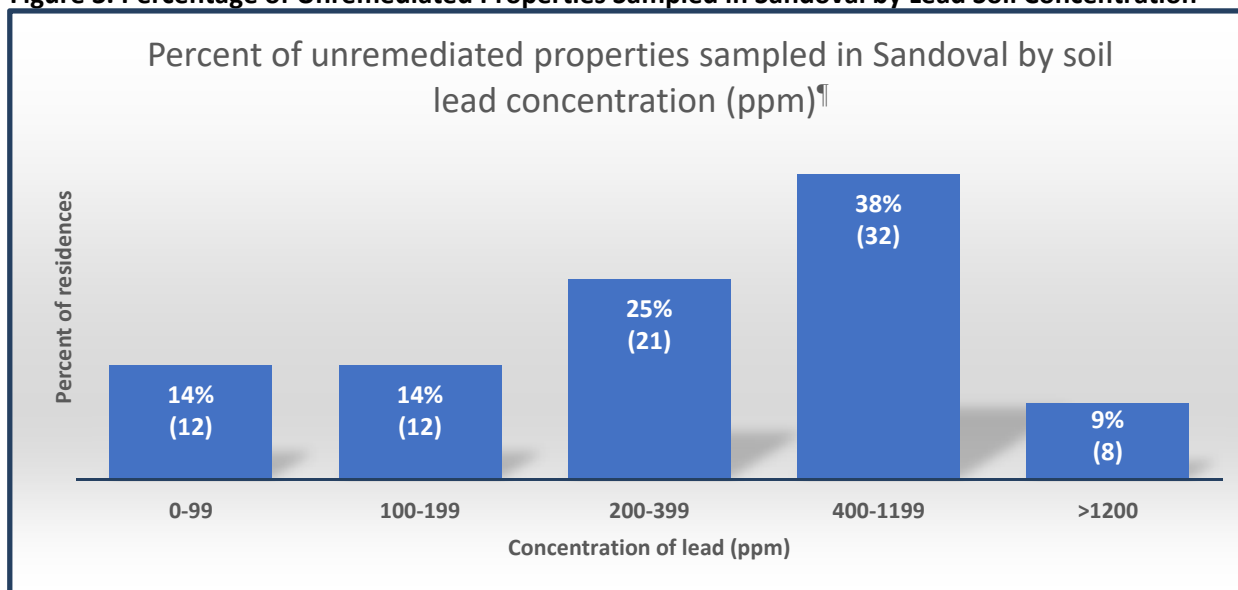
EMEG: ATSDR Environmental Media Evaluation Guide (EMEG): chronic (365+) or intermediate (1-14) days of exposure

RSL: U.S. EPA Risk Screening Level (RSL), chronic

<sup>d</sup>No ATSDR health-based CV exists for screening lead in surface soil because there is no clear threshold for health effects associated with lead exposures. For decision-making, the U.S. EPA uses a lead regional screening level (RSL) for residential soil of 400 ppm for taking remedial action

<sup>e</sup>This data is from the 8 remediated properties mentioned previously in the text and do not currently pose a current or future risk to occupants.

Figure 3 below shows the 85 unremediated properties by lead soil concentration. Using the U.S. EPA remedial action level of 400 ppm for lead, 41 of the 85 unremediated properties sampled had lead above 400 ppm in their soil. This indicated that approximately 48% of the 85 unremediated properties were above the U.S. EPA remedial action level of 400 ppm for lead.

**Figure 3. Percentage of Unremediated Properties Sampled in Sandoval by Lead Soil Concentration**

<sup>†</sup> PPM=Parts lead per million parts soil

The first step in ATSDR's assessment is to compare the lowest CV to the soil measurements reported by U.S. EPA. This step yields a list of pollutants that require further evaluation. Table 1 presents the metals exceeding a health-based CV that were chosen as contaminants of potential concern (COPCs), and are discussed further in the Health Implications section. These COPCs exceeded health-based CVs in at least one sample, and include antimony, arsenic, copper, iron, lead, and manganese.

### 6.3. Dose Calculations

ATSDR evaluated the scientific literature to review the most sensitive health effects that could be caused by exposure to pollutants selected for additional consideration. We used health-protective assumptions to calculate a site-specific daily dose that could be compared with ATSDR's MRLs or U.S. EPA's reference dose (RfD) to evaluate non-cancer health effects. When site-specific doses exceed the established health guidelines for a given contaminant (eg. MRL or RfD), an in-depth toxicological evaluation is conducted to better understand the likelihood of harmful effects from exposure.

To calculate the daily doses of each contaminant, ATSDR uses standard factors for dose calculation [ATSDR, 2016a,b]. We assumed that people are exposed daily to the maximum concentration measured and as well as other health-protective exposure assumptions. A description of ATSDR dose calculations, and subsequent cancer and non-cancer risks, can be found in Appendix C. ATSDR uses a model, rather than traditional dose calculations, to evaluate lead exposures. More information about the ATSDR evaluation of lead is presented in the Health Implications section.

## 7. Health Implications

In this section, ATSDR addresses the question of whether exposure to lead, arsenic, and other metals at the concentrations detected in soil would result in adverse health effects. While the relative toxicity of a chemical is important, the human body's response to a chemical exposure is determined by several things, including:

- The concentration (how much) of the chemical the person was exposed to.
- The amount of time the person was exposed (how long).
- How the person was exposed (through breathing, eating, drinking, or direct contact with something containing the chemical).

Lifestyle factors (for example, occupation and personal habits) have a major impact on the likelihood, magnitude, and duration of exposure. Individual characteristics such as age, sex, nutritional status, overall health, and genetic constitution affect how a human body absorbs, distributes, metabolizes, and eliminates a contaminant. A unique combination of all these factors will determine the body's response to a contaminant and any harmful health effects a person may suffer from exposure. In the following sections, ATSDR summarizes the relevant epidemiologic and experimental information for arsenic, lead, and other metals. ATSDR then provides its public health evaluation of each chemical.

Note that ATSDR calculated risk on an assumption of daily exposure to soil 9 months out of a year, because the ground freezes and/or has snow cover for an average of three months out of the year.

### 7.1. Antimony

Antimony is a silvery white metal of medium hardness that breaks easily. Although antimony is naturally found in the Earth's crust, soil usually contains very low concentrations of antimony. Antimony is usually mixed with other metals such as lead and zinc to form mixtures of metals called alloys. These alloys are used in lead storage batteries, solder, sheet and pipe metal, bearings, castings, type metal, ammunition, and pewter. Antimony enters the environment during the mining and processing of antimony-containing ores and in the production of antimony metal, alloys, and antimony oxide, and combinations of antimony with other substances. Small amounts of antimony are released into the environment by incinerators and coal-burning power plants [ATSDR 2017].

Antimony was detected in the 2009 and 2010 soil sampling conducted by Illinois and U.S. EPA at concentrations between 0.3 and 74 ppm, with 3 properties of the 54 sampled properties above the ATSDR chronic CV for children of 23 ppm (concentrations detected: 26, 71, and 74 ppm). The USGS reported a mean antimony concentration of samples collected throughout the state of 0.70 ppm, with a range of 0.5-1.21 ppm. The levels of antimony identified in these three properties are above ATSDR's CVs and are also above Illinois background levels. Thus, antimony was selected as a contaminant of potential concern and evaluated further in this report.

#### *Non-cancer hazard:*

ATSDR does not have a chronic oral MRL for antimony, but U.S. EPA has a chronic RfD of 0.0004 mg/kg/day. The highest dose calculated from the maximum detect of antimony in the residential yard being evaluated (74 ppm antimony) is in young toddlers (1-2 years of age), and is 0.0015 mg/kg/day, which exceeds the U.S. EPA RfD of 0.0004 mg/kg/day for antimony. To calculate the RfD, the U.S. EPA identified the lowest dose of exposure that resulted in health effects (called the *lowest observed adverse effect level* (LOAEL)) of 0.35 mg/kg/day in a rat study (Schroeder et al., 1970). In this study, 50 male and 50 female rats were given 5 ppm potassium antimony tartrate (expressed as an exposure of 0.35 mg/kg/day) in water. Exposed rats had a decreased lifespan (both sexes), decreased blood glucose levels (males), and altered cholesterol levels (both sexes). Since there was only one dose of antimony administered and that dose resulted in measurable health effects, a no observed adverse effect level (NOAEL) could not be established. The LOAEL of 0.35 mg/kg/day was divided by an uncertainty factor of 1000 (10 because this is an animal study and not a human study x 10 to protect sensitive individuals x 10

for the use of a LOAEL and not a NOAEL) [IRIS, 1987]. The highest calculated dose of 0.0015 mg/kg/day for toddlers (1-2 years of age) is 200 times below the LOAEL derived by Shroeder et al. (1970).

The ATSDR MRL for intermediate oral exposure (14 days to 1 year), published in 2017, is 0.0006 mg/kg/day [ATSDR, 2017]. This MRL was derived from a study of rats dosed with drinking water containing various levels of antimony. The most sensitive endpoint noted in the critical study used to derive the intermediate MRL is the decrease in serum glucose levels (15-17%) in female rats at a dose of  $\geq 0.64$  mg/kg/day [Poon et al., 1998]. The NOAEL in this study was identified as 0.06 mg/kg/day. The NOAEL was divided by 100 (because this is an animal study and not a human study  $\times 10$  to protect sensitive individuals) to yield the MRL of 0.0006 mg/kg/day.

The highest dose (0.0011 mg/kg/day) based on daily exposure 9 months out of the year from the maximum detection of antimony (74 ppm) is in young toddlers (1-2 years of age), which is slightly above the MRL of 0.0006 mg/kg/day, but below the NOAEL of 0.06 mg/kg/day. Total antimony is not considered to be cancer-causing, therefore, a cancer evaluation of antimony exposures was not conducted by ATSDR.

***Antimony concentrations in soils were 200 times below those associated with adverse health effects in scientific studies. Antimony exposures are unlikely to harm people's health.***

## 7.2. Arsenic

Arsenic, a naturally occurring element, is widely distributed in the Earth's crust, which contains about 3.4 ppm arsenic [Wedepohl, 1991]. Most arsenic compounds have no smell or distinctive taste. Although elemental arsenic sometimes occurs naturally, arsenic is usually found in the environment in two forms—inorganic (arsenic combined with oxygen, chlorine, and sulfur) and organic (arsenic combined with carbon and hydrogen). Arsenic is released to the environment through natural sources such as wind-blown soil and volcanic eruptions. Man-made sources of arsenic include nonferrous metal mining and smelting, pesticide application, coal combustion, wood combustion, and waste incineration.

Arsenic was detected in the 2009 and 2010 sampling at concentrations between 3.6 and 24 ppm, with three properties out of the 54 having arsenic concentrations above the ATSDR chronic exposure CV of 17 ppm for children. The range of detection for the properties with arsenic exceedances were 17.2-24 ppm. We can compare the concentrations on these properties to background data collected by the United States Geological Survey (USGS). The USGS reported a mean arsenic concentration of 13.4 ppm from 605 samples collected throughout the state, with a range of 1-245 ppm [USGS, 2017]. While not significantly above the mean Illinois arsenic average, the levels of arsenic identified above ATSDRs CVs are also above background levels. Thus, arsenic was selected as a contaminant of concern. Note that for risk calculations, ATSDR assumed a default of 60% bio-availability in the body.

### *Non-cancer hazard*

The chronic oral MRL (0.0003 mg/kg/day) is based on a study in which many farmers (both male and female) were exposed to high levels of arsenic in well water in Taiwan. U.S. EPA's oral RfD is also 0.0003 mg/kg/day [U.S. EPA, 2008]. A clear relationship was observed for skin damage with increasing concentrations. No changes were observed in 17,000 people exposed to 0.0008 mg/kg/day; discoloration and thickening of the skin was reported in farmers exposed to 0.014 mg/kg/day, and people exposed to 0.038–0.065 mg/kg/day experienced an increased incidence of skin damage [Tseng et al. 1968; Tseng 1977]. Collectively, these and other studies indicate that the threshold dose for dermal effects (ex., hyperpigmentation and hyperkeratosis) is approximately 0.002 mg/kg/day [ATSDR, 2007].

The Department of Health and Human Services (DHHS), the International Agency for Research on Cancer (IARC), and U.S. EPA have all determined that inorganic arsenic can cause skin, lung, and bladder cancers [NRC, 2001].

The highest dose (0.00021 mg/kg/day) from the maximum detection of arsenic (24 ppm) is in young toddlers (1-2 years of age), which is below the MRL of 0.0003 mg/kg/day for arsenic (see Appendix D, Table 2). Thus, arsenic levels measured by USEPA in the 2009 and 2010 do not pose an elevated risk for non-cancer health effects.

#### *Cancer Risk*

Epidemiological studies and case reports of humans exposed to arsenic or arsenic compounds for medical treatment, in drinking water, or occupationally have demonstrated that exposure to arsenic and inorganic arsenic compounds increases the risk of cancer. Cancer from arsenic exposure has been identified in the skin, lung, digestive tract, liver, urinary bladder, kidney, and immune (lymphatic) and bone marrow/stem cell (hematopoietic) systems [NTP, 2016].

ATSDR calculated cancer risk for residents exposed daily for 7 days a week for 12 months per year for 21 years as a child and 12 years as an adult (33 years) using an oral cancer slope factor of 1.5 (mg/kg/day)<sup>-1</sup>. ATSDR assumed default maximum intake rates for a resident exposed at the highest concentration detected in this evaluation (24 ppm) which yields an additional cancer risk of 5 people in a population of 100,000 people. This risk (5 per 100,000 people or  $5 \times 10^{-5}$  (0.00005)) is low; the American Cancer Society (ACS) estimates that the average American male has a 50% chance of developing cancer in his lifetime (0.5) and the average American female has a 33% chance of developing cancer in her lifetime (0.33).<sup>4</sup> Exposure to arsenic does not pose an elevated cancer risk in the properties sampled.

***Arsenic concentrations in the soil at all Sandoval properties sampled are not likely to harm people's health.***

### **7.3. Copper**

Copper is a metal that occurs naturally throughout the environment, in rocks, soil, water, and air. Copper is an essential element in plants and animals (including humans), and is necessary in the human body for cellular energy production, for the creation of connective tissue, for brain and nervous system function, and in metabolizing iron to aid in the formation of red blood cells. Dietary adequate intake (AI) for copper ranges from 200 µg/day for infants less than 6 months old to 1300 µg/day for breast-feeding mothers. It is plentiful in beef liver, some seafood (mollusks, oysters, crab), and nuts [OSU, 2017a]. Copper exposure is not known to cause cancer in humans.

Copper is used to make many kinds of products like wire, plumbing pipes, and sheet metal. Copper is used in the production of U.S. pennies, and is also combined with other metals to make brass and bronze pipes and faucets. Copper compounds are commonly used in agriculture to treat plants for diseases like mildew, for water treatment and, as preservatives for wood, leather, and fabrics [ATSDR, 2004].

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<sup>4</sup> <https://www.cancer.org/cancer/cancer-basics/lifetime-probability-of-developing-or-dying-from-cancer.html>



Copper was detected in the 2009 and 2010 sampling conducted by Illinois and U.S. EPA at concentrations between 11 and 1,850 ppm, with 2 properties of the 54 sampled having concentrations above the ATSDR intermediate CV for children of 570 ppm. The concentrations at these two properties were 970 and 1,850 ppm. The USGS (2017) reported a mean copper concentration of 605 samples collected throughout the state of 27.6 ppm, with a range of 3-2,780 ppm. The levels of copper identified in these two properties are above ATSDR's CV, but within the range of Illinois background levels. Copper was selected as a contaminant of concern.

Copper toxicity includes gastrointestinal, liver, and kidney effects at varying concentrations [OSU, 2017a]. ATSDR's oral MRL for intermediate exposure is based on gastrointestinal effects observed in men and women exposed to copper in drinking water for two months. The NOAEL in this study was 0.042 mg/kg/day; it was divided by three to account for human variability, yielding an MRL of 0.014 mg/kg/day [ATSDR, 2004]. U.S. EPA's chronic RfD is 0.04 mg/kg/day [U.S. EPA, 2018]<sup>5</sup>. Assuming daily play and direct contact with bare soil for nine months of the year (with no exposure during winter months with hard freeze/snow conditions) the dose from the maximum detection of copper measured in surface soil (1,850 ppm) is 0.025 mg/kg/day for a young toddler between 1 and 2 years of age. This value is below the NOAEL of 0.042 mg/kg/day and the RfD of 0.04 mg/kg/day.

***Copper concentrations in the soil at all Sandoval properties sampled are not likely to harm people's health.***

#### **7.4. Iron**

Iron is a metal that is abundant in soil and many food products. Iron is an essential component of hundreds of proteins and enzymes that support essential biological functions, such as oxygen transport, energy production, and DNA synthesis [OSU, 2017b]. Exposure can occur through oral or skin contact with soil, water, food, and other substances that contain iron. There is uncertainty as to whether a chronic overload due to oral intake is possible in individuals with a normal ability to control iron absorption [NCEH and U.S. EPA, 2006].

Iron was detected in the 2009 and 2010 sampling conducted by Illinois and U.S. EPA, ranging between 9,200 and 75,700 ppm, with 1 property of the 54 sampled being above the U.S. EPA regional non-cancer screening level (RSL) for children of 55,000 ppm. The USGS reported a mean iron concentration of samples collected throughout the state of 25,263 ppm, with a range of 1,400-145,000 ppm [USGS, 2017]. The concentration of iron identified at this property is above the ATSDR's CV. Thus, iron was selected as a contaminant of concern to assess the risk to residents at this property.

Iron is necessary in the human body, and the body efficiently metabolizes it. U.S. EPA has established a provisional RfD for iron of 0.7 mg/kg/day, which is believed to be a safe dose of iron to consume over the course of a lifetime [U.S. EPA, 2018]<sup>6</sup>. Assuming daily play and direct contact with bare soil for nine months of the year (with no exposure during winter months with hard freeze/snow conditions), the highest dose (0.99 mg/kg/day) from the maximum detection of iron (75,700 ppm) is in young toddlers (1-2 years of age), which is above the RfD of 0.7 mg/kg/day. Iron is unlikely to pose an increased risk for non-cancer health effects at this property and other properties sampled in Sandoval.

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<sup>5</sup> <https://epa-heast.ornl.gov/>

<sup>6</sup> <https://epa-heast.ornl.gov/>



***Iron concentrations in the soil at all Sandoval properties sampled are not likely to harm people's health.***

### **7.5. Lead**

Lead is a naturally occurring blue-gray metal that has been used by humans for many purposes for thousands of years. It has been used in paints, glazes, water pipes and solder, fixtures, roofs, windows, leaded glass crystal, ammunition, and batteries. Lead exposure has been identified as a concern, especially in children and developing fetuses. Over the past 40 years lead has been phased out of non-battery products (like gasoline, paint, solder, and water systems). Today, the vast majority of lead in the United States (88%) is used in the production of lead-acid storage batteries [USGS, 2016]. However, the past widespread use of lead has resulted in lead being routinely found in air, soil, and water throughout the United States.

No ATSDR health-based CV exists for screening lead in surface soil because there is no clear threshold for health effects associated with lead exposures. However, for decision-making, U.S. EPA uses a lead regional screening level (RSL) for residential soil of 400 ppm for taking remedial action, and 1,200 ppm for properties requiring priority action (those with high accessibility to sensitive populations) [U.S. EPA, 2017b]. In unremediated properties, lead was detected in the 2009, 2010, and 2017 sampling conducted by Illinois and U.S. EPA at concentrations between 10 and 1,970 ppm, with 41 (unique properties) of 85 sampled being above the U.S. EPA residential cleanup value of 400 ppm and 8 of those properties exceeded the priority removal level of 1,200 ppm.

In the 2017 sampling, preliminary results showed that many lead samples had a high percentage of soluble lead (considered "*highly bioavailable*"). Solubility is important because it indicates how much of the lead could potentially be absorbed in the body (become *bioavailable*). Of 18 samples analyzed for relative bioavailability (RBA), there were 11 properties with more than 400 ppm total lead in the soil (Appendix B, Table 2). The highest recorded levels of lead were 1,380 ppm in bulk soil (unsieved sample) and 1,530 ppm in fine soil (sieved to capture smaller, more easily inhaled and ingested soil) for lead (Appendix B, Table 2). The RBA for this sample was 72% in the bulk sample and 69% in the fine sample (Appendix B, Table 2). The seven properties with the highest concentrations of lead identified in this sampling effort were remediated in fall of 2017.

The USGS reported a mean lead concentration of 605 samples collected throughout the state of 62.9 ppm, with a range of 20-1,910 ppm [USGS, 2017]. ATSDR does not have a comparison value for lead as no exposure to lead is considered to be safe or beneficial. Therefore, lead was selected for further assessment.

As noted previously, chipping or flaking paint in homes built before lead was banned in paint in 1978 are a major source of lead. Nationally, an estimated 22 percent of U.S. children six years of age and younger live in a home where there is a lead hazard (defined as lead in an accessible condition, such as deteriorated lead-containing paint, or lead-contaminated dust or dirt) [IDPH, 2015]. Of homes built before 1940, an estimated 68 percent have a lead hazard; 43 percent of homes built between 1940 and 1959 have a lead hazard. Rental units where low-income families and young children reside are most likely to have a lead hazard. In Illinois, 23 percent of homes were built before 1940 and 24 percent were built between 1940 and 1959 [IDPH, 2015]. It is estimated that 60 percent of Sandoval homes were built in 1979 or earlier, 19 percent were built before 1940 and 7 percent were built between 1940 to 1959 [U.S. Census Bureau, 2017].

Lead is not an essential nutrient and is toxic to the body. Although it can affect many body systems, it mainly impacts the neurological system. Lead does not cause cancer. Ideally, soil concentrations would be below levels that could result in elevated blood lead levels in the most sensitive populations (in particular, young children).

Because of historical widespread use, lead is often found in the body at low levels. In the past three decades, however, blood lead levels (BLL) in the public have decreased by 78% as a result of the regulation of lead in gasoline, paint, and plumbing materials [ACCLPP 2007]. Lead can affect various organ systems and be stored in the bones; lead not stored in bones leaves the body as waste. About 99% of the amount of lead taken into the body of an adult will be excreted in the waste within a couple of weeks, while about 30% of the lead taken into the body of a child will leave in the waste. Most of the remaining lead moves into bones and teeth. Lead can stay in bones for decades; however, some lead can leave bones and reenter the blood and organs under certain circumstances; for example, during pregnancy, after a bone is broken, and during advancing age [ATSDR, 2015].

In May 2012, the Centers for Disease Control and Prevention (CDC) updated its recommendations on children's blood lead levels. By shifting the focus to primary prevention of lead exposure, CDC wants to reduce or eliminate dangerous lead sources in children's environments before they are exposed. CDC's recommendation and health effects of lead include [ATSDR, 2015]:

- *Blood Lead Reference Level now 5 µg/dL* – Until 2012, children were identified as having a blood lead level of concern if the test result was 10 or more micrograms per deciliter (µg/dL) of lead in blood. Although experts now use a reference level of 5 µg/dL, this value is under review and may be reduced further in the future.
- *Health Effects in Children with Measurable Blood Lead Levels less than 5 µg/dL and 10 µg/dL* – There is no clear threshold for some of the more sensitive health effects associated with lead exposures. In children, the National Toxicology Program reports conclusions on health effect studies of low-level lead exposure for both <5 µg/dL and <10 µg/dL where there is sufficient evidence of:
  - Decreased academic achievement (<5 µg/dL),
  - Decreased intelligence quotient (IQ) (<5 µg/dL and <10 µg/dL),
  - Decreased specific cognitive measures (<5 µg/dL),
  - Increased incidence of attention-related and problem behavior (<5 µg/dL),
  - Decreased hearing (<10 µg/dL),
  - Reduced postnatal growth (<10 µg/dL), and
  - Delays in puberty (<10 µg/dL).
- *Health Effects of Lead on Developing Fetuses* – Lead crosses the placenta; consequently, it can pass from a pregnant woman to her developing fetus. Follow-up testing, increased patient education, and environmental, nutritional and behavioral interventions are indicated for all pregnant women with BLLs greater than or equal to 5 µg/dL to prevent undue exposure to the developing fetus and newborn. Too much lead in a pregnant women's body can:
  - Put her at risk for miscarriage,
  - Cause the baby to be born too early or too small,
  - Hurt the baby's brain, kidneys, and nervous system, and
  - Cause the child to have learning or behavior problems.
- *Health Effects for Adults* – Adults who are exposed to lead over many years could develop kidney problems, high blood pressure, cardiovascular disease, and cognitive dysfunction.

Neither ATSDR nor U.S. EPA has developed a MRL or RfD for exposure to lead. ATSDR notes that no clear threshold exists for some of the more sensitive health effects associated with lead exposures. CDC and ATSDR recommend reducing lead exposure wherever possible.

The Integrated Exposure Uptake Bio kinetic Model for Lead in Children (IEUBK) model is designed to integrate exposure from lead in air, water, soil, dust, food, paint, and other sources with pharmacokinetic modeling to predict blood lead concentrations in children 6 months to 7 years of age. The model estimates a distribution of blood lead concentrations centered on the geometric mean blood lead concentration. The IEUBK model is a predictive tool that provides results that can be used for making public health decisions.

ATSDR used the IEUBK to predict the probability of elevated blood lead concentrations in the community from soil measurements reported by Illinois EPA and U.S. EPA. The IEUBK Model predicts that a high percentage of young children in the homes sampled in Sandoval could have blood lead levels above the current CDC reference level of 5 µg/dL. Many factors can influence lead exposure and uptake and have a direct impact on blood lead levels. Examples include the lead bioavailability and individual nutritional status, lead exposure risk factors, seasonality, exposure age, and multiple sources of lead exposure. The IEUBK over predicted blood leads on the sampled properties in Sandoval compared to actual blood lead data. However, the higher risk of elevated blood lead it identified supports our recommendation to sample and remediate additional properties with elevated levels of lead in the soil on properties in Sandoval.

**Table 2. Probability of children exceeding the CDC Reference Level and estimated blood leads at various soil concentrations using the IEUBK Model<sup>a,b</sup>**

Lead concentration range (ppm)	Estimated probability (%) of exceeding a BLL of 5 µg/dL	Estimated geometric mean BLL (µg/dL)	# of properties (Surface 0-6 in)
ND-99	NA-2.30	NA-1.96	12
100-199	2.4-13.8	1.97-3.00	12
200-399	14.0-48.8	3.01-4.93	21
400-799	48.9-86.0	4.94-8.31	23
800-1199	86.1-95.7	8.32-11.2	9
>1200	>96.3	>11.6	8

<sup>a</sup>The reference level is based on the highest 2.5% of the U.S. population of children ages 1-5 years. That level is currently 5 µg/dL and based on the 2009-2010 National Health and Nutrition Examination Survey (NHANES). The current (2011-2012) geometric mean level for that age group is 0.97 (µg/dL). CDC will periodically update the reference level.

<sup>b</sup>Blood lead levels were estimated using the EPA Integrated Exposure Uptake Bio kinetic (IEUBK) model with default assumptions with exception of blood lead level set to 5 µg/dL. Model run with results displayed as density curve for ages 0 to 60 months, relative bioavailability of 0.6 and geometric standard deviation (GSD) of 1.6.

**Lead in soil at over 40 Sandoval properties sampled could cause harm to children, especially those six years of age and younger. Pregnant women are also at a greater risk for harmful exposures to lead.**

### 7.6. Manganese

Manganese is a naturally occurring metal that is found in many types of rocks. Manganese occurs naturally in most foods, and can be found in beans, leafy green vegetables, nuts, tea, and some fruit (like pineapple). Manganese is a very important nutrient in the human diet and is required for the metabolism of carbohydrates, amino acids, and cholesterol; it is needed for the development of healthy cartilage and bones; and for collagen formation in human skin cells for wound healing. Dietary adequate

intake (AI) for manganese ranges from 0.003 mg/kg/day for infants less than 6 months old to 2.6 mg/kg/day for breast-feeding mothers [OSU, 2017c].

Manganese is used principally in steel production to improve hardness, stiffness, and strength. It may also be used as an additive in gasoline to improve the octane rating of the gas.

Manganese was detected in the 2009 and 2010 soil sampling conducted by Illinois and U.S. EPA ranging between 80 and 3,760 ppm, with 1 property of the 54 sampled being above the ATSDR chronic exposure CV for children of 2,900 ppm. The property that exceeded 23 ppm had a concentration of 3,760 ppm manganese. The USGS (2017) reported a mean manganese concentration of samples collected throughout the state of 1,005 ppm, with a range of 15-13,800 ppm. The levels of manganese identified in this property is above the ATSDRs CV and are also above Illinois mean background levels. Thus, manganese was selected as a contaminant of concern to assess the risk to residents at this property.

Manganese is a known neurotoxin, especially for people exposed occupationally to high levels in dust. High exposures may manifest with symptoms similar to Parkinson's disease, including tremors, difficulty walking, and other motor and cognitive deficits. Limited evidence suggests that high manganese intakes from drinking water may also be associated with neurological symptoms similar to those of Parkinson's disease. ATSDR does not have an oral MRL for manganese, but U.S. EPA has an RfD of 0.05 mg/kg/day. This RfD is based on studies on many large populations consuming normal diets over an extended period of time with no adverse health effects, with a general NOAEL identified as 10 mg/day. The manganese RfD is a concentration of manganese that one can ingest every day for a lifetime that is not anticipated to cause harmful noncancerous health effects [U.S. EPA, 2017c]. Oral manganese exposure does not cause cancer.

ATSDR calculated a dose for the highest concentration of manganese measured during this investigation and the only one exceeding ATSDR's chronic CV (3,760 ppm). Assuming daily play and direct contact with bare soil for nine months of the year (with no exposure during winter months with hard freeze/snow conditions), the maximum calculated dose for a toddler aged between 1-2 years is 0.078 mg/kg/day. This dose is slightly above the U.S. EPA RfD manganese but well below levels at which harmful effects have been documented in the scientific literature [ATSDR 2012]. This property had no other elevated metals, including site-related contaminants.

***Manganese concentrations in the soil at all Sandoval properties are not likely to harm people's health.***

### **7.7. Other Metals**

There are currently no CVs available for calcium, magnesium, potassium, sodium, and thallium. Calcium, magnesium, potassium, and sodium are considered essential nutrients for the human body and are not evaluated further in this assessment. All these metals were present at or below background levels for the state of Illinois [USGS, 2017].

### **7.8. Blood Lead Data Review**

#### ***Measured Blood Lead Data in Sandoval***

ATSDR reviewed available BLL data from the IDPH. Blood lead data for BLLs of 10 µg/dL or greater was available in children 6 years and younger from 1997 to 2015. Blood lead data for BLLs of 5 to 9 µg/dL in children 6 years and younger were only available from 2012 to 2015. Blood lead data for the Village of Sandoval showed a downward trend of children with elevated BLLs greater than 10 µg/dL from the year

1997 to 2015 (Figure 4 below and Appendix B, Table 1). Children with BLLs being 5 to 9 µg/dL were slightly elevated in 2012 compared to the county and state levels, but were lower than the county and state levels from 2013 to 2015 (shown in Table 3 below). In addition, the IDPH reported that Marion County does not have any high-risk zip codes with elevated BLLs [ILDPH, 2016].

**Table 3. Blood Lead Data for Children with 5 to less than 10 µg/dL Blood Lead Levels in the Village of Sandoval, Marion County and the State of Illinois from 2012-2013**

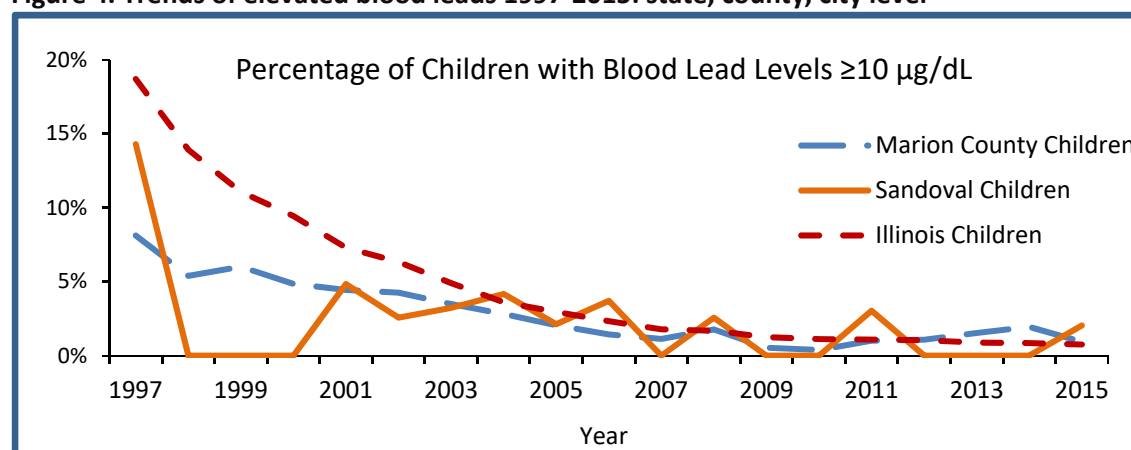
Year	Sandoval Children Tested	Sandoval 5-<10 µg/dL	% Sandoval 5-<10 µg/dL	Marion County Children Tested	Marion County 5-<10 µg/dL	% Marion County 5-<10 µg/dL	Illinois Children Tested	Illinois 5-<10 µg/dL	% Illinois 5-<10 µg/dL
2012	33	5	15%	839	62	7%	291,153	23,045	8%
2013	43	1	2%	785	39	5%	277,669	17,676	6%
2014	52	1	2%	773	26	3%	269,230	16,133	6%
2015	49	0	0%	747	23	3%	256,545	83,96	3%

\*Micrograms per deciliter (µg/dL)

Source: Illinois Department of Public Health - Illinois Lead Program Data 1997-2015

<http://dph.illinois.gov/topics-services/environmental-health-protection/lead-poisoning-prevention/childhood-surveillance>

**Figure 4. Trends of elevated blood leads 1997-2015: state, county, city level<sup>‡</sup>**



<sup>‡</sup>CDC now recommends intervention and follow-up for children with BLLs ≥5 µg/dL, but these data were not captured prior to 2012. To include historical data, this figure displays BLLs ≥10 µg/dL, the former CDC guidance level for lead.

ATSDR recognizes that even low levels of lead in blood have been shown to have harmful effects, therefore supports additional efforts by U.S. EPA to reduce lead levels in soil at the Village of Sandoval. The agency also understands parents with young children may still be concerned about lead exposures. To address these concerns, parents may wish to talk to their pediatrician or the Marion County Health Department about blood lead testing. Blood lead testing is a simple procedure usually covered in whole or in part by health insurance or government entitlement programs such as Medicaid.

### 7.9. Limitations

ATSDR recognizes that there are inherent limitations in the public health assessment process, but providing a framework that puts site-specific exposures and the potential for harm into perspective is one of the primary goals of this health assessment process [ATSDR, 2005]. These limitations include the previously mentioned data limitations of the 2010 XRF and Lab sampling that showed there was a poor correlation for all metals, excluding Lead, between the Lab and XRF data. Blood lead data for children

with 5-9 µg/dL BLLs were unavailable from the year 1997 to 2011. This limited ATSDR to only being able to evaluate children with BLLs 5-9 µg/dL in Sandoval from 2012 to 2015. Actual exposures may have been different from those described in this document.

## 8. Current Site Activities

In July 2017, ATSDR provided the U.S. EPA with the recommendation that properties with sensitive populations and high levels of lead in the soil be prioritized for immediate action. Upon receiving this recommendation, the U.S. EPA conducted the remediation of ten additional properties identified as having the highest concentrations of lead in the soil in the fall of 2017. Three of these properties were sites with sensitive populations on the premises and the remaining seven were residential. One of the residential properties was one of the two homes on the original priority action list that denied access for cleanup in 2011. U.S. EPA is currently drafting a remediation plan for additional soil sampling and site cleanup.

## 9. Conclusions

ATSDR reached four conclusions following its review of the U.S. EPA, Illinois EPA and the ILDPH data:

1. Unborn babies can be exposed to lead from maternal contact with contaminated soil and young children who accidentally ingest soil and dust containing lead while playing in yards in the Sandoval community are at a higher risk to experience long term health problems from lead exposures. These exposures pose a public health hazard.
2. The extent and magnitude of soil contamination has not been adequately characterized in the community. Concentrations of lead in residential soils do not follow a deposition pattern of historical releases from the former Sandoval Zinc property, and it appears that the contamination has occurred using smelter waste as fill material in the community. Although 93 properties have been sampled to date, there are over 600 residential properties in the Village of Sandoval. There are no records of who removed material from the site or what areas of Sandoval received the waste, comprehensive residential sampling is warranted to identify high-risk properties.
3. Blood lead data for children six years and younger for children in Sandoval are generally typical of reference populations. Blood lead data for children six years and younger available for review in Sandoval, Marion County, and the state of Illinois show a similar decline over time, with similar percentages of children having BLLs above the CDC guidance value of 5 µg/dL. In addition, no towns in Marion County, including Sandoval, are high-risk zip codes as determined by the Illinois State Lead Program.
4. Concentrations of antimony, arsenic, copper, iron, and manganese exceeded health based comparison values in a limited number of properties. Further evaluation of exposure to these metals indicates that harmful effects are unlikely. All other metals found in the soil were present at or below background concentrations for the state of Illinois [USGS, 2017].



## 10. Recommendations

Following its review of available information, ATSDR recommends that because no level of lead in children's blood has been proven safe, ATSDR and CDC recommend reducing lead exposure wherever possible.

ATSDR recommends the following to parents:

1. Discuss lead exposure with your child's pediatrician and consider having your children's blood lead tested if you are concerned about your child's exposure.
2. Take measures to reduce exposure to lead from soil and other possible sources to children and pregnant women :
  - After working or playing in the yard
    - take shoes off before entering your home
    - use a damp cloth or damp/wet mop to remove dust and dirt from your home
    - wash hands, wash toys, and wash pets.
  - Create a raised bed and fill with clean soil for gardening to reduce exposures from gardening and digging. Rinse produce well to remove garden soil.
  - Eat a diet rich in iron, calcium, vitamins C&D, and zinc (found in dairy, green vegetables, and lean meat) because they keep the body from absorbing lead. These minerals are especially important in the diets of pregnant women and young children.
3. Monitor your children's behavior while playing outdoors and make every effort to prevent your children from accidentally or deliberately eating soil.
4. Allow U.S. EPA to sample your soil to find out if your family is at risk for lead exposure.

Following its review of available information, ATSDR recommends that U.S. EPA:

1. Continue timely soil remediation to protect public health.
2. Continue timely soil sampling in properties that have not been adequately characterized.

## 11. Public Health Action Plan

The purpose of the public health action plan is to ensure that this evaluation not only identifies potential and ongoing public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. ATSDR will do the following:

1. ATSDR will continue to provide public health guidance and recommendations to U.S. EPA and Illinois EPA.
2. ATSDR will continue to support health education efforts by state and federal enforcement agencies and local and state health agencies to address the community health concerns and continued efforts to identify and reduce exposure to chemicals in the soil wherever possible. This may be done through attending public meetings, workshops, and other stakeholder meetings as well as in the preparation of fact sheets, summary sheets, and additional health consultations summarizing and interpreting data.
3. ATSDR will review any ongoing sampling data and prepare additional documents to assist U.S. EPA during the remedial process in risk characterization, remedial prioritization, and health communication.





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Appendix A. Figures

Figure 1. Area Map for the Village of Sandoval, Illinois

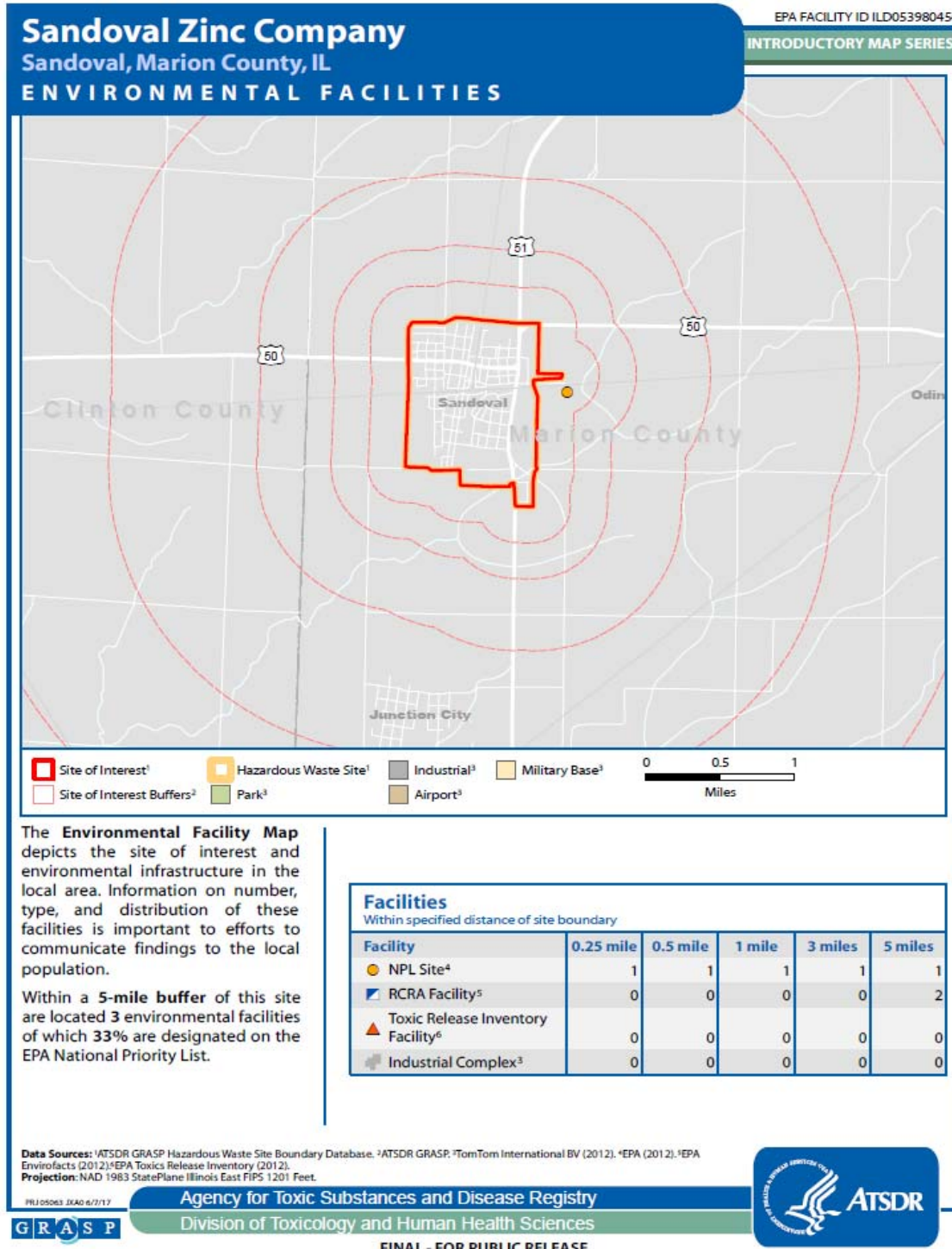




Figure 2. Demographic Statistics for the Village of Sandoval, Illinois

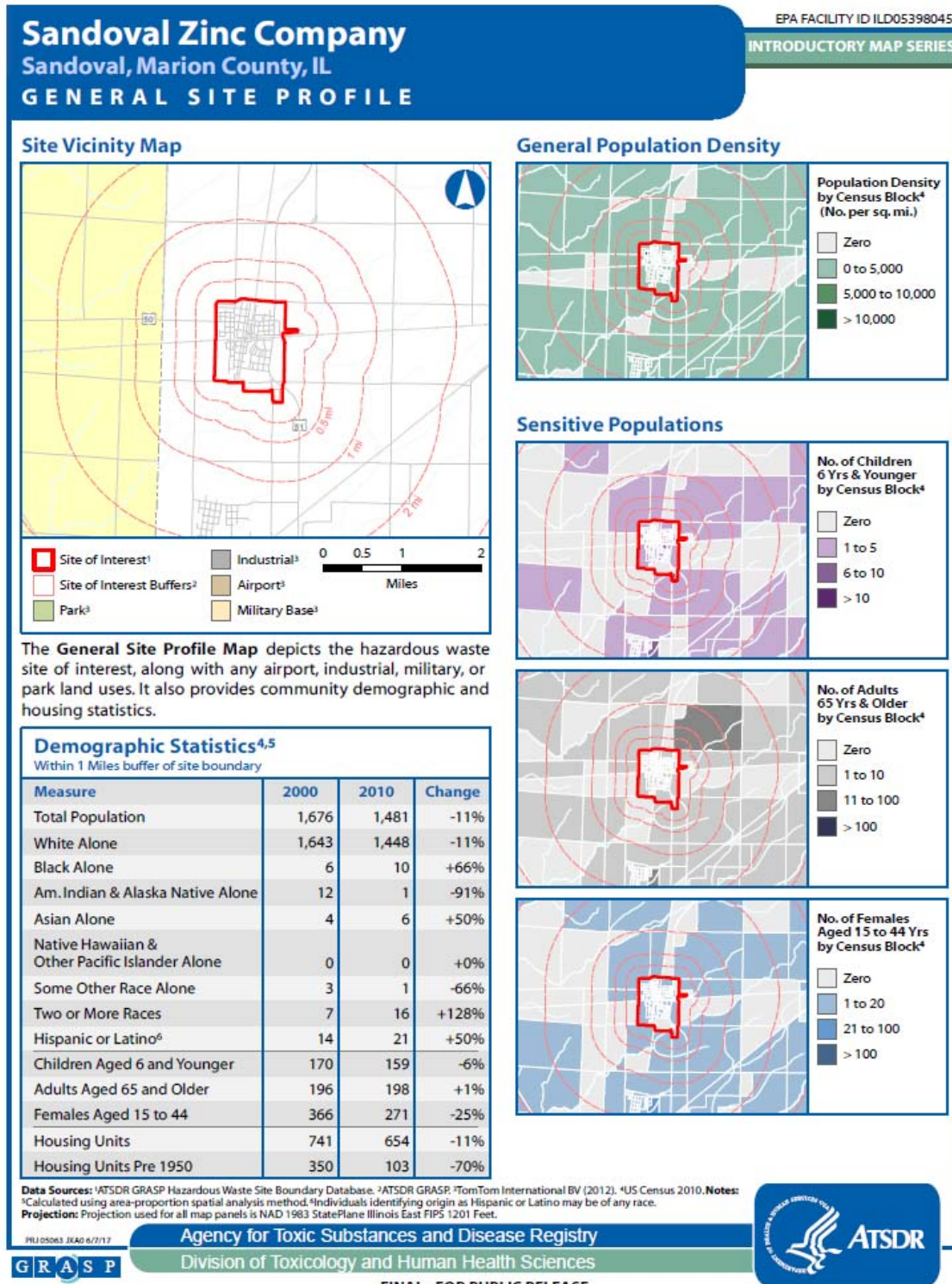
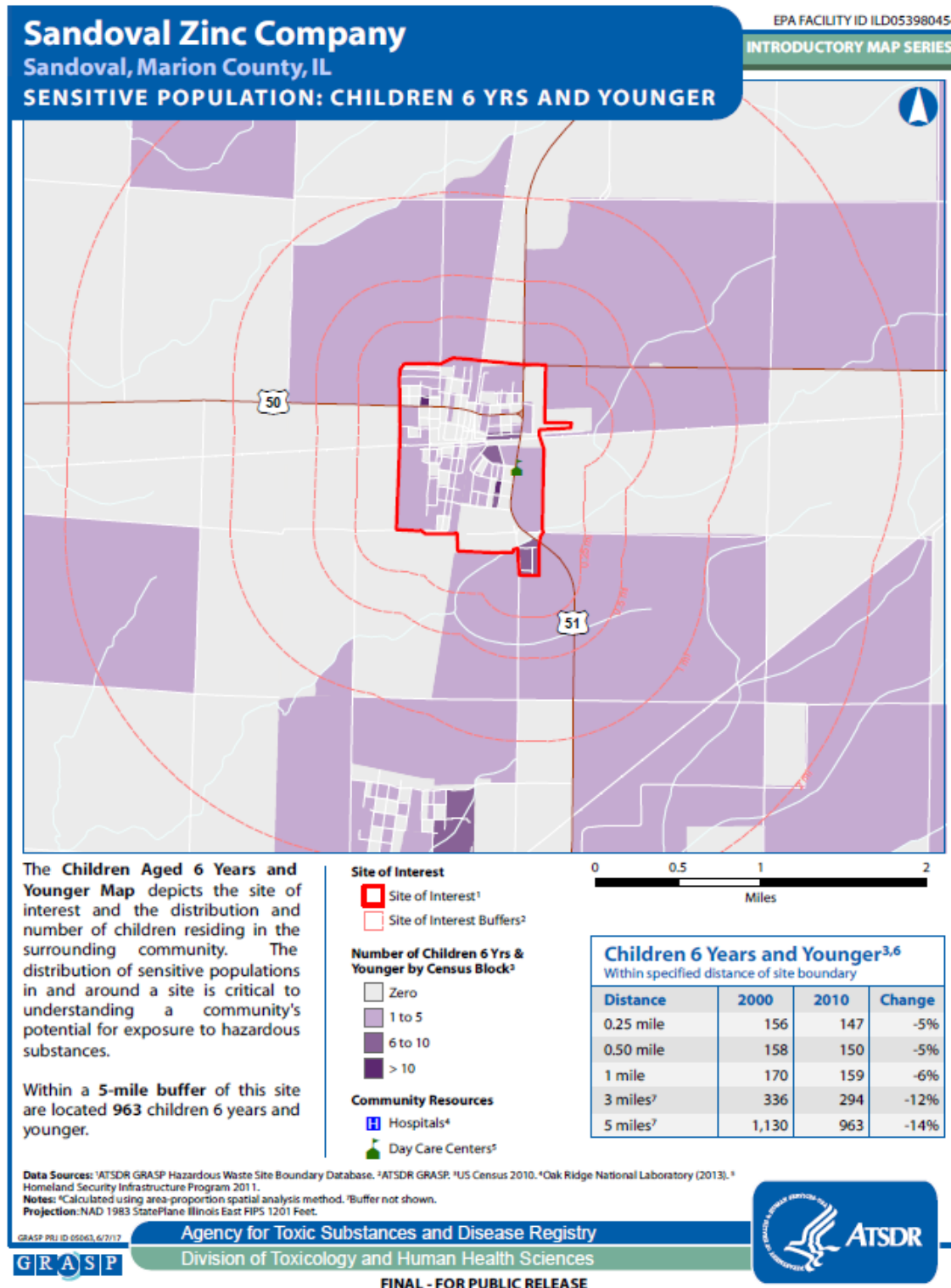


Figure 3. Population of Children ages six and younger for the Village of Sandoval.





## Appendix B. Data Tables

**Table 1. Blood Lead Data for the Village Sandoval, Marion County and State of Illinois.**

Year Children were Tested	Sandoval Children Tested	<sup>β</sup> % of Children Tested in Sandoval	Sandoval Children Tested ≥10 µg/dL	% of Sandoval Children tested ≥10 µg/dL	†Sandoval Children Tested 5-<10 µg/dL	†% of Sandoval Children tested 5-<10 µg/dL	Marion County Children Tested	Marion County Children Tested ≥10 µg/dL	% of Marion County Children tested ≥10 µg/dL	†Marion Children Tested 5-<10 µg/dL	†% of Marion County Children tested 5-<10 µg/d	Illinois Children Tested	Illinois Children Tested ≥10 µg/dL	% of Illinois Children tested ≥10 µg/dL	†Illinois Children Tested 5-<10 µg/dL	†% of Illinois Children tested 5-<10 µg/d
1997	35	21%	5	14%	~NA	~NA	493	40	8%	~NA	~NA	245,093	45,809	19%	~NA	~NA
1998	41	24%	0	0%	~NA	~NA	427	23	5%	~NA	~NA	234,419	32,611	14%	~NA	~NA
1999	22	13%	0	0%	~NA	~NA	350	21	6%	~NA	~NA	238,365	26,384	11%	~NA	~NA
2000	21	12%	0	0%	~NA	~NA	330	16	5%	~NA	~NA	244,442	23,063	9%	~NA	~NA
2001	62	36%	3	5%	~NA	~NA	743	33	4%	~NA	~NA	277,788	20,251	7%	~NA	~NA
2002	39	23%	1	3%	~NA	~NA	799	34	4%	~NA	~NA	263,069	16,653	6%	~NA	~NA
2003	62	36%	2	3%	~NA	~NA	718	25	3%	~NA	~NA	267,997	13,130	5%	~NA	~NA
2004	48	28%	2	4%	~NA	~NA	711	20	3%	~NA	~NA	272,757	9,843	4%	~NA	~NA
2005	47	28%	1	2%	~NA	~NA	634	13	2%	~NA	~NA	275,108	8,123	3%	~NA	~NA
2006	54	32%	2	4%	~NA	~NA	700	10	1%	~NA	~NA	278,078	6,480	2%	~NA	~NA
2007	42	25%	0	0%	~NA	~NA	707	8	1%	~NA	~NA	296,998	5,270	2%	~NA	~NA
2008	39	23%	1	3%	~NA	~NA	793	14	2%	~NA	~NA	304,807	5,126	2%	~NA	~NA
2009	47	28%	0	0%	~NA	~NA	947	5	1%	~NA	~NA	297,227	3,720	1%	~NA	~NA
2010	42	26%	0	0%	~NA	~NA	789	3	0%	~NA	~NA	300,290	3,356	1%	~NA	~NA
2011	33	21%	1	3%	~NA	~NA	791	8	1%	~NA	~NA	290,862	3,164	1%	~NA	~NA
2012	33	21%	0	0%	5	15%	839	9	1%	62	7%	291,153	3,035	1%	23,045	8%
2013	43	27%	0	0%	1	2%	785	12	2%	39	5%	277,669	2,434	1%	17,676	6%
2014	52	33%	0	0%	1	2%	773	15	2%	26	3%	269,230	2,279	1%	16,133	6%
2015	49	31%	1	2%	0	0%	747	7	1%	23	3%	256,545	1,926	1%	8,396	3%

†Data was unavailable for some years.

\*Micrograms per deciliter (µg/dL)

~Not Available

<sup>β</sup>The population of children ≤6 for Sandoval in 2000 was 170 and in 2010 was 159 (Appendix A, Figure 2). For the Year 1997 to 2009 the population of 170 was used to calculate the % of children tested, while the population of 159 from the year 2010 was used for the years 2010 to 2015.

Source: Illinois Department of Public Health - Illinois Lead Program Data 1997-2015

<http://dph.illinois.gov/topics-services/environmental-health-protection/lead-poisoning-prevention/childhood-surveillance>

**Table 2. 2017 Lead Relative Bioavailability Data**

Location	Bulk <sup>a</sup> Total Lead (ppm)	Bulk RBA <sup>b</sup> (%)	Fine <sup>a</sup> Total Lead (ppm)	Fine RBA (%)
Property 1	593	50	745	44
Property 2	380	47	448	46
Property 2	416	38	434	43
Property 2	370	50	493	51
Property 3	587	54	621	56
Property 4	524	47	680	35
Property 5	933	71	1,180	65
Property 5	466	59	568	51
Property 5	548	46	536	53
Property 6	904	86	1,200	68
Property 7	525	60	454	65
Property 8	526	18	69.2	60
Property 8	560	61	692	55
Property 8	1,150	49	1,350	57
Property 8	561	41	583	49
Property 8	538	43	603	49
Property 8	621	48	695	53
Property 8	288	52	463	48
Property 9	602	29	723	28
Property 9	416	40	710	29
Property 10	1,380	72	1,530	69
Property 11	1,080	49	1,230	68
Property 11	1,290	59	968	63
Property 11	1,100	78	1,410	63

<sup>a</sup>Bulk and Fine refers to how large the soil particles were that were evaluated (fine soils were <150 um; bulk means that no filtering of soil size was conducted).

<sup>b</sup>Relative Bioavailability (RBA).

\*Parts per million (ppm)

## Appendix C. Dose Calculations

### Non-cancer evaluation:

For non-cancer illnesses, we first estimate the health risk for children. Because children are smaller and are assumed to swallow more soil than adults do, their exposure dose is higher. For an assessment of the non-cancer health risk, ATSDR uses the following formula to estimate a dose for ingestion to soil:

$$D = (C \times IR \times EF \times CF) / BW$$

D = exposure dose (milligrams per kilogram per day or mg/kg/day)

C = contaminant concentration (milligrams per kilogram or mg/kg)

IR = intake rate of contaminated soil (milligrams per day or mg/day)

EF = exposure factor (unit less)

CF = conversion factor ( $10^{-6}$  kilograms per milligram or kg/mg)

BW = body weight (kilograms or kg)

The exposure factor is calculated with the following equation:

$$EF = F \times ED / AT$$

EF = exposure factor (unit less)

F = frequency of exposure (days/year)

ED = exposure duration (years)

AT = averaging time (days--ED x 365 days/year for non-carcinogens; 78 years x 365 days/year for carcinogens)

ATSDR uses the following assumptions for calculating child doses of metals from ingestion of soil:

- 1) Children ingest an average of 200 milligrams (mg) of soil per day;
- 2) A 1 to 2-year-old child weighs an average of 11.4 kg, or about 25 pounds;
- 3) Children ingest contaminated surface soil at the maximum concentration measured for each contaminant.

### Cancer evaluation:

As the available toxicological data indicates that only arsenic is carcinogenic, cancer risks have not been calculated for antimony, copper, iron, lead, and manganese. ATSDR uses the following equation to estimate the cancer risk for various age groups and adds them together to estimate cancer risk from exposures during childhood and adulthood:

$$\text{Cancer Risk}^7 = [C \times IR \times CF \times EF \times ED \times SF] / [BW \times AT]$$

C = maximum arsenic soil concentration in milligrams per kilogram (mg/kg)

IR = age-group specific incidental soil ingestion rate in milligrams per day (mg/day)

CF = conversion factor from kilograms to milligrams

EF = exposure frequency in days per year

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<sup>7</sup> Cancer risk (CR) is derived for 33 years which is the default residential occupancy period. For children, CRs are derived for a combined child receptor: RME (21 years) at a given residence. The RME CR for the combined child is derived by summing all the cancer risks for each age group from birth to < 21 years. The adult CR assumes living at the residence for 33 (RME) years.

ED = exposure duration in years (reasonable maximum residential exposure of 33 yrs [ATSDR a, 2016])

SF = cancer slope factor per milligrams per kilogram per day (mg/kg/day)<sup>-1</sup>

BW = age-group specific body weight in kilograms (kg)

AT = averaging time in days

Doses from dermal contact with soil are calculated as follows:

*Dermal Absorbed Dose*

$$DAD = [C_{\text{soil/sediment}} \times CF \times AF \times ABS_d \times SA \times EF] / BW$$

DAD = Dermal Absorbed Dose (mg/kg-day)

C<sub>soil/sediment</sub> = Chemical concentration in soil or sediment (mg/kg)

EF<sub>chronic</sub> = Exposure Factor (EV x F x ED)/AT

- EV = Event Frequency (ev/d)
- F = Frequency of Exposure (d/wk x wk/yr)
- ED = Exposure Duration (yr)
- AT = Averaging Time
  - noncancer = ED (yr) x F (7d/wk x 52.14 wks/yr)
  - cancer = 78 yr x F (7 d/wk x 52.14 wk/yr)

CF = Conversion factor (10<sup>-6</sup> kg/mg)

AF = Adherence factor of soil/sediment to skin (mg/cm<sup>2</sup>-event)

ABS<sub>d</sub> = Dermal absorption fraction for soil and sediment

SA = Surface Area available for contact (cm<sup>2</sup>)

BW = Body Weight (kg)

\*For default exposure scenarios, the EF = 1 for acute, intermediate and chronic exposure

See the Determining Life Expectancy and Exposure Factor EDG for how to calculate intermediate and acute EFs

*Dermal Dose Administered*

$$DDa = [C_{\text{soil/sediment}} \times CF \times AF \times ABS_d \times SA \times EF] / [BW \times ABS_{GI}]$$

DDa = Dermal Dose administered (mg/kg-day)

C<sub>soil/sediment</sub> = Chemical concentration in soil (mg/kg)

EF<sub>chronic</sub> = Exposure Factor (EV x F x ED)/AT\*

- EV = Event Frequency (ev/d)
- F = Frequency of Exposure (d/wk x wk/yr)
- ED = Exposure Duration (yr)
- AT = Averaging Time
  - noncancer = ED x F
  - cancer = 78 yr x F

CF = Conversion factor (10<sup>-6</sup> kg/mg)

AF = Adherence factor of soil to skin (mg/cm<sup>2</sup>-event) (time weighted average)

ABS<sub>d</sub> = PCB Dermal absorption fraction for soil and sediment

SA = Surface Area available for contact (cm<sup>2</sup>)

BW = Body Weight (kg)

ABS<sub>GI</sub> = Gastrointestinal absorption factor, unit less

## Appendix D. Screening and Dose Tables

**Table 1. Comparison Value (CV) basis for Initial Screening**

Pollutant	Exposure Medium	Maximum Concentration (ppm)	ATSDR CV	ATSDR CV	Selected for Further Evaluation?
Antimony	Soil/Sediment	74	23	RMEG Child	Yes
Arsenic	Soil/Sediment	24	17	Chronic EMEG Child / RMEG Child	Yes
Copper	Soil/Sediment	1,850	570	Intermediate EMEG Child	Yes
Iron	Soil/Sediment	75,700	NA	NA	Yes
Manganese	Soil/Sediment	3,760	2,900	RMEG Child	Yes

\* Parts per million (ppm); Reference dose media evaluation guides (RMEGs); Environmental media evaluation guides (EMEGs)

**Table 2. Soil Dose Tables: Soil/Sediment Ingestion & Dermal**

### Summary

The Summary displays the results for the default residential scenario for exposure to soil/sediment through ingestion and dermal contact combined. The calculations use default exposure parameters from ATSDR's Exposure Dose Guidance [ATSDR, 2016a,b] .

Exposure Group	Body Weight (kg)	# of days of exposure per week	# of weeks of exposure	# of years of exposure	Default Soil Intake Rates (mg/day) RME	Default Adherence Factor (mg/cm <sup>2</sup> -event)	Combined Skin Surface Area (cm <sup>2</sup> )
6 weeks to < 1 year	8.2	7	39	33	100	0.2	1,772
1 to < 2 years	11.4	7	39	33	200	0.2	2,299
2 to < 6 years	17.4	7	39	33	200	0.2	2,592
6 to < 11 years	31.8	7	39	33	200	0.2	3,824
11 to < 16 years	56.8	7	39	33	200	0.2	5,454
16 to < 21 years	71.6	7	39	33	200	0.2	6,083
Adult	80	7	39	33	100	0.7	6,030

\*Kilograms (kg); Milligrams per day (mg/day); Reasonable maximum exposure (RME); Milligrams per cubic centimeter per event (mg/cm<sup>2</sup>-event); Centimeters squared (cm<sup>2</sup>)

**Combined Residential Results for Standard Age Groups**

**Chronic Exposure**

Exposure Group	Residential Exposure Assessment			
	Chronic Dose (mg/kg/day)	Chronic Hazard Quotient	Cancer Risk <sup>§</sup>	
			RME	ED (yrs)
<b>ANTIMONY (EPC: 74 mg/kg; Chronic RfD: 0.0004 mg/kg/day; CSF: NA<sup>3</sup>)</b>				
6 weeks to < 1 year	0.00083	2.1 <sup>a</sup>	NC	0.88
1 to < 2 years	0.0011	2.8 <sup>a</sup>		1
2 to < 6 years	0.00075	1.9 <sup>a</sup>		4
6 to < 11 years	0.00044	1.1 <sup>a</sup>		5
11 to < 16 years	0.00027	0.66		5
16 to < 21 years	0.00022	0.54		5
Total exposure duration for child cancer risk				
Adult	8.9E-05	0.22	NC	33
<b>ARSENIC (EPC: 24 mg/kg; Chronic MRL: 0.0003 mg/kg/day; CSF: 1.5 (mg/kg/day)<sup>-1</sup>)</b>				
6 weeks to < 1 year	0.00015	0.52	3.4E-5 <sup>β</sup>	0.88
1 to < 2 years	0.00021	0.70		1
2 to < 6 years	0.00014	0.47		4
6 to < 11 years	8.1E-05	0.27		5
11 to < 16 years	4.8E-05	0.16		5
16 to < 21 years	3.9E-05	0.13		5
Total exposure duration for child cancer risk				21
Adult	1.6E-05	0.032	1.1E-5 <sup>β</sup>	33

Exposure Group	Residential Exposure Assessment			
	Chronic Dose (mg/kg/day)	Chronic Hazard Quotient	Cancer Risk <sup>§</sup>	
			RME	ED (yrs)
Birth to < 21 years + 12 years during adulthood			5.0E-05 <sup>β</sup>	33
<b>COPPER (EPC: 1,850 mg/kg; Chronic MRL/RfD: NA; CSF: NA<sup>3</sup>)</b>				
6 weeks to < 1 year	0.017	NC	NC	0.88
1 to < 2 years	0.025	NC		1
2 to < 6 years	0.016	NC		4
6 to < 11 years	0.009	NC		5
11 to < 16 years	0.0051	NC		5
16 to < 21 years	0.0041	NC		5
Total exposure duration for child cancer risk				21
Adult	0.0018	NC	NC	33
<b>IRON (EPC: 75,700 mg/kg; Chronic MRL/RfD: NA; CSF: NA<sup>3</sup>; Ingestion Results Only )</b>				
6 weeks to < 1 year	0.69	NC	NC	0.88
1 to < 2 years	0.99	NC		1
2 to < 6 years	0.65	NC		4
6 to < 11 years	0.36	NC		5
11 to < 16 years	0.20	NC		5
16 to < 21 years	0.16	NC		5
Total exposure duration for child cancer risk				21
Adult	0.071	NC	NC	33

Exposure Group	Residential Exposure Assessment			
	Chronic Dose (mg/kg/day)	Chronic Hazard Quotient	Cancer Risk §	
			RME	ED (yrs)
<b>MANGANESE (EPC: 3,760 mg/kg; Chronic RfD: 0.05 mg/kg/day; CSF: NA<sup>3</sup>)</b>				
6 weeks to < 1 year	0.065	1.3 <sup>α</sup>	NC	0.88
1 to < 2 years	0.78	1.6 <sup>α</sup>		1
2 to < 6 years	0.053	1.1 <sup>α</sup>		4
6 to < 11 years	0.035	0.69		5
11 to < 16 years	0.023	0.47		5
16 to < 21 years	0.020	0.4		5
Total exposure duration for child cancer risk				21
Adult	0.0072	0.14	NC	33

β Cancer risk is greater than 1.0E-6. The health assessor should conduct further toxicological evaluation.

α Hazard Quotients are greater than one. The health assessor should conduct further toxicological evaluation.

§ Cancer risk (CR) is derived for 33 years which is the default residential occupancy period. For children, CRs are derived for a combined child receptor: RME (21 years) at a given residence. The RME CR for the combined child is derived by summing all the cancer risks for each age group from birth to < 21 years. The adult CR assumes living at the residence for 33 (RME) years.

<sup>3</sup> Carcinogenicity not determined; Cancer risk was not calculated.

\*Milligrams per kilogram per day (mg/kg/day); Reasonable maximum exposure (RME); Exposure duration (ED); Exposure point concentration (EPC); Milligrams per kilogram (mg/kg); Reference dose (RfD); Cancer slope factor (CSF); Not available (NA); Not calculated (NC)