

Health Consultation

Review of 2009 and 2010 Soil Data

FLAT CREEK IMM

(a/k/a SUPERIOR WASTE ROCK)

SUPERIOR, MINERAL COUNTY, MONTANA

EPA FACILITY ID: MT0012694970

APRIL 2, 2014

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

An ATSDR health consultation is a verbal or written response from ATSDR 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 which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry (ATSDR)
Division of Community Health Investigations
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List of Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
BLL	blood lead level
CCA	chromated copper arsenate
CDC	Centers for Disease Control and Prevention
CDM	CDM Federal Programs Corporation
CLP	Contract Laboratory Program
CREG	cancer risk evaluation guide
CSF	cancer slope factor
CV	comparison value
DHHS	Department of Health and Human Services
EMEG	environmental media evaluation guide
EPA	U.S. Environmental Protection Agency
EI	exposure investigation
FS	feasibility study
IARC	International Agency for Research on Cancer
IC	institutional controls
kg	kilogram
IEUBK	Integrated Exposure Uptake Biokinetic Model for Lead in Children
IMM	Iron Mountain Mine and Mill
LOAEL	lowest-observed-adverse-effect-level
MCEHP	Mineral County Environmental Health and Planning
MCHD	Mineral County Health Department
MDEQ	Montana Department of Environmental Quality
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
MRL	minimal risk level
NOAEL	no-observed-adverse-effect-level
NPL	National Priorities List
PHA	public health assessment
ppm	parts per million
RALs	remedial action levels
RfD	reference dose
RI	remedial investigation
ROD	record of decision
SSL	soil screening level
TCRA	time-critical removal action
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
URS	URS Operating Services, Inc.
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
XRF	X-ray fluorescence spectrometer

1.0 Summary

INTRODUCTION The Agency for Toxic Substances and Disease Registry's (ATSDR's) 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.

In February 2004, ATSDR received a petition for a public health evaluation of heavy metal contamination in soil and water in Superior, Montana. In April 2009, the U.S. Environmental Protection Agency (EPA) proposed the Flat Creek Iron Mountain Mine and Mill (IMM) site in Superior to its National Priorities List (NPL).

In a January 2010 Public Health Assessment (PHA), ATSDR concluded that prior to removal actions, levels of arsenic and lead in soil for some town properties were at levels that could harm people's health for children and adults who lived at or visited these areas and engaged in contact-intense activities¹ on a daily basis. ATSDR recommended additional characterization of town soil. This health consultation evaluates the public health significance of arsenic and lead levels found during EPA's 2009 and 2010 soil sampling events in Superior.

- CONCLUSIONS**
1. ATSDR concludes that past and current exposures to arsenic and lead in residential and non-residential soil for most town of Superior properties (greater than 80% of the properties) are not expected to harm people's health.
 2. However, ATSDR also concludes that past and current exposures to elevated levels of arsenic and lead in residential and non-residential soil for some Superior properties (less than 20% of the properties) could harm people's health during contact-intense activities.
 3. Following remedial efforts by EPA that are still ongoing (Alternative 4, excavation and disposal of contaminated soils), re-testing of soil at select properties with remediation if needed, and implementation of institutional controls at property RY627, ATSDR concludes that future exposures to arsenic and lead in residential and non-residential soil in Superior would not be expected to harm people's health.
-

BASIS FOR DECISION During 2009–2010, soil samples from approximately 95% of all properties in town were analyzed and most of the sample results (about 65% of the

¹ Contact-intense activities include digging with shovels and other tools, and playing with toys (like toy trucks and action figures) on the ground surface. Adults and children can be exposed by putting soiled hands or toys in their mouth or by breathing or eating dust generated by their activities.

**BASIS FOR
DECISION
(continued)**

arsenic results and 81% of the lead results) were below relevant health-based comparison values.

Although exposure to most town soil is not expected to harm people's health, past and current exposures to arsenic and lead at some Superior properties are at levels that could be associated with harmful health effects. Children may have experienced and may continue to experience transient harmful effects (nausea, vomiting, and diarrhea) following short-term exposures to arsenic when engaged in contact-intense activities. Long-term (a year or longer) exposures to elevated arsenic concentrations were and are of potential public health concern for non-cancerous health effects and long-term (life-time) exposures represent a low cancer risk, particularly at some residential properties. The potential exists for residents, especially children, to have elevated blood lead levels following past and current exposure to soil lead levels at some properties.

Limitations of ATSDR's evaluation include that the agency does not know whether children live at or visit the properties with the highest arsenic and lead levels and engage in contact-intense activities. Also, ATSDR used EPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) to evaluate lead exposures. In some instances, running the IEUBK model with the maximum lead concentrations detected in the past and currently resulted in blood lead levels above the range of values that were used in the calibration and empirical validation of the model. Therefore, ATSDR was not able to rely on the model in these instances.

The levels of arsenic and lead that remain in town are not expected to harm people's health in the future once

- a) remedial efforts are conducted under Alternative 4 as outlined in the record of decision (ROD),
- b) ten residential property quadrants (RY030-E, RY043-B, RY086-C, RY091-E, RY095-B, RY095-C, RY101-A, RY101-E, RY102-B, and RY240-D), and six non-residential property quadrants (RY112-A, RY118-O, RY146-B, RY289-F, RY289-G, and RY398-B) are re-tested, and then remediated under Alternative 4 if needed, and
- c) institutional controls are implemented at non-residential property RY627, as specified in the ROD.

NEXT STEPS

1. Parents can monitor their children's behavior while playing outdoors and prevent their children from intentionally or inadvertently eating soil known to contain elevated levels of arsenic and lead.
 2. Residents may consider prudent public health measures they can take to reduce exposures and to protect themselves, their families, and visitors (see Appendix C.)
 3. EPA plans to remediate additional residential and non-residential properties under Alternative 4 (see Appendix D.)
 4. EPA may consider re-testing, preferably using laboratory analytical methods, sixteen residential and non-residential property quadrants, and then remediate under Alternative 4 if needed. These property quadrants are RY030-E, RY043-B, RY086-C, RY091-E, RY095-B, RY095-C, RY101-A, RY101-E, RY102-B, RY112-A, RY118-O, RY146-B, RY240-D, RY289-F, RY289-G, and RY398-B.
 5. EPA plans to implement institutional controls at non-residential property RY627, as specified in the ROD.
-

**FOR MORE
INFORMATION**

You can call ATSDR at 1-800-CDC-INFO and ask for information on the Flat Creek IMM site.

2.0 Statement of Issues

Residents of Superior, Montana, expressed concern regarding exposures to waste tailings from the Iron Mountain Mine and Mill (IMM) site located near the town of Superior (see Figure 1, Appendix A). Waste tailings from the mine site were used as surface soil fill on public and residential properties in the town of Superior. Contaminated areas include driveways, yards, gardens, public rights-of-way (e.g., along roads), and public areas (e.g., fair grounds).

In a January 2010 Public Health Assessment (PHA), ATSDR concluded that prior to removal actions, levels of arsenic and lead in soil for some town properties were at levels that could harm people's health for children and adults who lived at or visited these areas and engaged in contact-intensive activities² on a daily basis [ATSDR 2010]. ATSDR recommended additional characterization of town soil. In 2009, the U.S. Environmental Protection Agency (EPA) directed CDM Federal Programs Corporation (CDM) to perform a remedial investigation (RI) of the Flat Creek IMM site. As part the RI, CDM collected soil samples from residential properties and public access areas in Superior during 2009 and 2010 [CDM 2011a].

This health consultation evaluates the public health significance of arsenic and lead levels found during the 2009 and 2010 soil sampling events in Superior.

3.0 Site Description and History

The town of Superior is comprised largely of residential properties and service industries. The economy for the area of Superior is based mostly on tourism and recreation related service industries [MDEQ 2003]. Hunting, camping, and other outdoor activities are common in the region. According to the 2010 census, 786 persons live in the town of Superior [Bureau of the Census 2010]. Approximately 26% are age 65 and older and 6% are children 6 years or younger. Children are more susceptible than adults to exposure to hazardous substances because of their frequent hand to mouth behavior, small size, and developing bodies. Figure 2, Appendix A, provides additional demographic statistics.

The Iron Mountain Mine and Mill (IMM) site is located 3.5 miles northeast of the town of Superior (see Figure 1, Appendix A). Established in 1888, the IMM was a zinc, lead, copper, silver, and gold mine [MDEQ 2004]. This mine was the primary producer of silver, zinc, and lead in the area [USDA 2004]. Throughout its years of operation, the IMM operations brought mineral deposits to the surface. These deposits were concentrated in soil and waste tailings at and near the mine site, and some were intentionally transported off site. The mine changed ownership multiple times until its closure in 1954. The property is currently owned by ASARCO, a subsidiary of Grupo México.

All that remains of the mill and other mining buildings are their foundations. A large waste rock pile and some waste tailings deposits still exist on the mine property, although a majority of the waste tailings have been washed downstream onto the Flat Creek floodplain [EPA 2002a].

² Contact-intensive activities include digging with shovels and other tools, and playing with toys (like toy trucks and action figures) on the ground surface. Adults and children can be exposed by putting soiled hands or toys in their mouth or by breathing or eating dust generated by their activities.

The IMM site is located along Flat Creek near its confluence with Hall Gulch. Flat Creek is about 9 miles long and flows in a southwesterly direction towards the town of Superior [USDA 2004]. Shortly after entering the city limits, Flat Creek runs through a culvert before joining the Clark Fork River. Most of the length of Flat Creek lies within the jurisdiction of the U.S. Department of Agriculture (USDA) Forest Service. Assessment of Flat Creek indicates that tailings are present for up to several miles south of the mine site, ranging from trace amounts in the steeper stream segments to extensive deposits in the flatter and more open floodplain. Additionally, some waste tailings were used as fill material in the town.

Exhibit 1 provides a timeline of events for the IMM site that includes significant clean-up and public health-related activities associated with the site. Following Exhibit 1, selected events are described in further detail.

Exhibit 1. Iron Mountain Mine and Mill Timeline of Events

Date	Event
1888	Iron Mountain Mine established
1954	Iron Mountain Mine and Mill closed
February 2002	MCEHP collected biological samples (blood and urine) from residents in Superior, MT
June 2002	EPA collected soil samples in Superior, MT
August 2002	EPA conducted a TCRA to remove contaminated soil from properties in Superior, MT
2004	MDEQ listed the Iron Mountain Mine and Mill site on the Montana Comprehensive Environmental Cleanup and Responsibility Act Priority List
2004	ATSDR received a petition to evaluate heavy metal contamination in soil and groundwater in Superior, MT
August–September 2009	EPA collected soil samples as part of its remedial investigation
September 2009	EPA listed the Flat Creek IMM site on its National Priorities List
November 2009	MCHD requested ATSDR conduct an Exposure Investigation
January 2010	ATSDR released its Public Health Assessment report evaluating heavy metal contamination in soil and groundwater in Superior, MT
June–August 2010	EPA collected additional soil samples as part of its remedial investigation
July 2010	ATSDR collected biological samples (blood and urine) from residents in Superior, MT, as part of its Exposure Investigation
July–August 2010	EPA conducted a second TCRA to remove contaminated soils from properties in Superior, MT
2011	EPA initiated a feasibility study to evaluate remedial alternatives
September 2011	EPA continued efforts related to the second TCRA to address contamination at selected properties
July 2012	EPA released the ROD documenting Alternative 4 (excavation and disposal of contaminated soils) as the selected remedy. The ROD lists properties that were cleaned up during the TCRA events as well as specific property quadrants that should be cleaned up in the next phase of remediation.

EPA	U.S. Environmental Protection Agency
MCEHP	Mineral County Environmental Health and Planning
MCHD	Mineral County Health Department
MDEQ	Montana Department of Environmental Quality
MT	Montana
ROD	record of decision
TCRA	time-critical removal action

In February 2002, Mineral County Environmental Health and Planning (MCEHP) collected blood lead and urine arsenic samples from individuals living in Superior. Results showed that Superior residents were not exposed to unusually-high arsenic concentrations a few days (2–3 days) prior to their urine collection and all blood lead concentrations were below 10 micrograms per deciliter ($\mu\text{g}/\text{dL}$). However, these results did not represent peak exposure levels to soil, sediment and waste tailings, such as those that might occur in the summer when outdoor activities occur.

In June 2002, EPA conducted limited soil sampling in the town of Superior and found multiple areas with soil containing elevated levels of arsenic and lead. In August 2002, EPA conducted a time-critical removal action (TCRA) in Superior. The removal action requirements of soil concentrations were those above 400 parts per million (ppm) of arsenic or 3,000 ppm of lead. Contaminated soils at the Superior High School track, the county fairground, and several residential properties that met the removal action requirements were excavated.

In 2004, the Montana Department of Environmental Quality (MDEQ) listed the Iron Mountain Mine and Mill site on its Comprehensive Environmental Cleanup and Responsibility Act Priority List.

Also in 2004, ATSDR received a petition for a public health evaluation of heavy metal contamination in soil and water in Superior, Montana. In response to the 2004 petition, ATSDR evaluated available data to determine whether harmful health effects are expected from exposures to heavy metal contamination in soil and water. In a January 2010 Public Health Assessment (PHA), ATSDR concluded that coming into frequent contact with waste tailings on the Iron Mountain Mine and Mill site, the Flat Creek floodplain, and the town of Superior could harm people's health [ATSDR 2010]. Frequent, contact-intense activities with the waste tailings may result in exposures that are a public health hazard.

The ATSDR PHA noted that there is some uncertainty about the levels of arsenic and lead that remain in the town of Superior [ATSDR 2010]. Because only about 16% of the residential yards were sampled during the 2002 TCRA effort, the potential existed for properties in town that were not sampled by EPA in 2002 to contain waste tailings material with elevated levels of arsenic and lead. In August and September 2009, additional soil samples were collected from 313 residential properties and public access areas in Superior as a part of the RI [CDM 2011a]. In September 2009, EPA listed the Flat Creek IMM site on its National Priorities List (NPL).

In 2008 and 2009, a community-wide upgrade and replacement of the municipal water supply lines was completed. Road beds were sampled and contaminated materials encountered during the waterline replacement were disposed at the municipal landfill in Missoula, Montana, or at the temporary repository being used by EPA's Removal Branch in Superior [CDM 2011a].

In response to a November 2009 request from the Mineral County Health Department (MCHD), ATSDR conducted an Exposure Investigation (EI) to further evaluate the potential for exposure of Superior residents to lead and arsenic. With the assistance of MCHD, ATSDR recruited 63 Superior residents to participate in the EI. The EI population consisted of 33 adults and 30 children under the age of 18 years of age. EI participants provided blood samples for lead testing and urine samples for arsenic testing. The EI was conducted during the summer (July 2010) when outdoor activity and the potential for exposure to soils were expected to be at their highest. However, the levels of blood lead and urinary arsenic detected in all EI participants were below the upper 95th percentile of a national reference range [ATSDR 2011]. ATSDR concluded in the EI Report that there was no evidence of unusually-high exposures to the lead and arsenic found in soil on residential and public property in Superior for the EI participants during the testing period [ATSDR 2011].

In 2010, additional soil samples were collected from 275 residential properties and public access areas, as well as 30 alleys, in Superior as a part of the RI. The alleys are generally unpaved areas in town. Also, EPA conducted a second TCRA to remove soils from properties in Superior that exceeded 400 ppm of arsenic or 3,000 ppm of lead. A total of 7,903 cubic yards of contaminated soil were removed from 29 properties [CDM 2011a, URS 2012]. Excavations were conducted to a minimum depth of 12 inches, but were advanced to 24 inches in gardens. Confirmation samples were taken from the bottom of the excavation. If concentrations were elevated in the confirmation samples, the removal group used discretion to determine if the excavation should be advanced further. All excavations were backfilled with clean soil. Of note, three additional properties identified during the second field season of the RI in 2010 were cleaned up in 2011 [EPA 2012a].

In 2011, EPA directed CDM to perform a feasibility study (FS) for the site [CDM 2011d]. The FS provided a detailed evaluation of five remedial alternatives to address contaminated soils in Superior, which are:

- | | |
|---------------|---|
| Alternative 1 | No Further Action |
| Alternative 2 | In-Place Capping of Contaminated soils |
| Alternative 3 | Excavation and Disposal of Contaminated Soil at Licensed Solid Waste Facilities |
| Alternative 4 | Excavation and Disposal of Contaminated Soils at the Mine Waste Joint Repository |
| Alternative 5 | Excavation of Contaminated Soils, Treatment and Disposal of Treated Soils at the Mine Waste Joint Repository [CDM 2011d]. |

The FS included a description of additional residential and non-residential quadrants that may potentially be remediated in the future, which are quadrants exceeding the remedial action limits of 100 ppm of arsenic or 400 ppm of lead in soil. In October 2011, in its proposed plan, EPA announced Alternative 4 as its preferred alternative for cleanup of contamination [EPA 2011a]. After a comment period on the preferred plan, the next step in the process is the record of decision (ROD), where EPA selects and documents its final remedial decision for the site. In

July 2012, the ROD was released documenting Alternative 4 as the selected remedy [EPA 2012a]. Appendix D provides a brief summary of Alternative 4 as described in the ROD.

4.0 Exposure Pathway Evaluation

To determine whether people are being exposed to contaminants or whether they were exposed in the past or will be exposed in the future, ATSDR examines the path between a contaminant and a person or group of people who could be exposed.

In the past, waste tailings from the mine were used as surface soil fill on public and residential properties [EPA 2001, EPA 2002a]. Contaminated areas were driveways, yards, gardens, public rights-of-way (e.g., along roads), public schools and the county fairgrounds. Of note, all properties, whether located *within* town limits or *just north* of town limits, are considered “the town of Superior” for this public health evaluation because the exposure pathway elements for each property are similar.

At private residences where mine tailings were used for driveway fill and for yards and gardens, residents are exposed to soil when it is stirred up by gardening, moving vehicles, and children playing. In addition, residents are exposed to soil contaminated with waste tailings when visiting high traffic areas within town, including the county fairgrounds, churches, parks, and schools.

Exposure to soil occurs primarily through dermal contact. In addition, people might accidentally ingest soil, as well as dust that is generated from disturbing the soil. Preschool age children tend to swallow more soil than do any other age group because they have more contact with soil and sediment through their play activities and they tend to exhibit mouthing of objects. Children in elementary school, teenagers, and adults tend to swallow much smaller amounts of soil. The amount of vegetative or other soil cover in an area, the amount of time spent outdoors, and weather conditions also influence people’s exposure to soil. In Superior, the ground is often frozen and covered in snow during the colder months thereby limiting soil exposures.

For this health consultation, ATSDR considers three exposure scenarios: past, present and future exposure to arsenic and lead in soil. ATSDR considers past exposure to be exposure to the arsenic and lead levels detected in soil prior to the 2010 and 2011 TCRA. ATSDR considers current exposure to be exposure to the arsenic and lead levels detected in soil following the 2010 and 2011 TCRA. ATSDR considers future exposure to be exposure to the arsenic and lead levels that would remain in Superior following cleanup under Alternative 4, as described in the ROD [EPA 2012a].

5.0 Soil Data

This health consultation focuses on arsenic and lead soil sampling data for the town of Superior collected as a part of the RI. The 2009 and 2010 sampling events included approximately 95% of all properties in town, or a total of 588 properties [EPA 2011a]. This included 500 residential and 88 non-residential properties. Non-residential properties included schools, churches, parks, the county fairgrounds, the hospital, medical offices, a gas station, various businesses, banks, and government offices. Although the current use of these properties is non-residential, Superior has

no zoning and it is possible that they could become residential properties in the future. In addition, 30 alleys were included in the 2010 sampling event [CDM 2011a].

5.1 Soil Sampling and Soil Removal Procedures

Soil sampling and analysis for assessment and planning under the RI and soil sampling and analysis in the field during the TCRAs were conducted independently by two different EPA contractors. CDM completed soil sampling for the RI using both X-ray fluorescence spectrometer (XRF) on-site screening as well as laboratory analysis of selected samples under the EPA Contract Laboratory Program (CLP) [CDM 2011a]. During the TCRAs, URS Operating Services, Inc. (URS) collected additional XRF samples to plan and target properties that were initially defined by CDM XRF results to exceed 3,000 ppm lead [URS 2012]. A summary of the two independent efforts follows.

5.1.1 Remedial Investigation (RI) Soil Sampling and Analysis

According to the RI, CDM established sampling areas, or “quadrants”, for each property. The quadrants were identified with a letter (A, B, C, and so on) appended to the property ID. For each quadrant, five aliquot locations were chosen. For three depth intervals (0 to 2 inches, 2 to 6 inches and 6 to 12 inches), composite samples were made for each quadrant using the individual aliquot samples from within that sampling area. The field team took additional samples identified as potential fill areas or areas that appeared to contain mine waste based on color or other visual cues [CDM 2011a].

CDM first used XRF on-site screening to analyze the composite soil samples collected from each of the 588 properties. Samples having XRF readings in excess of 250 ppm lead were submitted to the CLP laboratory for further analysis. Other samples were submitted for laboratory analysis for a variety of reasons, including as part of the 5% of non-elevated samples to be analyzed for quality assurance purposes, as part of the first week of samples shipped for XRF statistical analysis, to obtain more information on samples near an elevated sample location, and to address a concern noted in the field [CDM 2011a]. Over 1,000 samples from 345 properties were submitted to the CLP laboratory.

At the end of the 2010 field season, while the field team was still mobilized, CDM collected samples from 30 non-paved alleys. CDM divided each alley into two to three sampling locations and each sampling location was sampled at two depth intervals (0 to 2 inches and 2 to 6 inches). Five individual sampling points were chosen from each sampling location. The individual sampling points collected were composited into a single sample for each sampling location. A total of 162 composite alley samples were screened using XRF. Only one alley sampling location (AL033-B) had XRF readings above the screening level of 250 ppm for lead. No alley samples were sent for CLP laboratory analysis [CDM 2011a].

Of note, the detection limit of the XRF screening technique for arsenic is relatively high and arsenic concentrations may be masked by high lead concentrations when using this method. For this health consultation, ATSDR chose to evaluate the CLP laboratory data and not the XRF readings because (1) all soil samples with lead over 250 ppm were sent to the CLP laboratory, (2) the CLP laboratory used lower detection limits, and (3) the CLP laboratory had less contaminant interference. However, ATSDR did retain in its analysis the XRF readings for alley

sampling location AL033-B because CLP laboratory data were not available for this location and this location contained elevated levels of arsenic and lead.

5.1.2 Time Critical Removal Action Soil Sampling and Analysis

URS used the XRF results from the CDM RI effort to generate an initial target list of properties for cleanup. During TCRA field work, URS collected grab samples from properties and analyzed them using XRF on-site screening to plan soil excavation (pre-removal samples) and also to guide and confirm final excavation boundaries [URS 2012]. Only on-site XRF screening was used to analyze soil samples collected during the TCRA; soil samples were not submitted for laboratory analysis.

5.1.3 Soil Data Selected for ATSDR Analysis

The CLP laboratory samples were collected and analyzed in accordance with a work plan. According to the RI, the reporting limits met the expected limits, and completeness goals were achieved for number of samples collected and number of sample results acceptable for use [CDM 2011a]. As such, ATSDR considers the arsenic and lead CLP laboratory data to be suitable for the public health evaluation presented in this report.

Through its investigation, ATSDR found the soil removal efforts by URS under the 2010 and 2011 TCRA at each target property did not always correspond directly to the property quadrants defined by CDM in the RI. Additionally, the field XRF readings collected during the TCRA did not always replicate the CLP results documented in the RI. ATSDR used various information sources to connect or match the actual soil removals under the 2010 and 2011 TCRA to the original CLP laboratory results by quadrant. Information sources included CLP sample field notes for each property contained in Appendix B of the RI, CLP laboratory results, and text descriptions and satellite imagery for each property contained in the site removal report [CDM 2011a, URS 2012]. Documentation in the RI and/or site removal report was not always clear enough to allow a definitive match between the actual soil removal area for a property and the previous RI quadrant delineations and associated CLP results. As a result, some uncertainty exists about the status of some of these properties and ATSDR is recommending additional confirmation sampling for them (see Conclusions and Recommendations.)

5.2 Soil Data Screening

ATSDR reviews environmental data to determine whether the maximum detected chemical concentrations are above each chemical's protective health-based comparison values (CVs). A health-based environmental CV is the concentration of a chemical that is not likely to result in harmful health effects over a specified duration of exposure. ATSDR CVs are developed for specific media (air, water, and soil) and for specific durations of exposure (acute, intermediate, and chronic). Of note, CVs are based on default exposure assumptions and do not take into account site-specific information such as bioavailability.

Comparison values used by ATSDR scientists include ATSDR's cancer risk evaluation guides (CREGs) and environmental media evaluation guides (EMEGs). If an ATSDR CV is not available for a particular chemical, ATSDR can also screen environmental data with CVs developed by other sources. These CVs, as well as all other health-based screening criteria,

represent conservative levels of protection; they are not thresholds of toxicity. Although concentrations at or below a CV may reasonably be considered low or no risk, concentrations above a CV will not necessarily be harmful. To ensure that they will protect even the most sensitive populations (such as children or the elderly), CVs are intentionally designed to be much lower, usually by two or three orders of magnitude, than the corresponding no-observed-adverse-effect-levels (NOAELs) or lowest-observed-adverse-effect-levels (LOAELs) on which the CVs were based. Most NOAELs and LOAELs are established in laboratory animal studies; relatively fewer are derived from epidemiologic (chiefly occupational) studies. All ATSDR health-based CVs are non-enforceable and used for screening purposes only.

For this health consultation, ATSDR focused on environmental data for two contaminants in soil: arsenic and lead. ATSDR screens the arsenic data using its chronic child EMEG of 15 ppm³. No ATSDR health-based CV exists for lead; however, EPA recommends a soil screening level (SSL) of 400 ppm for lead in soil at residential properties [EPA 1998].

CDM provided the CLP laboratory data to ATSDR in electronic format [CDM 2011b]. Arsenic and lead sampling results were available for 1,028 samples (including duplicates) from 192 different residential and non-residential properties. Descriptive statistics for the data set are provided in Exhibit 2 in terms of the past, present, and future exposure scenarios previously described and Table 6, Appendix B, provides a definition of the statistical terms used in Exhibit 2. A companion graphic is included in Figure 3, Appendix A, to illustrate the distribution of individual arsenic and lead sample results for each exposure scenario; relevant comparison and screening value guidelines are included in the graphic for reference.

Of note, for remediated properties in the current exposure scenario and for properties proposed to be remediated in the future exposure scenario, ATSDR replaced these properties' sample results for arsenic and lead with values of 9.9 ppm and 21 ppm, respectively. These values correspond to the measured values for the clean topsoil brought in to replace contaminated soil that was removed during the 2010 and 2011 TCRAs [URS 2012]. Three different types of soil were brought in for use as clean backfill. ATSDR selected the arsenic and lead values for the topsoil backfill because the topsoil was placed in the upper foot of the excavation zones, which is the most relevant zone for exposure. Of the three types of backfill used, the topsoil had the highest levels of naturally occurring arsenic and lead [URS 2012].

³ The CREG for arsenic in soil (0.47 ppm) is below background levels, so the recommended soil CV is the EMEG (15 ppm) [ATSDR 2013].

Exhibit 2. Descriptive Statistics for Arsenic and Lead in Soil

	Past		Current*		Future*†	
	Residential	Non-residential	Residential	Non-residential	Residential	Non-residential
Arsenic, in parts per million						
Number of samples (n)	859	169	859	169	859	158†
Minimum	0.5	2.5	0.5	2.5	0.5	2.5
25 th percentile	2.8	13.4	2.8	9.9	2.8	9.9
Median	4.8	29.3	4.8	23.5	5.0	9.9
75 th percentile	18.1	98.6	9.9	60.0	9.9	13.2
Maximum	1,880	3,370	813	2,620	66.7	74.1
Interquartile range	15.3	85.2	7.1	50.1	7.1	3.3
Mean‡	58.3	174	18.0	110	7.4	12.9
Standard deviation	189	431	58.7	298	7.1	9.8
95% confidence interval on the mean‡	45.9–71.3	116–244	14.4–22.0	70.6–157	7.0–7.9	11.5–14.5
Number of samples ≥ 15 ppm arsenic EMEG	242	123	142	102	69	36
Number of properties with one or more samples ≥ 15 ppm	72	28	59	27	36	17
Lead, in parts per million						
Number of samples (n)	859	169	859	169	859	158†
Minimum	1.1	8.0	1.1	8.0	1.1	8.0
25 th percentile	7.9	128.0	7.9	101	7.9	21.0
Median	29.7	273	21.0	180	21.0	21.0
75 th percentile	191	715	91.5	470	33.5	130
Maximum	36,800	20,400	17,700	13,900	384	383
Interquartile range	183	587	83.7	369	25.7	109
Mean‡	446	1,101	135	636	43.5	83.4
Standard deviation	1,813	2,632	687	1,535	66.3	83.5
95% confidence interval on the mean‡	340–574	761–1521	98.1–188	436–891	39.3–48.1	71.5–96.6
Number of samples ≥ 400 ppm lead SSL	130	65	52	47	0	0
Number of properties with one or more samples ≥ 400 ppm	49	18	32	16	0	0

Data source: CDM 2011b, URS 2012.

* In the current and future exposure scenario calculations, sample results for remediated properties and properties proposed for remediation or re-testing/remediation (Tables 3A and 3B, Appendix B) were replaced with values for arsenic and lead of 9.9 ppm and 21 ppm, respectively. These values correspond to the measured values for the clean topsoil fill brought in to replace contaminated soil that was removed [URS 2012].

† All quadrant data for non-residential property RY627 are excluded from summary statistics for the future scenario because ATSDR assumes institutional controls will be implemented at this property, as specified in the record of decision for the site [EPA 2012a].

‡ Estimates for the mean and 95% confidence interval for the mean were obtained using bootstrap methods.

EMEG environmental media evaluation guide

ppm part per million

SSL soil screening level

In Exhibit 3, maximum detected concentrations for arsenic and lead are summarized by exposure scenario and sample depth. Details on the data set composition for each exposure scenario are provided in subsequent report subsections.

Exhibit 3. Maximum Detected Arsenic and Lead Concentrations in Soil by Exposure Scenario and Sample Depth							
Contaminant	Sample Depth Range (inches)	Maximum Contaminant Concentrations (ppm)					
		Past Scenario*		Current Scenario*		Future Scenario*†	
		Residential	Non-residential	Residential	Non-residential	Residential	Non-residential
Arsenic	0–2	1,750 RY303-D	2,620 RY627-B	737 RY036-D	2,620* RY627-B	50.9 RY007-D	52.2 RY386-C
	2–6	1,880‡ RY506-F	1,500 RY289-G	373 RY021-E	1,500 RY289-G	52.7 RY046-D	34.2 RY082-A
	6–12	1,440 RY086-D	3,370 RY118-P	813 RY240-D	655 RY112-A	66.7 RY015-B	74.1 RY112-E
Lead	0–2	7,530 RY086-D	13,900 RY402-A	2,660 RY257-C	13,900 RY402-A	378 RY483-A	333 RY100-C
	2–6	36,800 RY506-F	7,080 RY289-G	17,700 RY043-B	7,080 RY289-G	296 RY483-A	295 RY412-D
	6–12	17,800 RY600-A	20,400 RY115-A	5,540 RY240-D	4,740 RY112-A	384 RY387-E	383 RY112-E

Data source: CDM 2011b, URS 2012

* Within each exposure scenario, the highest concentration is highlighted in bold type. The corresponding sample location (property code, “RYxxx”, and quadrant, “-x”) are listed in gray type below each concentration.

† All quadrant data for non-residential property RY627 are excluded from consideration for the future scenario because ATSDR assumes institutional controls will be implemented at this property, as specified in the record of decision for the site [EPA 2012a].

‡ Sample was diluted during analysis.

ppm parts per million

As part of ATSDR’s screening analysis, sample results for residential versus non-residential properties were compared using the Wilcoxon-Mann-Whitney two-sample rank-sum test. For both arsenic and lead, the difference between residential and non-residential sample results was statistically significant in all exposure scenarios (p-value < 2.2E-16 for all cases, which is below the cutoff significance level of 0.05). A visual illustration of the arsenic and lead sample distributions shown in Figure 3, Appendix A, clearly shows that the non-residential properties typically have higher concentrations than the residential properties for all exposure scenarios.

5.2.1 Past Soil Levels

ATSDR considers past levels to be those arsenic and lead levels detected in soil prior to the 2010 and 2011 TCRAs; that is, the complete CLP laboratory data set of arsenic and lead levels from the 2009 and 2010 sampling events. As previously stated, arsenic and lead sampling results were available for 1,028 samples, which included duplicates. For the past scenario, 365 samples were

equal to or exceeded the ATSDR chronic child EMEG of 15 ppm arsenic and 195 samples were equal to or exceeded the EPA SSL of 400 ppm lead (see Exhibit 2.)

Of the 365 samples equal to or above arsenic's chronic child EMEG, 242 samples were from residential properties and 123 were non-residential properties. Of the 195 samples equal to or above lead's SSL, 130 samples were from residential properties and 65 were from non-residential properties. Tables 1 and 2, Appendix B, contain the arsenic and lead concentrations for residential and non-residential properties, respectively, that had at least one quadrant equal to or exceeding either the arsenic CV or the lead CV, or both, prior to the 2010 and 2011 TCRAs. For the three depth intervals, Exhibit 3 summarizes the maximum levels of arsenic and lead from residential and non-residential properties prior to the TCRAs (past scenario).

Only one alley sampling location (AL033-B) had XRF readings above 250 ppm for lead. The location AL033-B is in a commercial area of town and there are no nearby residential properties. The arsenic XRF readings were 250 ppm (0 to 2 inch depth) and 1,031 ppm (2 to 6 inch depth), and the lead XRF readings were 2,240 ppm (0 to 2 inch depth) and 5,215 ppm (2 to 6 inch depth). These XRF readings exceed CVs for arsenic and lead.

5.2.2 Current Soil Levels

As stated previously, EPA conducted TCRAs in 2010 and 2011 to remove soils of those properties in Superior that exceeded 400 ppm of arsenic or 3,000 ppm of lead. The quadrants included in EPA's 2010 and 2011 TCRAs are provided in Table 1 (residential quadrants) and Table 2 (non-residential quadrants), Appendix B. ATSDR obtained this list of quadrants and their cleanup status by reconciling information from the RI [CDM 2011a], FS [CDM 2011d], and Site Removal [URS 2012] reports. Also included in Table 2, Appendix B, is the Forest Service property RY289-G. Although the RI indicates a small area of RY289-G was remediated, the FS lists both quadrants RY289-F and RY289-G for potential remediation [CDM 2011a, CDM 2011d].

To estimate current arsenic and lead levels in Superior soil, ATSDR first removed the sampling data from the quadrants URS remediated in 2010 and 2011 from the arsenic and lead CLP laboratory data set because it was assumed these quadrants contain clean soil fill material following the 2010 and 2011 TCRAs. ATSDR replaced those sampling data values that had been removed with the measured values for the clean topsoil fill. ATSDR screened the remaining data to determine how many samples continue to exceed CVs.

Of note, uncertainty exists about the status of a number of residential and non-residential property quadrants because (1) previous CLP results were elevated but results from field XRF screening during TCRA events could not replicate the CLP results and therefore no removal occurred during TCRA events, (2) report documentation was not clear enough to allow ATSDR to definitively match the actual soil removal area with the previous RI quadrant delineations and associated CLP results, or (3) site documentation indicates discrepancies, such as one document listing the quadrant for potential remediation and another indicating remediation already occurred. In these cases, ATSDR retained the CLP laboratory data for these property quadrants for the current scenario. The affected residential property quadrants are RY030-E, RY043-B, RY086-C, RY091-E, RY095-B, RY095-C, RY101-A, RY101-E, RY102-B, and RY240-D. The

affected non-residential property quadrants are RY112-A, RY118-O, RY146-B, RY289-F, RY289-G, and RY398-B.

Following the TCRAs, 244 samples (142 residential samples and 102 non-residential samples) remain equal to or above arsenic's chronic child EMEG. Ninety-nine samples (52 residential samples and 47 non-residential samples) remain above lead's SSL (see Exhibit 2). For the current exposure scenario, the distribution of arsenic and lead sample results above their respective comparison and reference screening values is visually illustrated in Figures 3, 4a, and 5a, Appendix A. For the three depth intervals, Exhibit 3 shows the maximum levels of arsenic and lead from residential and non-residential properties following the 2010 and 2011 TCRAs (current scenario).

In addition, because alley sampling location AL033-B was not included in the TCRAs, the arsenic and lead concentrations noted in Section 5.2.1 remain above CVs.

5.2.3 Future Soil Levels

ATSDR assumes the final remedy selected in the ROD (Alternative 4) will include remediation of the quadrants outlined in Exhibits 7-7 and 7-8 of the ROD [EPA 2012a]. The quadrants identified in the ROD for remediation in the future (starting in the summer of 2013) are listed in Table 3A, Appendix B. Table 3B in Appendix B provides a list of quadrants where ATSDR recommends follow up sampling because uncertainty exists about the status of these quadrants. With one exception, all of the properties listed in Table 3B are identified in the ROD (Exhibits 7-7 or 7-8) as having had or still needing remediation. The exception in Table 3B is non-residential property quadrant RY146-B. This quadrant had CLP results for arsenic (425 ppm) that exceeded the remediation action level of 100 ppm, but was not listed in the ROD for remediation.

To estimate future arsenic and lead levels in Superior soil, ATSDR first removed the sampling data from the quadrants listed in Tables 3A and 3B, Appendix B, from the arsenic and lead CLP laboratory data set because ATSDR assumes these quadrants will either be remediated under Alternative 4, or be re-tested and then remediated if needed, thereby eliminating future exposures. ATSDR replaced those sampling data values that had been removed with the measured values for the clean topsoil fill. ATSDR screened the resulting data set to determine how many samples continue to exceed CVs. Note that the quadrant data for non-residential property RY627 were excluded from the analysis; the ROD for the site acknowledges that high levels of arsenic and lead will remain at this property and that institutional controls are needed to protect human health [EPA 2012a].

Assuming the quadrants in Tables 3A and 3B, Appendix B, are remediated (excluding RY627 quadrants), 105 samples (69 residential samples and 36 non-residential samples) will remain equal to or above arsenic's chronic child EMEG. There will be no samples that remain equal to or above lead's SSL (see Exhibit 2). Tables 4 and 5, Appendix B, provide the arsenic and lead levels, as well as the sampling depths, of those residential and non-residential quadrants that are equal to or exceed CVs for the future exposure scenario. For the future exposure scenario, the distribution of arsenic and lead sample results above their respective comparison and reference screening values is visually illustrated in Figures 3, 4b, and 5b, Appendix A. For the three depth intervals, Exhibit 3 show the maximum levels of arsenic and lead from residential and non-residential properties following proposed additional remediation in Superior (future scenario).

In addition, because alley sampling location AL033-B was not included in the list of potential properties to be remediated, the arsenic and lead concentrations noted in Section 5.2.1 remain above CVs.

6.0 Discussion

In this section, ATSDR addresses the question of whether exposure to arsenic and lead at the concentrations detected 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 additional factors. These factors include

- the concentration (how much) of the chemical the person was exposed to,
- the amount of time the person was exposed (how long), and
- the way 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 individual's physiologic response to a chemical contaminant and any harmful health effects the individual may suffer as a result of the chemical exposure.

As part of its evaluation, ATSDR typically derives exposure doses for children and adults. Estimating an exposure dose requires identifying how much, how often, and how long a person may come in contact with some concentration of the contaminant in a specific medium (like soil). Exposure doses help ATSDR determine the likelihood that exposure to a chemical might be associated with harmful health effects. Of note, ATSDR typically uses *maximum* chemical concentrations to calculate doses for acute exposures and *average* (mean) chemical concentrations to calculate doses for chronic exposures. However, for this health consultation, ATSDR did not calculate average concentrations and used only maximum concentrations in its dose calculations. The reason for this is because CLP laboratory data were available for many properties from only one or two quadrants, which prevented calculation of a yard-wide average for each depth range. Using the maximum single value is more scientifically sound and more protective than taking an average of a very small number of values.

Two key steps in ATSDR's analysis involve (1) comparing the estimated site-specific exposure doses with observed effect levels reported in critical studies and (2) carefully considering study parameters in the context of site exposures [ATSDR 2005]. This analysis requires the examination and interpretation of reliable substance-specific health effects data. This includes reviews of epidemiologic (human) and experimental (animal) studies. These studies are characterized within ATSDR's toxicological chemical-specific profiles. Each peer-reviewed chemical profile identifies and reviews the key literature that describes a hazardous substance's toxicological properties. ATSDR also reviews more recently released studies discussed in the scientific literature that may not have been captured in our toxicological profiles to ensure that our public health evaluations are based on the most current scientific knowledge.

Of note, substance-specific health effects data are generally expressed in terms of “ingested dose” rather than “absorbed dose.” With regard to heavy metal exposure in soil, however, the distinction between ingested dose and absorbed dose is important. In general, ingestion of a metal in contaminated soil may be absorbed into the body to a much lesser extent than when the metal is ingested in drinking water or food.

Overall, assessing the relevance of available epidemiologic and experimental studies with respect to site-specific exposures requires both technical expertise and professional judgment. Because of uncertainties regarding exposure conditions and the harmful effects associated with environmental levels of exposure, definitive answers about whether health effects actually will or will not occur are not always possible. However, providing a framework that puts site-specific exposures and the potential for harm in perspective is possible and is one of the primary goals of ATSDR’s public health evaluation process [ATSDR 2005].

In the following text, ATSDR provides a summary of the relevant epidemiologic and experimental information for arsenic and lead. ATSDR then provides its public health evaluation of each chemical. For its analysis, ATSDR considers past, current, and potential future exposures to arsenic and lead in soil.

6.1 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). Sometimes, the specific form of arsenic present in the environment is not determined. Therefore, what form of arsenic a person may be exposed to is not always known.

Most simple organic forms of arsenic are less harmful than the inorganic forms [ATSDR 2007a]. Once in the environment, arsenic cannot be destroyed; it can only change forms or become attached to or separated from particles (e.g., by reacting with oxygen or by the action of bacteria in soil). Some forms of arsenic may be so tightly attached to particles or embedded in minerals that they are not taken up by plants and animals.

Arsenic is released to the environment through natural sources such as wind-blown soil and volcanic eruptions. However, anthropogenic (man-made) sources of arsenic release much higher amounts of arsenic than natural sources. These anthropogenic sources include nonferrous metal mining and smelting, pesticide application, coal combustion, wood combustion, and waste incineration. About 90% of all commercially produced arsenic is used to pressure-treat wood [ATSDR 2007a]. In the past, arsenic was widely used as a pesticide; in fact, some organic arsenic compounds are still used in pesticides. EPA states that pesticide manufacturers have voluntarily phased out certain chromated copper arsenate (CCA) use for wood products around the home and in children’s play areas; effective December 31, 2003, no wood treater or manufacturer may treat wood with CCA for residential uses, with certain exceptions [EPA 2011b].

People may be exposed through incidentally ingesting soil containing arsenic. Arsenic concentrations for uncontaminated soils generally range from 1–40 ppm, with a mean of 5 ppm

[ATSDR 2007a]. Arsenic concentrations in soils from various countries range from 0.1 to 50 ppm and can vary widely among geographic regions. The U.S. Geological Survey (USGS) reports a mean of 7.2 ppm and a range of less than 0.1–97 ppm in the United States [Shacklette and Boerngen 1984]. For Montana, MDEQ reports a mean of 29 ppm and a range of 0.94–187 ppm [MDEQ 2005]. Higher arsenic levels may be found in the vicinity of arsenic-rich geological deposits, some mining and smelting sites, or agricultural areas where arsenic pesticides had been applied in the past. For example, arsenic concentrations up to 27,000 ppm were reported in soils contaminated with mine or smelter wastes [EPA 1982].

Incidental ingestion of arsenic-contaminated soil is one way that arsenic can enter the body. Dermal exposure to arsenic is usually not of concern because only a small amount will pass through skin and into the body (4.5% of inorganic arsenic in soil) [Wester et al. 1993]. The metabolism of inorganic arsenic has been extensively studied in humans and animals. Several studies in humans indicate that arsenic is well absorbed across the gastrointestinal tract (approximately 95% absorption for inorganic arsenic compounds and 75–85% for organic arsenic compounds) [Bettley and O'Shea 1975, Buchet et al. 1981, Marafante et al. 1987, Zheng et al. 2002]. Once in the body, the liver changes (i.e., through methylation) some of the inorganic arsenic to less harmful organic forms that are more readily excreted in urine. Most forms of organic arsenic appear to undergo little metabolism. Both inorganic and organic forms of arsenic leave the body in urine. It is estimated that more than 75% of the absorbed arsenic dose is excreted in urine [Marcus and Rispin 1988]. Studies have shown that 45–85% of arsenic is eliminated within one to three days [Apostoli et al. 1999, Buchet et al. 1981, Crecelius 1977, Tam et al. 1979]. However, there appears to be an upper-dose limit to this mechanism working successfully to reduce arsenic toxicity [ATSDR 2007a].

As noted above, water-soluble forms of inorganic arsenic are well absorbed. Ingesting less soluble forms of arsenic results in reduced absorption. Studies in laboratory animals show that arsenic in soil is only one-half to one-tenth as bioavailable as soluble arsenic forms [Casteel et al. 1997, Freeman et al. 1993, Freeman et al. 1995, Groen et al. 1994, Rodriguez et al. 1999]. In one study, approximately 80% of the arsenic from ingested soil was eliminated in the feces compared with 50% of the soluble oral dose [Freeman et al. 1993]. The bioavailability of arsenic in soil may be reduced due to low solubility and inaccessibility [Davis et al. 1992]. Most of the bioavailable arsenic in water and soil is expected to be present as inorganic arsenic (trivalent arsenic and pentavalent arsenic, specifically) [Health Canada 1993].

ATSDR's acute oral minimal risk level⁴ (MRL) (0.005 milligrams per kilogram per day (mg/kg/day)) is based on a study in which 220 people in Japan were exposed to arsenic contaminated soy sauce for a 2–3 week period. The dose was estimated to be *0.05 mg/kg/day*, which is considered the LOAEL. Facial edema and gastrointestinal symptoms (nausea, vomiting, and diarrhea) were considered to be the critical effects seen at this dose [Mizuta et al. 1956]. The MRL is further supported by the case of a man and woman in upstate New York who experienced gastrointestinal symptoms after drinking arsenic-tainted water at an estimated dose of 0.05 mg/kg/day [Franzblau and Lilis 1989].

The chronic oral MRL (0.0003 mg/kg/day) is based on a study in which a large number of farmers (both male and female) were exposed to high levels of arsenic in well water in Taiwan.

⁴ The acute oral MRL is considered provisional because it is based on a serious LOAEL.

EPA's oral reference dose (RfD) is also 0.0003 mg/kg/day [EPA 2008]. A clear dose-response relationship was observed for characteristic skin lesions. A control group consisting of 17,000 people was exposed to 0.0008 mg/kg/day and did not experience adverse health effects. This is considered to be the NOAEL. Hyperpigmentation and keratosis of the skin were reported in farmers exposed to 0.014 mg/kg/day (less serious LOAEL). Those exposed to 0.038–0.065 mg/kg/day experienced an increased incidence of dermal lesions [Tseng et al. 1968, Tseng 1977]. The MRL is supported by a number of well-conducted epidemiological studies that identify reliable NOAELs and LOAELs for dermal effects [Borgoño and Greiber 1972, Cebrián et al. 1983, EPA 1981, Guha Mazumder et al. 1988, Haque et al. 2003, Harrington et al. 1978, Valentine et al. 1985, Zaldívar 1974]. Collectively, these studies indicate that the threshold dose for dermal effects (ex., hyperpigmentation and hyperkeratosis) is approximately *0.002 mg/kg/day*.

The Department of Health and Human Services (DHHS), the International Agency for Research on Cancer (IARC), and EPA have all determined that inorganic arsenic is carcinogenic to humans. There is convincing evidence from a large number of epidemiological studies and case reports that ingestion of inorganic arsenic increases the risk of developing skin cancer [Alain et al. 1993, Beane Freeman et al. 2004, Bickley and Papa 1989, Cebrián et al. 1983, Chen et al. 2003, Hauptert et al. 1996, Hsueh et al. 1995, Lewis et al. 1999, Lühtrath 1983, Mitra et al. 2004, Morris et al. 1974, Sommers and McManus 1953, Tay and Seah 1975, Tsai et al. 1998, Tsai et al. 1999, Tseng 1977, Tseng et al. 1968, Zaldívar 1974, Zaldívar et al. 1981]. A report by the National Research Council suggests that the risks calculated based on increases in incidence of lung and bladder cancers may be greater than those calculated based on incidences of skin cancer [NRC 2001]. In 2010, EPA proposed a revised cancer slope factor (CSF) for inorganic arsenic based on a review of the scientific basis supporting the human health cancer hazard and dose-response assessment of inorganic arsenic [EPA 2010].

For this health consultation, ATSDR derived exposure doses for Superior residents exposed to arsenic in soil based on the following equation.

Exhibit 4: Exposure Dose Equation for Ingestion of Soil

$$D = \frac{C \times IR \times EF \times AF \times CF}{BW}$$

where,

D	=	exposure dose in milligrams per kilogram per day (mg/kg/day)
C	=	chemical concentration in milligrams per kilogram (mg/kg)
IR	=	intake rate in milligrams per day (mg/day)
EF	=	exposure factor (unitless)
AF	=	bioavailability factor
CF	=	conversion factor, 1×10^{-6} kilograms/milligram (kg/mg)
BW	=	body weight in kilograms (kg)

In the absence of complete exposure-specific information regarding soil exposures, ATSDR applied several conservative exposure assumptions to define site-specific exposures as accurately as possible. These conservative assumptions would be expected to overestimate the actual risk associated with exposures that may have occurred. Specifically, ATSDR estimated exposure doses using the following general assumptions and default intake rates for exposure through ingestion of soil:

- The intake rate for a child was assumed to be 200 mg/day and an adult was assumed to be 100 mg/day.
- The exposure factor was assumed to be 1, representing daily exposure.
- The body weight of a child was assumed to be 16 kg and an adult was assumed to be 70 kg.
- The bioavailability was assumed to be 60%.

In the following text, ATSDR provides a brief description of the exposure scenarios and then compares the estimated, site-specific arsenic exposure doses with the observed effect levels reported in the critical studies.

6.1.1 Past Arsenic Exposures

ATSDR considers past arsenic exposure to be exposure to the arsenic levels detected in soil prior to the 2010 and 2011 TCRAs. Of the 1,028 samples collected from residential and non-residential properties in Superior as part of the RI, 663 samples (or about 65%) were below arsenic's chronic child EMEG of 15 ppm (Figure 3, Appendix A). Concentrations at or below a health-based comparison value may reasonably be considered low or no risk. Therefore, for most residential and non-residential properties, past exposures to arsenic in soil were not at levels of health concern.

Of the 1,028 samples analyzed, 365 samples exceeded arsenic's chronic child EMEG (see Exhibit 2), indicating further evaluation is needed to determine whether arsenic exposures at these sampling locations were of public health concern. For the maximum arsenic concentrations provided in Exhibit 3, ATSDR calculated exposure doses for children and adults (see Exhibit 5).

Exhibit 5. Arsenic Exposure Doses prior to the 2010 and 2011 TCRAs									
Residential				Non-Residential				Start Depth (inches)	End Depth (inches)
Sample Location	Conc. (ppm)	Child Dose (mg/kg/day)	Adult Dose (mg/kg/day)	Sample Location	Conc. (ppm)	Child Dose (mg/kg/day)	Adult Dose (mg/kg/day)		
RY303-D	1,750	0.01	0.002	RY627-B	2,620	0.02	0.002	0	2
RY506-F	1,880	0.01	0.002	RY289-G	1,500	0.01	0.001	2	6
RY086-D	1,440	0.01	0.001	RY118-P	3,370	0.03	0.003	6	12

Conc. concentration

mg/kg milligrams per kilogram

ppm parts per million

TCRA time-critical removal action

Prior to the 2010 and 2011 TCRAs, children's exposure doses based on the maximum arsenic levels in soil at both residential and non-residential properties were at a level of potential public health concern for acute (short-term) exposures because the estimated doses were approaching arsenic's acute LOAEL of 0.05 mg/kg/day. Prior to removal actions, if children lived at or visited these residential and non-residential areas of elevated arsenic soil concentrations and participated in contact-intense activities, it is plausible that they may have experienced transient harmful effects (nausea, vomiting, and diarrhea) following their short-term exposures.

For chronic exposures (i.e., those lasting a year or longer), children's exposure doses based on the maximum arsenic levels in soil at both residential and non-residential properties exceeded the threshold dose for dermal effects of approximately 0.002 mg/kg/day by about an order of magnitude (or about 10 times). ATSDR also notes that children's exposure doses at alley location AL033-B exceeded this threshold dose; however, ATSDR considers it unlikely that chronic exposure was occurring at this alley location. In addition, adult exposure doses based on the maximum arsenic levels in soil at both residential and non-residential properties were at and approaching this threshold dose. Of note, it is more likely that children and adults will come into frequent, repeated contact with residential soil; that is, the soil in a yard that contains a garden or play area. With the exception of non-residential properties like schools, it is less likely Superior residents will be exposed repeatedly, day-after-day, to non-residential soil. Overall, ATSDR considers chronic exposure in the past to elevated arsenic concentrations of potential public health concern for non-cancerous health effects, particularly at residential properties.

As part of its evaluation, ATSDR also calculated cancer risk estimates using the EPA arsenic oral CSF of $1.5 \text{ (mg/kg/day)}^{-1}$. Under quantitative cancer risk assessment methodology, cancer risk estimates are expressed as a probability (see Exhibit 6).

Exhibit 6: Cancer Risk Equation

$$\text{Cancer Risk} = D \times \text{CSF}$$

where,

D = adult exposure dose in milligrams per kilogram per day (mg/kg/day)
CSF = cancer slope factor in (mg/kg/day)⁻¹

Cancer risk estimates are expressed as the proportion of a population that may be affected by a carcinogen during a lifetime of exposure (24 hours/day, 365 days/year, for life). For example, an estimated cancer risk of 2×10^{-6} represents potentially two excess cancer cases in a population of one million over a lifetime of continuous exposure.

With regard to carcinogenic risk, most properties were below a level of potential concern for cancer. However, the maximum levels of arsenic in soil for some properties exceeded a cancer risk estimate of 1×10^{-4} (one case in ten thousand persons), which ATSDR typically considers a level of concern for lifetime cancer risk [ATSDR 2004]. Of note though, the harmful health effects observed in the studies on arsenic ingestion involved daily, long-term ingestion of elevated arsenic levels in drinking water. It is not likely that ingestion of large amounts of soil at the maximum levels detected at Superior properties in the past would occur 365 days a year for life, particularly at the non-residential properties and the alley. Therefore, ATSDR considers arsenic exposures in the past to represent a low cancer risk.

6.1.2 Current Arsenic Exposures

ATSDR considers current arsenic exposure to be exposure to the arsenic levels detected in soil following the 2010 and 2011 TCRAs. The TCRAs removed some of the most elevated concentrations of arsenic from properties in Superior. Following removal efforts, about 76% of the arsenic samples are below arsenic's chronic child EMEG. Therefore, for most residential and non-residential properties, current exposures to arsenic in soil are not at levels of health concern.

Following the TCRAs, 244 samples continue to exceed arsenic's chronic child EMEG, indicating further evaluation is needed to determine whether arsenic exposures at these sampling locations are of public health concern. For the maximum arsenic concentrations provided in Exhibit 3, ATSDR calculated exposure doses for children and adults (see Exhibit 7).

Exhibit 7. Arsenic Exposure Doses following the 2010 and 2011 TCRAs									
Residential				Non-Residential				Start Depth (inches)	End Depth (inches)
Sample Location	Conc. (ppm)	Child Dose (mg/kg/day)	Adult Dose (mg/kg/day)	Sample Location	Conc. (ppm)	Child Dose (mg/kg/day)	Adult Dose (mg/kg/day)		
RY036-D	737	0.006	0.0006	RY627-B	2,620	0.02	0.002	0	2
RY021-E	373	0.003	0.0003	RY289-G	1,500	0.01	0.001	2	6
RY240-D	813	0.006	0.0007	RY112-A	655	0.005	0.0006	6	12

Conc. concentration
 mg/kg milligrams per kilogram
 ppm parts per million
 TCRA time-critical removal action

Following the TCRAs, children's exposure doses based on the maximum arsenic levels in soil at non-residential properties continue to be of potential public health concern for acute (short-term) exposures because the estimated doses approach arsenic's acute LOAEL of 0.05 mg/kg/day. If children visit these non-residential areas of elevated arsenic soil concentrations and participated in contact-intense activities, it is plausible that they may experience transient harmful effects (nausea, vomiting, and diarrhea) following their short-term exposures.

For chronic exposures, children's exposure doses based on the maximum arsenic levels in soil at residential and non-residential properties exceed the threshold dose for dermal effects of approximately 0.002 mg/kg/day. As stated previously though, it is unlikely children will be exposed repeatedly, day-after-day, to non-residential soil. ATSDR also notes that children's exposure doses at alley location AL033-B continue to exceed this threshold dose; however, as stated previously, ATSDR considers it unlikely that chronic exposure is occurring at this location. In addition, adult exposure doses based on the maximum arsenic levels in soil at non-residential properties were at and approaching this threshold dose. Overall, ATSDR considers current chronic exposure to elevated arsenic concentrations of potential public health concern for non-cancerous health effects, particularly for children at residential properties.

With regard to carcinogenic risk, most properties are currently below a level of potential concern for cancer. However, the maximum levels of arsenic in soil at some properties continue to exceed a cancer risk estimate of 1×10^{-4} . Yet, ATSDR does not consider ingestion of large amounts of soil at the maximum levels detected at Superior properties to likely occur 365 days a year for life. Therefore, ATSDR considers current arsenic exposures to represent a low cancer risk.

Residents who know elevated arsenic levels are present in their yard can monitor their children outdoors to prevent their children from intentionally or inadvertently eating soil. Additional activities residents may do to reduce exposure to contaminated soil are discussed in Appendix C.

6.1.3 Future Arsenic Exposures

ATSDR considers future arsenic exposure to be exposure to the arsenic levels detected in soil following proposed future remediation efforts. As stated previously, Alternative 4 was chosen as the final remedy. To estimate future arsenic levels, ATSDR assumed the quadrants listed in Tables 3A and 3B, Appendix B, would be remediated, or re-tested and remediated if needed, (excluding RY627 quadrants, as noted previously), thereby eliminating future exposures. The ROD for the site acknowledges that high levels of arsenic and lead will remain in the soil at property RY627 and specifies that institutional controls are necessary to protect human health. Tables 4 and 5, Appendix B, show the concentrations that will exceed CVs for the future scenario. Following proposed future removal efforts, about 90% of the arsenic samples will be below arsenic's chronic child EMEG (excludes non-residential property RY627; see Exhibit 2). Therefore, for most residential and non-residential properties, estimated future exposures to arsenic in soil would not be at levels of health concern.

After remediation with Alternative 4, 105 samples continue to exceed arsenic's chronic child EMEG, indicating further evaluation is needed to determine whether arsenic exposures at these sampling locations will be of public health concern. For the maximum arsenic concentrations provided in Exhibit 3, ATSDR calculated exposure doses for children and adults (see Exhibit 8).

Exhibit 8. Arsenic Exposure Doses following Proposed Future Remediation									
Residential				Non-Residential				Start Depth (inches)	End Depth (inches)
Sample Location	Conc. (ppm)	Child Dose (mg/kg/day)	Adult Dose (mg/kg/day)	Sample Location	Conc. (ppm)	Child Dose (mg/kg/day)	Adult Dose (mg/kg/day)		
RY007-D	50.9	0.0004	0.00004	RY386-C	52.2	0.0004	0.00004	0	2
RY046-D	52.7	0.0004	0.00005	RY082-A	34.2	0.0003	0.00003	2	6
RY015-B	66.7	0.0005	0.00006	RY112-E	74.1	0.0006	0.00006	6	12

Conc. concentration
 mg/kg milligrams per kilogram
 ppm parts per million
 TCRA time-critical removal action

After proposed future remediation, children's and adult's exposure doses based on the maximum arsenic levels in soil at residential and non-residential properties are not of public health concern for acute exposures because the estimated doses are two to three orders of magnitude (or about 100 to 1,000 times) below arsenic's acute LOAEL of 0.05 mg/kg/day. Transient harmful effects (nausea, vomiting, and diarrhea) following short-term exposures would *not* be expected to occur in the future based on the arsenic levels that will remain in soil following removal efforts under Alternative 4.

For chronic exposures, children's and adult's exposure doses based on the maximum arsenic levels in soil at both residential and non-residential properties are not of public health concern because the estimated doses are one to two orders of magnitude (or about 10 to 100 times) below

arsenic's threshold dose for dermal effects of approximately 0.002 mg/kg/day. One exception is alley location AL033-B where children's exposure doses are at and exceeding this threshold dose. As stated previously, ATSDR considers it unlikely that chronic exposure would be occurring at alley location AL033-B. The visual illustration of the arsenic sample distributions shown in Figure 3, Appendix B, clearly shows that the non-residential properties have higher concentrations than the residential properties for all exposure scenarios, including the future scenario. Children are more likely to be exposed chronically to soil in residential yards than soil in non-residential areas of town. Overall, chronic exposure to the arsenic concentrations likely to be present in the future are not expected to be of public health concern for non-cancerous health effects provided that the properties outlined in the ROD and listed in Tables 3A and 3B, Appendix B,

- are remediated (Table 3A),
- are sampled to verify arsenic and lead are below action levels at selected quadrants (Table 3B) and remediated if needed, and
- have institutional controls implemented as appropriate (non-residential property RY627.)

With regard to carcinogenic risk, most properties are currently below a level of potential concern for cancer. Although the maximum levels of arsenic in soil at a few locations continue to exceed a cancer risk estimate of 1×10^{-4} , these locations include alley location AL033-B. Further, ATSDR does not consider ingestion of large amounts of soil at the maximum levels detected at Superior properties like the alley to likely occur 365 days a year for life. Therefore, ATSDR considers future arsenic exposures to represent a very low cancer risk.

6.2 Lead

Lead is a naturally occurring bluish-gray metal found in the Earth's crust at about 15–20 ppm. Lead rarely occurs in its elemental state, but rather in its +2 oxidation state in various ores throughout the earth. The most important lead containing ores are galena, anglesite, and cerussite. The largest industrial use of lead today is for the production of lead batteries, largely used in the automobile industry. Other uses of lead include the production of lead alloys, use in soldering materials, shielding for x-ray machines, and in the manufacture of corrosion and acid resistant materials used in the building industry. Today, lead can be found in all parts of our environment [ATSDR 2007b].

The use of lead as a gasoline additive has been gradually phased out and was completely banned by 1995 in the United States. Its use in paints was banned in 1978. However, human exposure to lead continues because lead does not degrade in the environment. Leaded paint is still prevalent in many older homes in the United States, and peeling or flaking paint contributes to indoor and outdoor dust levels.

Lead can affect almost every organ and system in the body, although the main target for lead toxicity is the nervous system. Exposure to high amounts of lead resulting in blood lead levels (BLLs) of 100–120 µg/dL in adults or 70–100 µg/dL in children can induce encephalopathy, a general term that describes various diseases that affect brain function. Symptoms develop following prolonged exposure and include dullness, irritability, poor attention span, epigastric

pain, constipation, vomiting, convulsions, coma, and death [Chisolm 1962, Chisolm 1965, Chisolm and Harrison 1956, Kehoe 1961, Kumar et al. 1987].

Children are more vulnerable to lead poisoning than adults. A child who swallows large amounts of lead may develop blood anemia, severe stomachache, muscle weakness, and brain damage. Unborn children can be exposed to lead through their mothers. Harmful health effects may include premature births, smaller babies, decreased mental ability, learning difficulties, and reduced growth in young children [ATSDR 2007b].

In general, the level of lead in a person's blood gives a good indication of recent exposure to lead and also correlates well with adverse health effects. Previously, the Centers for Disease Control and Prevention (CDC) responded to the accumulated evidence of adverse effects associated with lead exposures by lowering the BLL of concern from 60 $\mu\text{g}/\text{dL}$ blood to 25 $\mu\text{g}/\text{dL}$. In 1991, CDC recommended lowering the level for individual intervention to 15 $\mu\text{g}/\text{dL}$ and implementing community-wide primary lead poisoning prevention activities in areas where many children have BLLs greater than 10 $\mu\text{g}/\text{dL}$. However, this level, which was originally intended to trigger community-wide prevention activities, has been misinterpreted frequently as a definitive toxicological threshold. There is growing evidence of IQ deficits in children with blood lead levels below 10 $\mu\text{g}/\text{dL}$. Effects at BLLs less than 10 $\mu\text{g}/\text{dL}$ are also reported for other behavioral domains, particularly attention-related behaviors and academic achievement. New findings suggest that the adverse health effects of BLLs less than 10 $\mu\text{g}/\text{dL}$ in children extend beyond cognitive function to include cardiovascular, immunological, and endocrine effects. Additionally, such effects do not appear to be confined to lower socioeconomic status populations [ACCLPP 2012].

In January 2012, CDC's Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended that CDC adopt the 97.5 percentile for children 1 to 5 years old as the reference value for designating elevated BLLs in children. The 97.5 percentile currently is 5 $\mu\text{g}/\text{dL}$ [ACCLPP 2012]. This new value means more children will be identified as having lead exposures earlier and parents, doctors, public health officials, and communities can take action earlier [CDC 2012].

Because there is no clear threshold for some of the more sensitive health effects, no guidelines for a low or no risk dose of lead intake have been established. EPA has no RfD and ATSDR has no MRL to serve as a low or no risk oral dose below which adverse health effects are unlikely to occur. However, lead cannot be entirely eliminated from the environment so there will always be some residual levels following cleanup actions at lead-contaminated sites and children may be exposed to non-site-specific sources of lead (e.g., lead-based paint in homes built before 1978.)

Because neither ATSDR nor EPA has developed an MRL or RfD for exposure to lead, the usual approach of estimating exposure to an environmental contaminant and then comparing this dose to a health guideline cannot be used. Instead, environmental data are used to predict BLLs in order to determine if any follow up action is needed. For this health consultation, ATSDR used two approaches to predict BLLs.

1. ATSDR evaluated exposure to lead by using a biological model that predicts a blood lead concentration that would result from exposure to environmental lead contamination. Specifically, ATSDR used EPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK).

2. ATSDR used an integrated regression analysis approach to evaluate lead exposures. This approach utilizes slope values from select studies that correlate environmental exposure to BLLs. This analysis approach is outdated and is not the first choice method any longer, but it was one of the methods used in the previously released 2010 PHA for this site. It is thus presented here for the sake of comparison to the 2010 PHA findings.

For the biological model approach, the IEUBK model is designed to integrate exposure from lead in air, water, soil, dust, diet, paint, and other sources with pharmacokinetic modeling to predict blood lead concentrations in children 6 months to 7 years of age. The four main components of the current IEUBK model are: (1) an exposure model that relates environmental lead concentrations to age-dependent intake of lead into the gastrointestinal tract; (2) an absorption model that relates lead intake into the gastrointestinal tract and lead uptake into the blood; (3) a biokinetic model that relates lead uptake in the blood to the concentrations of lead in several organ and tissue compartments; and (4) a model for uncertainty in exposure and for population variability in absorption and biokinetics [EPA 1994].

The IEUBK model results can be viewed as a predictive tool for estimating changes in blood concentrations as exposures are modified [EPA 1994]. The IEUBK model provides choices a user may make in estimating a child's blood lead concentration. These are referred to "user-specified" parameters or decisions. The reliability of the results obtained using the model is very dependent on the selection of the various coefficients and default values that were used. In setting a lead cleanup level at a site, EPA's goal is to 'limit exposure to lead levels such that a typical child or group of similarly exposed children would have an estimated risk of no more than 5% of exceeding a blood lead level of 10 $\mu\text{g}/\text{dL}$ [EPA 1998]. The use of solely default parameters in the IEUBK model yields a soil lead level of about 400 ppm, which EPA recommends as a soil screening level (SSL) for lead in soil at residential properties [EPA 1998].

For the regression analysis approach, environmental lead levels are multiplied by the percentage of time a person is exposed to a particular source and then multiplied by an appropriate regression slope factor. The slope factors can be derived from regression analysis studies that determine BLLs for a similar route of exposure. Typically, these studies also identify standard errors describing the regression line of a particular source of lead exposure [ATSDR 2007b].

In the following sections, ATSDR provides its evaluation of past, current, and future lead exposures using these two approaches (IEUBK model and slope factor analysis.)

6.2.1 Past Lead Exposures

ATSDR considers past lead exposure to be exposure to the lead levels detected in soil prior to the 2010 and 2011 TCRAs. Of the 1,028 samples collected from residential and non-residential properties in Superior as part of the RI, 833 samples (or about 81%) were below lead's SSL of 400 ppm (Figure 3, Appendix A).

Of the 1,028 samples analyzed, 195 samples exceeded lead's SSL of 400 ppm (see Exhibit 2). ATSDR ran the IEUBK model (IEUBKwin Model 1.1 Build 11) using default parameters for all inputs except (1) the soil level, which was set to site-specific maximum levels for each model run, and (2) the BLL reference level for risk estimation, which was set to 5 $\mu\text{g}/\text{dL}$. However, running the IEUBK model with the maximum lead concentrations for the past scenario results in

blood lead levels above 30 $\mu\text{g}/\text{dL}$. Blood lead levels over 30 $\mu\text{g}/\text{dL}$ are above the range of values that were used in the calibration and empirical validation of the model [EPA 2002b]. Therefore, EPA states the model should not be relied upon to predict BLLs above 30 $\mu\text{g}/\text{dL}$ [EPA 2002b, EPA 2002c].

ATSDR conducted a slope factor analysis using the most protective correlation between BLLs and soil concentration found in the epidemiologic studies—a 0.0068- $\mu\text{g}/\text{dL}$ increase in blood lead level per ppm of lead in soil [Angle et al. 1984]. This correlation value, or slope factor, is based on studies where children (1–18 years old) were exposed to lead regularly and frequently in a residential setting. The standard errors describing the regression line for this particular study were 0.0068 ± 0.00097 $\mu\text{g}/\text{dL}$.

For the maximum lead concentrations provided in Exhibit 3 for the past scenario, ATSDR calculated potential BLL increases using this slope factor. The slope factor approach estimated that daily exposure to the maximum soil lead levels detected in both residential and non-residential properties could have potentially increased BLLs by over 40 $\mu\text{g}/\text{dL}$. The estimated upper range of BLLs were more than two times the levels that can induce encephalopathy. Of note though, the predicted BLLs are overstated. First, the sources of soil lead in the Angle et. al (1984) study included fallout from leaded gasoline and lead paint, as well as fallout from multiple secondary lead smelters. The bioavailability of lead (and slope factor) from any of these sources would likely exceed that of lead from mine tailings. Second, the relationship between blood lead and environmental lead concentrations is somewhat non-linear at blood lead concentrations above 40 $\mu\text{g}/\text{dL}$ in adults and 30 $\mu\text{g}/\text{dL}$ in children [EPA 1994].

Overall, prior to the TCRAs, Superior properties with high levels of lead in soil had the potential for elevating BLLs in exposed residents. Therefore, ATSDR considers that residents' (especially children's) daily exposure in the past to soil in the areas of town with elevated lead concentrations could have harmed their health.

6.2.2 Current Lead Exposures

ATSDR considers current lead exposure to be exposure to the lead levels detected in soil following the 2010 and 2011 TCRAs. The TCRA removed some of the most elevated concentrations of lead from properties in Superior. Following removal efforts, about 90% of the lead samples are below lead's SSL of 400 ppm (see Exhibit 2.)

Following the TCRAs, 99 samples (52 residential and 47 non-residential) exceed lead's SSL of 400. As described in the past scenario, ATSDR ran the IEUBK model (IEUBKwin Model 1.1 Build 11) using default parameters for all inputs except the maximum soil levels (which are found in Exhibit 3, current scenario) and the BLL reference level for risk estimation (which was set to 5 $\mu\text{g}/\text{dL}$.) Like with past lead exposures, however, most of the maximum soil lead concentrations are associated with blood lead levels above 30 $\mu\text{g}/\text{dL}$, which indicates the model should not be used to predict BLLs. In the one case where the maximum lead concentration (property RY257-C) resulted in model predicted BLLs below 30 $\mu\text{g}/\text{dL}$, the IEUBK outputs show the probability of exceeding a BLL of 5 $\mu\text{g}/\text{dL}$ is about 100%.

Although no longer considered the best analysis approach, ATSDR also conducted a slope factor analysis using the most protective correlation between BLLs and soil concentration found in the epidemiologic studies ($0.0068 \pm 0.00097 \mu\text{g}/\text{dL}$). This was done for the sake of consistency with the analysis performed in the 2010 Flat Creek PHA. For the maximum lead concentrations provided in Exhibit 3 for the current scenario, the slope factor approach estimated that daily exposure to the maximum soil lead levels detected in both residential and non-residential properties could have potentially increased BLLs by 16–138 $\mu\text{g}/\text{dL}$. The 2010 PHA found daily exposure to the average soil lead level from the five residential yards where removal efforts occurred (5,563 ppm) could have potentially increased BLLs by 32–43 $\mu\text{g}/\text{dL}$. As stated previously, these estimated BLL ranges are overstated because (1) the bioavailability of lead from the Angle et. al (1984) study likely exceeds that of lead from mine tailings and (2) the relationship between blood lead and environmental lead concentrations is somewhat non-linear at blood lead concentrations above 40 $\mu\text{g}/\text{dL}$ in adults and 30 $\mu\text{g}/\text{dL}$ in children [EPA 1994].

Overall, following the TCRA's, high levels of lead in soil remain at some Superior properties indicating there is the potential for elevating BLLs in exposed residents. Therefore, ATSDR considers that residents' (especially children's) daily exposure to soil in the areas of town with elevated lead concentrations could currently harm their health.

6.2.3 Future Lead Exposures

ATSDR considers future lead exposure to be exposure to the lead levels detected in soil following proposed future remediation efforts. As stated previously, Alternative 4 was chosen as the final remedy. To estimate future lead levels, ATSDR assumed the quadrants listed in Tables 3A and 3B, Appendix B, would be remediated, or re-tested and remediated if needed, (excluding RY627 quadrants, as noted previously), thereby eliminating future exposures. The ROD for the site acknowledges that high levels of arsenic and lead will remain in the soil at property RY627 and specifies that institutional controls are necessary to protect human health. Tables 4 and 5, Appendix B, show the concentrations that will exceed CVs following remediation with Alternative 4. Following the proposed removal efforts, all of the lead samples will be below lead's SSL of 400 ppm (see Exhibit 2).

As described in the previous scenarios, ATSDR ran the IEUBK model (IEUBKwin Model 1.1 Build 11) using default parameters for all inputs except the maximum soil levels (which are found in Exhibit 3) and the BLL reference level for risk estimation (which was set to 5 $\mu\text{g}/\text{dL}$.) For the maximum lead concentrations provided in Exhibit 3 (future scenario), the IEUBK outputs showing the probability of exceeding a BLL of 5 $\mu\text{g}/\text{dL}$ are provided in Exhibit 9.

Exhibit 9. IEUBK Output Probabilities following Future Remediation with Alternative 4

Residential			Non-Residential			Start Depth (inches)	End Depth (inches)
Sample Location	Conc. (ppm)	Probability (%) of exceeding a BLL of 5 µg/dL	Sample Location	Conc. (ppm)	Probability (%) of exceeding a BLL of 5 µg/dL		
RY483-A	378	37	RY100-C	333	30	0	2
RY483-A	296	24	RY412-D	295	24	2	6
RY387-E	384	38	RY112-E	383	38	6	12

BLL blood lead level

Conc. concentration

IEUBK Integrated Exposure Uptake Biokinetic Model

ppm parts per million

µg/dL micrograms per deciliter

For the maximum lead concentrations provided in Exhibit 3 (future scenario), ATSDR also calculated potential BLL increases following proposed future remediation using the most protective slope factor and assuming daily exposure (see Exhibit 10).

Exhibit 10. Potential Blood Lead Level Increases following Future Remediation with Alternative 4

Residential		Non-Residential		Start Depth (inches)	End Depth (inches)
Sample Location	BLL Increase Range (µg/dL)	Sample Location	BLL Increase Range (µg/dL)		
RY483-A	2.2–2.9	RY100-C	1.9–2.6	0	2
RY483-A	1.7–2.3	RY412-D	1.6–2.1	2	6
RY387-E	2.2–3.0	RY112-E	2.2–3.0	6	12

BLL blood lead level

µg/dL micrograms per deciliter

The IEUBK model outputs showed the probability of exceeding a BLL of 5 µg/dL is between 24–38% for the future scenario. Conversely, the slope factor approach estimated that daily exposure to the maximum soil lead levels detected in both residential and non-residential properties could potentially increase BLLs by 3 µg/dL or less.

Overall, ATSDR finds that future exposures to lead in residential and non-residential soil for town of Superior properties would not be expected to harm people's health for the following reasons:

1. Although the IEUBK model predictions based on a reference level of 5 µg/dL show a high probability of children having elevated BLLs, the model default parameters likely overestimate the risk. For example, the default parameter in the IEUBK model for the gastrointestinal bioavailability of lead in soil and dust is 30%. However, the bioavailability of lead in soil varies widely depending on factors such as the chemical

species of lead, mineral matrix, and soil particle size. Epidemiological studies have shown that blood lead levels are more likely to be elevated near lead smelters than near lead mines [Danse et al. 1995, Steele et al. 1990]. This may be due to the greater bioavailability of lead in smelter particulate emissions, which are typically smaller than mine tailing particulates and contain a more soluble chemical form of lead.

2. The visual illustration of the lead sample distributions shown in Figure 3, Appendix B, shows that the non-residential properties typically have higher concentrations than the residential properties for all exposure scenarios, including the future scenario. Children are more likely to be exposed chronically to soil in residential yards than soil in non-residential areas of town.
3. In Superior, the ground is often frozen and covered in snow during the colder months thereby limiting soil exposures.
4. ATSDR's EI Report found that there was no evidence of unusual exposures to the lead found in soil in Superior for the EI participants during the testing period in July 2010. This EI included participants from residential properties that were identified to have soil lead levels above 2,999 ppm and was conducted when outdoor activity and the potential for exposure to soils were expected to be at their highest. The levels of lead detected in the 63 EI participants blood samples (0.31 – 3.01 $\mu\text{g}/\text{dL}$) were below the upper 95th percentile of a national reference range.

For these reasons, ATSDR does not expect future soil lead levels in Superior to contribute to elevated BLLs. However, the agency recognizes that even low levels of lead in blood have been shown to have harmful effects. ATSDR understands parents with young children may remain concerned about lead exposures. ATSDR recommends concerned residents take prudent public health measures to reduce their exposure (see Appendix C.) ATSDR also supports any future health education efforts undertaken by the MCHD. In addition, ATSDR can address questions about exposure to lead (toll-free 1-800-CDC-INFO.) When contacting ATSDR, please state you are requesting information related to the Flat Creek IMM site.

7.0 Child Health Considerations

In communities faced with environmental contamination, the many physical differences between children and adults need to be emphasized. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults, and thus they breathe dust, soil, and vapors closer to the ground. A child's lower body weight and higher air intake rate results in a greater dose of hazardous substances per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, medical care, and risk identification. Thus, adults need as much information as possible to make informed decisions about their children's health. Therefore, in this health consultation, ATSDR has particularly focused on the evaluation of children's exposure to arsenic and lead contamination and on the potential health effects associated with these exposures. Please refer to Section 6 which contains detailed discussions on children's exposures.

Of note, sensitive populations not discussed specifically in this health consultation, such as children who eat non-food items like soil (that is, exhibit pica behavior), could also receive doses of health concern. Groups that are at an increased risk for pica behavior are children aged 1–3 years old. Although it is known that children live in Superior, ATSDR does not know whether they exhibit pica behavior. If children who exhibit pica behavior live at or visit areas of town known to contain elevated levels of arsenic and lead, ATSDR suggests that parents monitor their children’s behavior while playing outdoors to prevent their children from intentionally eating soil.

8.0 Conclusions

ATSDR concludes that past and current exposures to arsenic and lead in residential and non-residential soil for most town of Superior properties are not expected to harm people’s health. During 2009 and 2010, soil samples from approximately 95% of all properties in town were analyzed and most of the sample results (about 65% of the arsenic results and 81% of the lead results) were below relevant health-based comparison values. Additionally, ATSDR’s EI Report found that there was no evidence of unusual exposures to the lead and arsenic found in soil in Superior for the EI participants during the testing period in July 2010. The levels of blood lead and urinary arsenic detected in all EI participants were below the upper 95th percentile of a national reference range.

However, ATSDR concludes that past and current exposures to elevated levels of arsenic and lead in residential and non-residential soil for some Superior properties could harm people’s health.

Arsenic—

- Prior to the 2010 and 2011 TCRAs conducted by EPA, if children lived at or visited residential and non-residential areas of elevated arsenic soil concentrations and participated in contact-intense activities⁵, it is plausible that they may have experienced transient harmful effects (nausea, vomiting, and diarrhea) following their short-term exposures.
- Following the 2010 and 2011 TCRAs, children’s exposure to elevated arsenic soil concentrations in some non-residential areas continues to be of health concern for short-term arsenic exposures.
- Chronic exposure to elevated arsenic concentrations were and are of potential public health concern for non-cancerous health effects, particularly for children at residential properties.
- Past and current arsenic exposures represent a low cancer risk, particularly at residential properties.

Lead—

- Prior to the 2010 and 2011 TCRAs, the potential existed for residents, especially children, to have elevated BLLs following daily exposure to the maximum levels of lead in soil.

⁵ Contact-intense activities include digging with shovels and other tools, and playing with toys (like toy trucks and action figures) on the ground surface. Adults and children can be exposed by putting soiled hands or toys in their mouth or by breathing or eating dust generated by their activities.

- Following the 2010 and 2011 TCRAs, the potential continues to exist for residents, especially children, to have elevated BLLs at some properties following daily exposure to the maximum levels of lead in soil.

ATSDR concludes that future exposures to arsenic and lead in residential and non-residential soil for town of Superior properties would not be expected to harm people's health provided that (1) the properties outlined in the ROD are remediated under Alternative 4, (2) the residential and non-residential properties listed in Table 3B, Appendix B, are re-tested and remediated if appropriate, and (3) institutional controls are implemented at non-residential property RY627, as specified in the ROD [EPA 2012a].

9.0 Recommendations

1. Parents can monitor their children's behavior while playing outdoors and prevent their children from intentionally or inadvertently eating soil known to contain elevated levels of arsenic and lead.
2. Residents may consider prudent public health measures they can take to reduce exposures and to protect themselves, their families, and visitors (see Appendix C).
3. EPA's proposal to remediate additional residential and non-residential properties under Alternative 4 (excavation and disposal of contaminated soils) is protective of public health and may proceed as planned.
4. EPA may consider re-testing, preferably using laboratory analytical methods, sixteen residential and non-residential property quadrants, and then remediate under Alternative 4 if needed. These property quadrants are RY030-E, RY043-B, RY086-C, RY091-E, RY095-B, RY095-C, RY101-A, RY101-E, RY102-B, RY112-A, RY118-O, RY146-B, RY240-D, RY289-F, RY289-G, and RY398-B.
5. EPA may implement institutional controls at non-residential property RY627, as specified in the ROD [EPA 2012a].

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12.0 References

[ACCLPP] Advisory Committee on Childhood Lead Poisoning Prevention. 2012. Low level lead exposure harms children: a renewed call for primary prevention. Available at: http://www.cdc.gov/nceh/lead/ACCLPP/Final_Document_030712.pdf

Alain G, Tousignant J, Rozenfarb E. 1993. Chronic arsenic toxicity. *Int J Dermatol* 32(12):899-901. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Angle CR, Marcus A, Cheng I-H, et al. 1984. Omaha childhood blood lead and environmental lead: A linear total exposure model. *Environ Res* 35:160-170. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for lead (update). Atlanta: US Department of Health and Human Services.

Apostoli P, Bartoli D, Alessio L, et al. 1999. Biological monitoring of occupational exposure to inorganic arsenic. *Occup Environ Med* 56(12):825-832. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2004. Guidance manual for the assessment of joint toxic action of chemical mixtures. Atlanta: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2005. Public health assessment guidance manual (update). Atlanta: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2007a. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services. Available at: <http://www.atsdr.cdc.gov/toxprofiles/tp2.html>.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2007b. Toxicological profile for lead (update). Atlanta: US Department of Health and Human Services. Available at: <http://www.atsdr.cdc.gov/toxprofiles/tp13.html>.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2010. Public Health Assessment for Flat Creek IMM (aka Superior Waste Rock), Superior, Mineral County, MT. Atlanta: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2011. Biological monitoring for exposure to lead and arsenic, Superior, Mineral County, MT. Health consultation, exposure investigation. Atlanta: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2013. Updated comparison value tables - March 2013. Comparison value spreadsheet provided via email by Annemarie

DePasquale, ATSDR, to agency staff on March 8, 2013. Atlanta: US Department of Health and Human Services.

Beane Freeman LE, Dennis LK, Lynch CF, et al. 2004. Toenail arsenic content and cutaneous melanoma in Iowa. *Am J Epidemiol* 160(7):679-687. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Bettley FR, O'Shea JA. 1975. The absorption of arsenic and its relation to carcinoma. *Br J Dermatol* 92:563-568. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Bickley LK, Papa CM. 1989. Chronic arsenicism with vitiligo, hyperthyroidism, and cancer. *N J Med* 86(5):377-380. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Borgoño JM, Greiber R. 1972. Epidemiological study of arsenicism in the city of Antofagasta. *Trace Subst Environ Health* 5:13-24. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Buchet JP, Lauwerys R, Roels H. 1981. Comparison of the urinary excretion of arsenic metabolites after a single oral dose of sodium arsenite, monomethylarsonate or dimethylarsinate in man. *Int Arch Occup Environ Health* 48:71-79. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Bureau of the Census. 2010. U.S. Census Bureau. 2010 Summary File 1, 100% Data. Available at <http://www.census.gov/>. Last accessed 2 December 2011.

Casteel SW, Brown LD, Dunsmore ME, Weis CP, Henningsen GM, Hoffman E, Brattin WJ, Hammon TL. 1997. Relative bioavailability of arsenic in mining wastes. Document control number: 4500-88-AORH. Prepared for US Environmental Protection Agency, Region VIII, Denver, Colorado. Cited in Battelle and Exponent. 2000. Final guide for incorporating bioavailability adjustments into human health and ecological risk assessments at US Navy and Marine Corps Facilities. Part 1: overview of metals bioavailability. Prepared for Naval Facilities Engineering Service Center and Engineering Field Activity West.

[CDC] Centers for Disease Control and Prevention. 2005. Preventing lead poisoning in young children: a statement by the Centers for Disease Control and Prevention. Atlanta: US Department of Health and Human Services.

[CDC] Centers for Disease Control and Prevention. 2012. Blood lead levels in children fact sheet. Atlanta: US Department of Health and Human Services. Available at: http://www.cdc.gov/nceh/lead/ACCLPP/Lead_Levels_in_Children_Fact_Sheet.pdf

[CDM] CDM Federal Programs Corporation. 2011a. Final remedial investigation report: Flat Creek/IMM Superfund site, Mineral County, MT, Operable Unit 1. Prepared for the US Environmental Protection Agency (EPA). Work Assignment No.: 3383-327. Helena, MT.

[CDM] CDM Federal Programs Corporation. 2011b. Electronic mail from Karen Ekstrom, CDM, to Danielle Langmann, Agency for Toxic Substances and Disease Registry, containing an Excel data attachment with the CLP laboratory data for the Flat Creek IMM site, Superior, Mineral County, Montana. September 20, 2011.

[CDM] CDM Federal Programs Corporation. 2011c. Electronic mail from Karen Ekstrom, CDM, to Danielle Langmann, Agency for Toxic Substances and Disease Registry, containing information about removal efforts for the Flat Creek IMM site, Superior, Mineral County, Montana. October 25, 2011.

[CDM] CDM Federal Programs Corporation. 2011d. Final feasibility study report: operable unit 1, Flat Creek/IMM Superfund site, Mineral County, MT. Prepared for the US Environmental Protection Agency (EPA). Work Assignment No.: 3383-327. Helena, MT.

Cebrián ME, Albores A, Aguilar M, et al. 1983. Chronic arsenic poisoning in the north of Mexico. *Hum Toxicol* 2:121-133. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Chen YC, Guo YL, Su HJ, et al. 2003. Arsenic methylation and skin cancer risk in southwestern Taiwan. *J Occup Environ Med* 45(3):241-248. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Chisolm JJ. 1962. Aminoaciduria as a manifestation of renal tubular injury in lead intoxication and a comparison with patterns of aminoaciduria seen in other diseases. *J Pediatr* 60:1-17. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for lead (update). Atlanta: US Department of Health and Human Services.

Chisolm JJ. 1965. Chronic lead intoxication in children. *Dev Med Child Neurol* 7:529-536. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for lead (update). Atlanta: US Department of Health and Human Services.

Chisolm JJ, Harrison HE. 1956. The exposure of children to lead. *Pediatrics* 18:943-958. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for lead (update). Atlanta: US Department of Health and Human Services.

Creclius EA. 1977. Changes in the chemical speciation of arsenic following ingestion by man. *Environ Health Perspect* 19:147-150. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Danse IHR, Garb LG, Moore HR. 1995. Blood lead surveys of communities in proximity to lead-containing mill tailings. *Am Ind Hyg Assoc J* 56:384-393.

Davis A, Ruby MV, Bergstrom PD. 1992. Bioavailability of arsenic and lead in soils from the Butte, Montana, mining district. *Environ Sci Technol.* 26(3):461-468. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

[EPA] US Environmental Protection Agency. 1981. Community health associated with arsenic in drinking water in Millard County, Utah. Cincinnati, OH: US Environmental Protection Agency, Health Effects Research Laboratory. EPA600181064. PB82108374. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

[EPA] US Environmental Protection Agency. 1982. Exposure and risk assessment for arsenic. Washington, DC: US Environmental Protection Agency, Office of Water Regulations and Standards. PB85221711. EPA440485005. 1.14.68. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

[EPA] US Environmental Protection Agency. 1994. Guidance manual for the integrated exposure uptake biokinetic model for lead in children. NTIS #PB93-963510, EPA 9285.7-15-1. Office of Solid Waste and Emergency Response. Washington, DC.

[EPA] US Environmental Protection Agency. 1998. Clarification to the 1994 revised interim soil lead (Pb) guidance for CERCLA sites and RCRA corrective action facilities. OSWER Directive No. 9200.4-27P, Document no. EPA/540/F-98/030, PB98-963244. Washington, DC: Office of Solid Waste and Emergency Response.

[EPA] US Environmental Protection Agency. 2001. Electronic mail from Rosemary Rowe, EPA Montana Office, summarizing past and current activities related to the Iron Mountain Mill site and town of Superior, Mineral County, Montana. August 7, 2001.

[EPA] US Environmental Protection Agency. 2002a. Analytical results report for focused site inspection. Iron Mountain Mill, Superior, Mineral County, Montana. January 24, 2002.

[EPA] US Environmental Protection Agency. 2002b. Reference manual: documentation of updates for the integrated exposure uptake biokinetic model for lead in children (IEUBK). OSWER #9285.7-44. Office of Solid Waste and Emergency Response. Washington, DC.

[EPA] US Environmental Protection Agency. 2002c. Short sheet: overview of the IEUBK model for lead in children. EPA #PB 99-9635-8, OSWER #9285.7-31. Office of Solid Waste and Emergency Response. Washington, DC.

[EPA] US Environmental Protection Agency. 2008. Integrated Risk Information System (IRIS). Arsenic. Available at: <http://www.epa.gov/ncea/iris>.

[EPA] US Environmental Protection Agency. 2010. IRIS toxicological review of inorganic arsenic (cancer) (2010 external review draft). Washington, DC. EPA/635/R-10/001.

[EPA] US Environmental Protection Agency. 2011a. Flat Creek IMM Superfund Site, Operable Unit 1, Superior, MT: EPA announces proposed plan. US EPA Region 8: Helena, MT.

[EPA] US Environmental Protection Agency. 2011b. Chromated copper arsenate (CCA). Current as of July 2011. Office of Pesticide Programs. Washington, DC. Available at: <http://www.epa.gov/oppad001/reregistration/cca/>.

[EPA] US Environmental Protection Agency. 2012a. Record of decision for Flat Creek/IMM Superfund Site, Operable Unit 1, Mineral County, MT. US EPA Region 8: Helena, MT.

[EPA] US Environmental Protection Agency. 2012b. Recommendations for default value for relative bioavailability of arsenic in soil. OSWER 9200.1-113. Office of Solid Waste and Emergency Response. Washington, DC.

Franzblau A, Lilis R. 1989. Acute arsenic intoxication from environmental arsenic exposure. Arch Environ Health 44(6):385-390. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Freeman GB, Johnson JD, Killinger JM, Liao SC, Feder PI, Davis AO, Ruby MV, Chaney RL, Lovre SC, Bergstrom PD. 1993. Bioavailability of arsenic in soil impacted by smelter activities following oral administration in rabbits. Fundam Appl Toxicol. 21(1):83-88. Cited in Battelle and Exponent. 2000. Final guide for incorporating bioavailability adjustments into human health and ecological risk assessments at US Navy and Marine Corps Facilities. Part 1: overview of metals bioavailability. Prepared for Naval Facilities Engineering Service Center and Engineering Field Activity West.

Freeman GB, Schoof RA, Ruby MV, Davis AO, Dill JA, Liao SC, Lapin CA, Bergstrom PD. 1995. Bioavailability of arsenic in soil and house dust impacted by smelter activities following oral administration in cynomolgus monkeys. Fundam Appl Toxicol. 28(2):215-222. Cited in Battelle and Exponent. 2000. Final guide for incorporating bioavailability adjustments into human health and ecological risk assessments at US Navy and Marine Corps Facilities. Part 1: overview of metals bioavailability. Prepared for Naval Facilities Engineering Service Center and Engineering Field Activity West.

Groen, K., H. Vaessen, J.J.G. Kliest, J.L.M. deBoer, T.V. Ooik, A. Timmerman, and F.F. Vlug. 1994. Bioavailability of Inorganic Arsenic from Bog Ore-Containing Soil in the Dog. *Environ. Health Perspect.*, 102(2): 182-184. Cited in Battelle and Exponent. 2000. Final guide for incorporating bioavailability adjustments into human health and ecological risk assessments at US Navy and Marine Corps Facilities. Part 1: overview of metals bioavailability. Prepared for Naval Facilities Engineering Service Center and Engineering Field Activity West.

Guha Mazumder DN, Chakraborty AK, Ghose A, et al. 1988. Chronic arsenic toxicity from drinking tubewell water in rural west Bengal. *Bull WHO* 66(4):499-506. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Haque R, Mazumder DN, Samanta S, et al. 2003. Arsenic in drinking water and skin lesions: Dose-response data from West Bengal, India. *Epidemiology* 14(2):174-182. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Harrington JM, Middaugh JP, Morse DL, et al. 1978. A survey of a population exposed to high concentrations of arsenic in well water in Fairbanks, Alaska. *Am J Epidemiol* 108(5):377-385. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Hauptert TA, Wiersma JH, Goldring JM. 1996. Health effects of ingesting arsenic-contaminated groundwater. *Wis Med J* 95(2):100-104. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Health Canada. 1993. Canadian Environmental Protection Act. Priority substances list assessment report: arsenic and its compounds. Government of Canada, Environment Canada. Available at: http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/ps11-lsp1/arsenic_comp/index_e.html.

Hsueh YM, Cheng GS, Wu MM, et al. 1995. Multiple risk factors associated with arsenic-induced skin cancer: Effects of chronic liver disease and malnutritional status. *Br J Cancer* 71(1):109-14. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

[IARC] International Agency for Research on Cancer. 1980. Arsenic and arsenic compounds. In: IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. Some metals and metallic compounds. IARC monographs, Vol. 23. Lyon, France: World Health Organization. International Agency for Research on Cancer, 39-141. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Kehoe RA. 1961. The metabolism of lead in man in health and disease: Present hygienic problems relating to the absorption of lead: The Harben lectures, 1960. *J R Inst Public Health*

Hyg 24:177-203. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for lead (update). Atlanta: US Department of Health and Human Services.

Kumar S, Jain S, Aggarwal CS, et al. 1987. Encephalopathy due to inorganic lead exposure in an adult. *Jpn J Med* 26:253-254. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for lead (update). Atlanta: US Department of Health and Human Services.

Lewis DR, Southwick JW, Ouellet-Hellstrom R, et al. 1999. Drinking water in Utah: A cohort mortality study. *Environ Health Perspect* 107(5):359-365. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Lüchtrath H. 1983. The consequences of chronic arsenic poisoning among Moselle wine growers: Pathoanatomical investigations of post-mortem examinations performed between 1960 and 1977. *J Cancer Res Clin Oncol* 105:173-182. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Marafante E, Vahter M, Norin H, et al. 1987. Biotransformation of dimethylarsenic acid in mouse, hamster and man. *J Appl Toxicol* 7(2):111-117. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Marcus WL, Rispin AS. 1988. Threshold carcinogenicity using arsenic as an example. In: Cothorn CR, Mehlman MA, Marcus WL, eds. *Advances in modern environmental toxicology*. Vol. XV: Risk assessment and risk management of industrial and environmental chemicals. Princeton, NJ: Princeton Scientific Publishing Co., 133-158. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

[MDEQ] Montana Department of Environmental Quality. 2003. Source water delineation and assessment report, town of Superior, public water supply. July 31, 2003.

[MDEQ] Montana Department of Environmental Quality. 2004. Historical narrative: Iron Mountain Mine. Available at: <http://www.deq.state.mt.us/AbandonedMines/linkdocs/techdocs/137tech.asp>. Last accessed 21 July 2004.

[MDEQ] Montana Department of Environmental Quality. 2005. Action level for arsenic in surface soil. Montana Department of Environmental Quality, Remediation Division. Available at: <http://www.deq.mt.gov/StateSuperfund/PDFs/ArsenicPositionPaper.pdf>.

Mitra SR, Mazumder DN, Basu A, et al. 2004. Nutritional factors and susceptibility to arsenic-caused skin lesions in West Bengal, India. *Environ Health Perspect* 112(10):1104-1109. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Mizuta N, Mizuta M, Ito F, et al. 1956. An outbreak of acute arsenic poisoning caused by arsenic-contaminated soy-sauce (shōyu): A clinical report of 220 cases. *Bull Yamaguchi Med Sch* 4(2-3):131-149. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Morris JS, Schmid M, Newman S, et al. 1974. Arsenic and noncirrhotic portal hypertension. *Gastroenterology* 66(1):86-94. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

[NRC] National Research Council. 2001. Arsenic in drinking water. 2001 Update. Washington, DC: National Academy Press. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Rodriguez, R.R., N.T. Basta, S.W. Casteel, and L.W. Pace. 1999. An In Vitro Gastrointestinal Method to Estimate Bioavailable Arsenic in Contaminated Soils and Solid Media. *Environ. Sci. Technol.*, 33(4): 642-649. Cited in Battelle and Exponent. 2000. Final guide for incorporating bioavailability adjustments into human health and ecological risk assessments at US Navy and Marine Corps Facilities. Part 1: overview of metals bioavailability. Prepared for Naval Facilities Engineering Service Center and Engineering Field Activity West.

Shacklette HT and JG Boerngen. 1984. Element concentrations in soils and surficial materials of the conterminous United States. US Geological Survey Professional Paper 1270. US Government Printing Office: Washington.

Sommers SC, McManus RG. 1953. Multiple arsenical cancers of the skin and internal organs. *Cancer* 6:347-359. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Steele MJ, Beck BD, Murphy BL, et al. 1990. Assessing the contribution from lead in mining wastes to blood lead. *Reg Toxicol Pharmacol* 11:158-190.

Tam GKH, Charbonneau SM, Bryce F, et al. 1979. Metabolism of inorganic arsenic (^{74}As) in humans following oral ingestion. *Toxicol Appl Pharmacol* 50:319-322. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Tay C, Seah C. 1975. Arsenic poisoning from anti-asthmatic herbal preparations. *Med J Aust* 2:424-428. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Tsai M, Chien R, Hsieh S, et al. 1998. Primary hepatic angiosarcoma: Report of a case involving environmental arsenic exposure. *Chang Keng I Hsueh Tsa Chih* 21(4):469-474. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Tsai SM, Wang TN, Ko YC. 1999. Mortality for certain diseases in areas with high levels of arsenic in drinking water. *Arch Environ Health* 54(3):186-193. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Tseng, WP, Chu HM, How SW, et al. 1968. Prevalence of skin cancer in an endemic area of chronic arsenicism in Taiwan. *J Natl Cancer Inst* 40:453-463. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Tseng, WP. 1977. Effects and dose-response relationships of cancer and Blackfoot disease with arsenic. *Environ Health Perspect* 19:109-119. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

[URS] URS Operating Services, Inc. 2012. Flat Creek IMM NPL Site Removal Report, Superior, Mineral County, Montana. Prepared for the US Environmental Protection Agency (EPA). Contract No. EP-W-05-050. Denver, Colorado.

[USDA] United States Department of Agriculture. 2004. Flat Creek tailings, Lolo National Forest: final site investigation. USDA Forest Service, Region 1. February 18, 2004.

Valentine JL, Reisbord LS, Kang HK, et al. 1985. Arsenic effects on population health histories. In: Mills CF, Bremner I, Chesters JK, eds. *Trace elements in man and animals - TEMA 5: Proceedings of the Fifth International Symposium on Trace Elements in Man and Animals*. Slough, UK: Commonwealth Agricultural Bureaux, 289-294. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Wedepohl KH. 1991. The composition of the upper earth's crust and the natural cycles of selected metals. *Metals in natural raw materials. Natural resources*. In: Merian E, ed. *Metals and their compounds in the environment. Occurrence, analysis, and biological relevance*. New York, NY: VCH, 3-17. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Wester RC, Maibach HI, Sedik L, et al. 1993. *In vivo* and *in vitro* percutaneous absorption and skin decontamination of arsenic from water and soil. *Fundam Appl Toxicol* 20(3):336-340. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

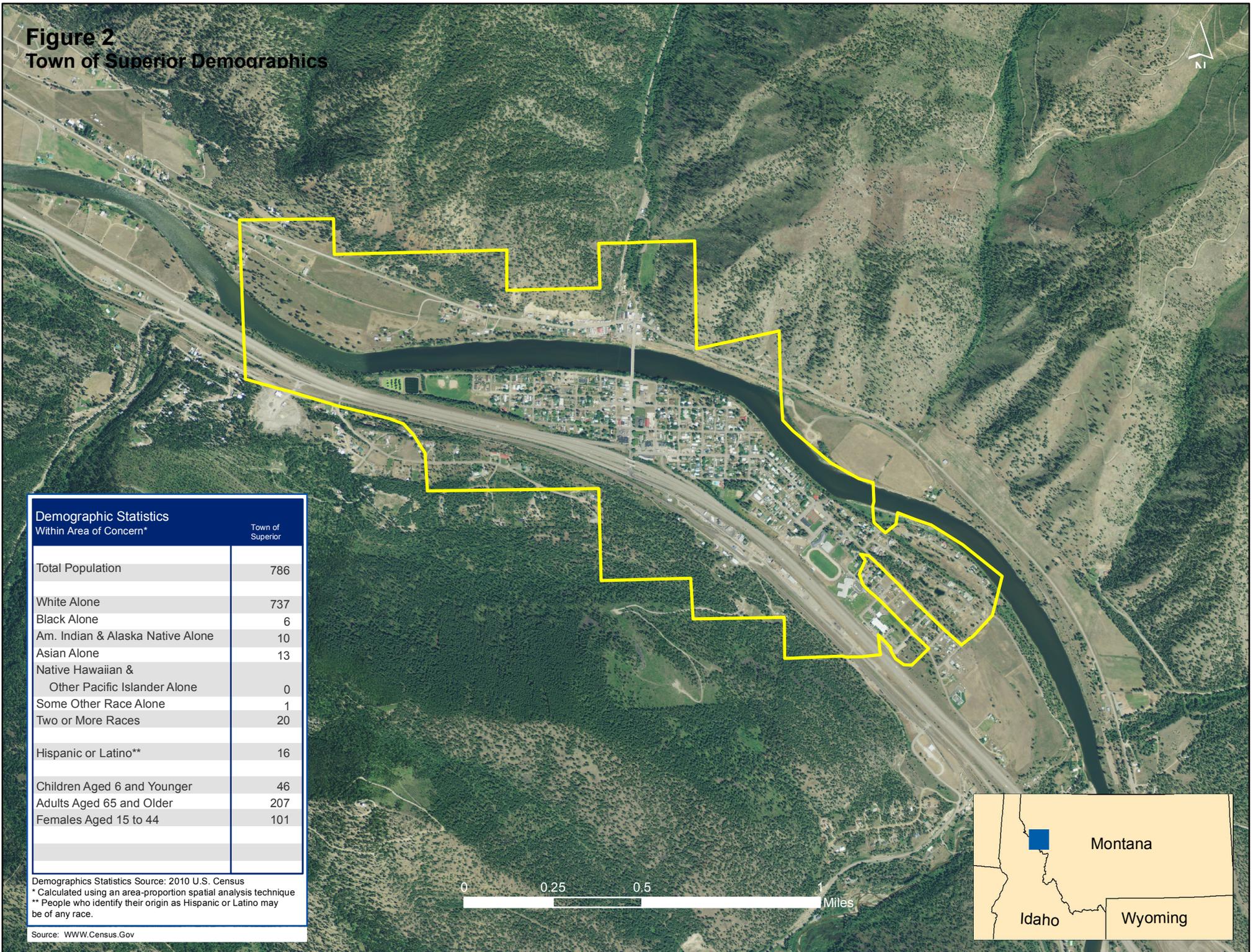
Zaldívar R. 1974. Arsenic contamination of drinking water and foodstuffs causing endemic chronic poisoning. *Beitr Pathol* 151:384-400. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Zaldívar R, Prunés L, Ghai G. 1981. Arsenic dose in patients with cutaneous carcinomata and hepatic haemangio-endothelioma after environmental and occupational exposure. *Arch Toxicol* 47:145-154. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Zheng Y, Wu J, Ng JC, et al. 2002. The absorption and excretion of fluoride and arsenic in humans. *Toxicol Lett* 133(1):77-82. Cited in Agency for Toxic Substances and Disease Registry. 2007. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services.

Appendix A: Figures

Figure 2
Town of Superior Demographics



Demographic Statistics Within Area of Concern*		Town of Superior
Total Population		786
White Alone		737
Black Alone		6
Am. Indian & Alaska Native Alone		10
Asian Alone		13
Native Hawaiian & Other Pacific Islander Alone		0
Some Other Race Alone		1
Two or More Races		20
Hispanic or Latino**		16
Children Aged 6 and Younger		46
Adults Aged 65 and Older		207
Females Aged 15 to 44		101

Demographics Statistics Source: 2010 U.S. Census
 * Calculated using an area-proportion spatial analysis technique
 ** People who identify their origin as Hispanic or Latino may be of any race.
 Source: WWW.Census.Gov

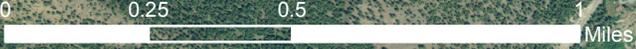
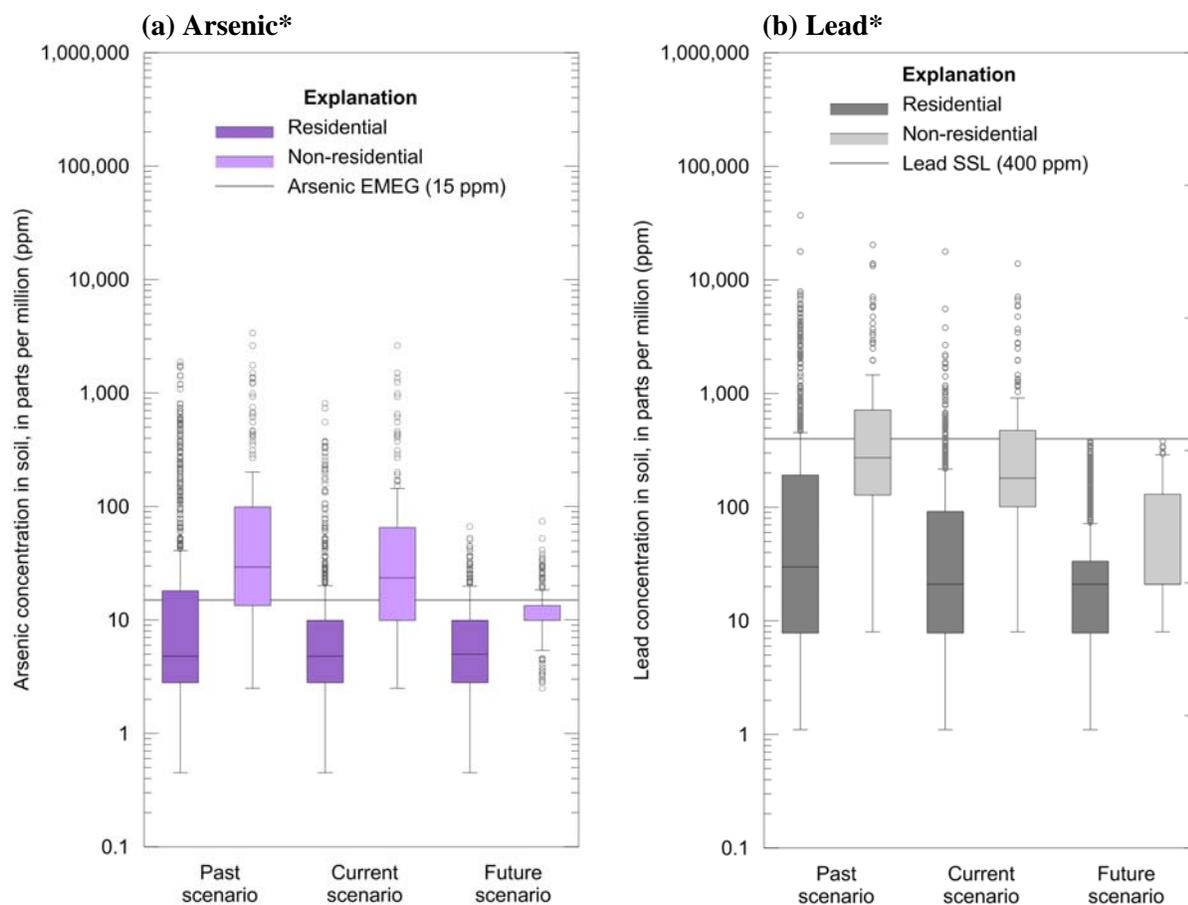


Figure 3. Boxplots showing the distribution of (a) arsenic and (b) lead in soil data (individual samples) for past, present, and future scenarios

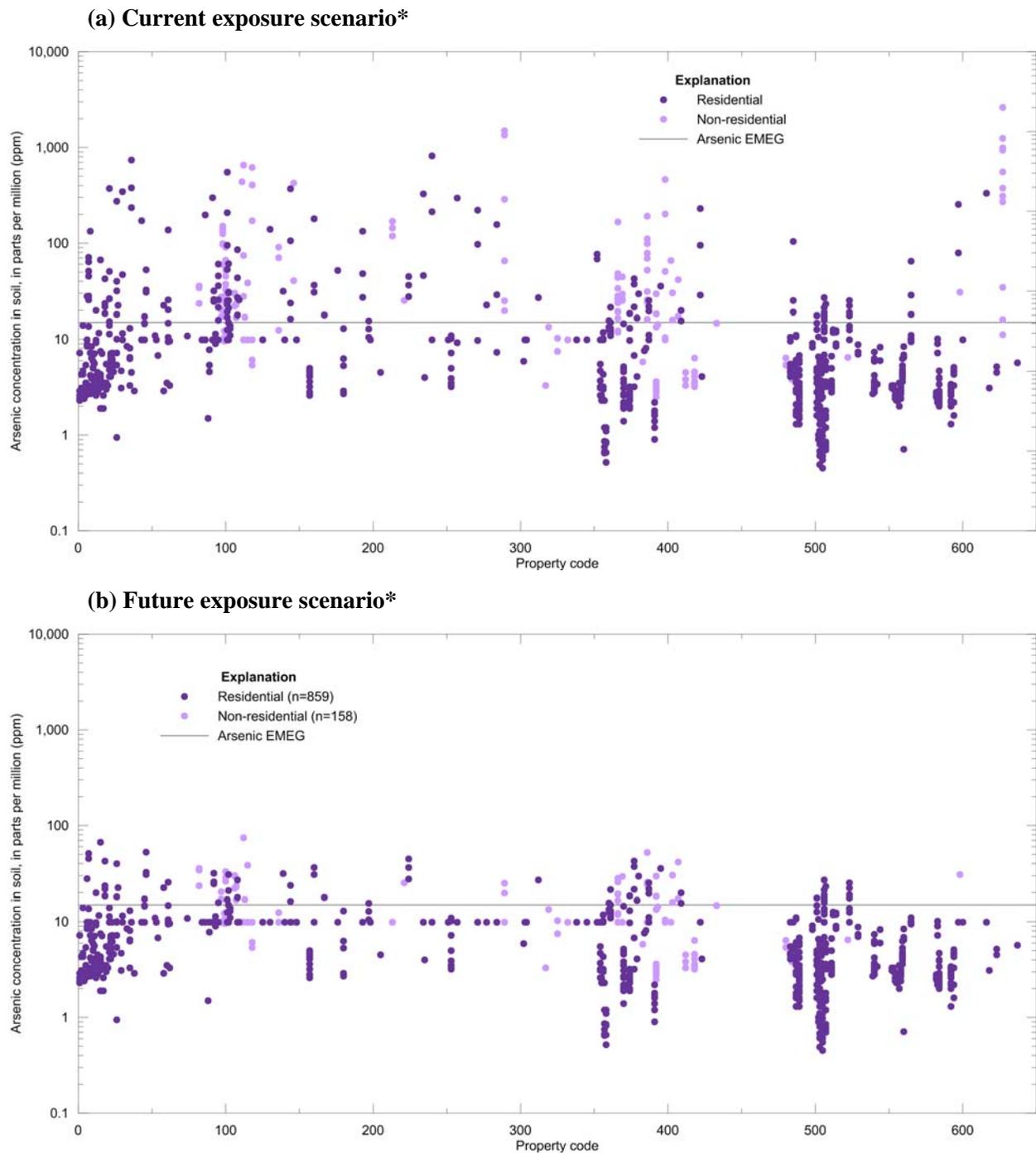


Data sources: CDM 2011b, URS 2012.

* For the current and future scenarios, post-cleanup sample results were revised to measured values of 9.9 ppm for arsenic and 21 ppm for lead for the clean replacement topsoil fill [URS 2012]. All quadrant data for non-residential property RY627 are excluded from the future scenario because institutional controls are specified for this property in the record of decision for the site [EPA 2012a]. As a result, the number of samples for the future scenario is lower than for the current scenario. The number of *residential samples* for all scenarios is 859. The number of *non-residential samples* for the past and current scenarios is 169; the number of *non-residential samples* for the future scenario is 158.

EMEG environmental media evaluation guide
 ppm parts per million
 SSL soil screening level

Figure 4. Arsenic concentrations in soil representing (a) the current exposure scenario and (b) the future exposure scenario

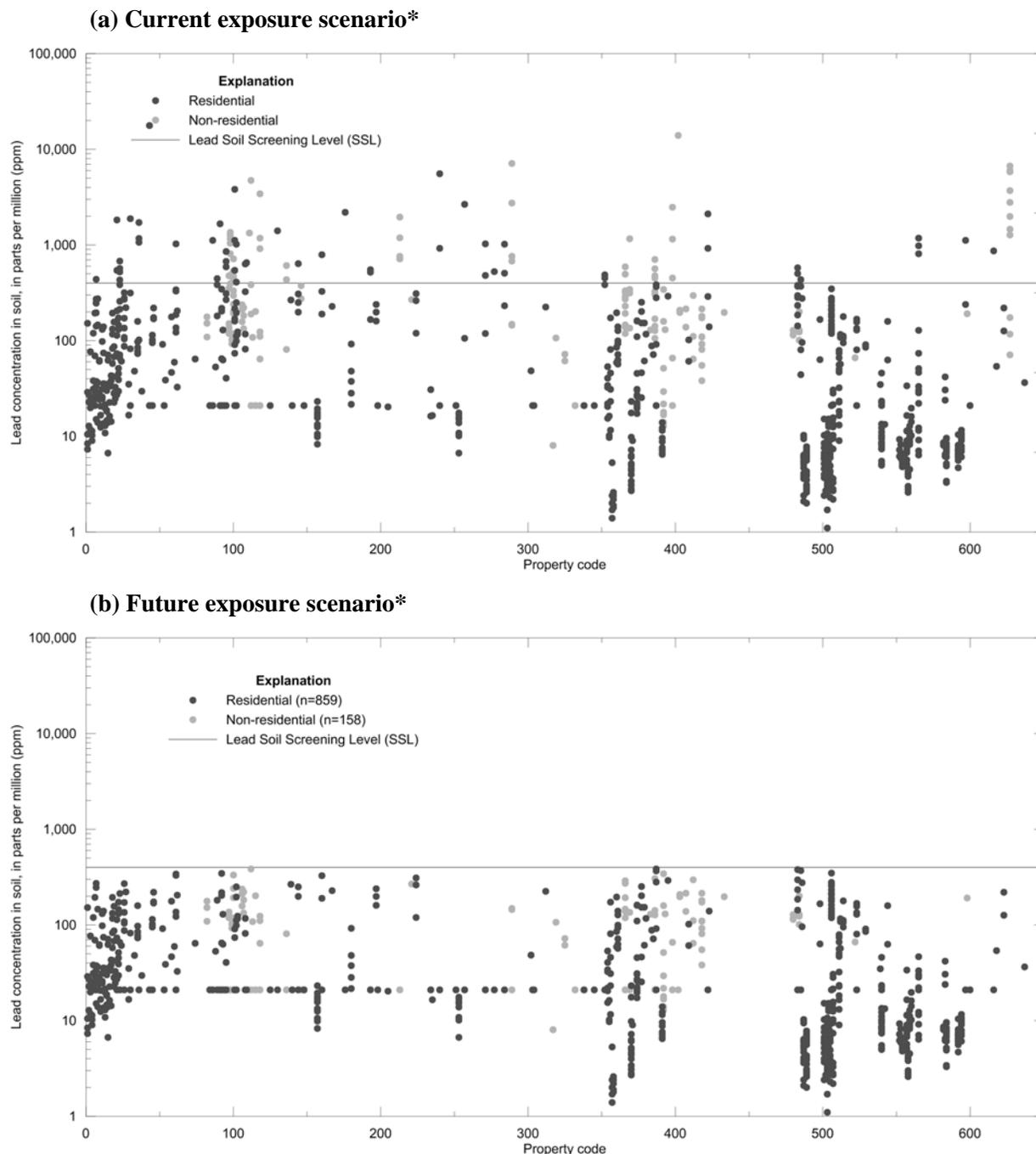


Data sources: CDM 2011b, URS 2012.

* For both scenarios, post-cleanup arsenic sample results were revised to measured values of 9.9 ppm for the clean replacement fill [URS 2012]. All quadrant data for non-residential property RY627 are excluded from the future scenario because institutional controls are specified in the record of decision [EPA 2012a]. As a result, the number of samples for the future scenario is lower than for the current scenario.

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Figure 5. Lead concentrations in soil representing (a) the current exposure scenario, and (b) the future exposure scenario



Data sources: CDM 2011b, URS 2012.

* For both scenarios, post-cleanup lead sample results were revised to measured values of 21 ppm for the clean replacement fill [URS 2012]. All quadrant data for non-residential property RY627 are excluded from the future scenario because institutional controls are specified in the record of decision [EPA 2012a]. As a result, the number of samples for the future scenario is lower than for the current scenario.

SSL soil screening level

Appendix B: Tables

Table 1. Residential Arsenic and Lead Concentrations* prior to and following the 2010/2011 Time-Critical Removal Actions (TCRAs) (10 pages)

Residential Sample Location	Concentrations prior to the TCRAs		CDM 2011 Target [‡]	URS 2012 Actual [‡]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY006-A	8.9	69.5			8.9	69.5	0	2	8/3/2009
RY006-A	27.9[†]	194			27.9	194	6	12	8/3/2009
RY006-B	2.9	29.7			2.9	29.7	0	2	8/3/2009
RY006-C	8.5	25.9			8.5	25.9	0	2	8/3/2009
RY006-D	790	3150	X	X	9.9	21	0	2	8/3/2009
RY006-D	186	873	X	X	9.9	21	2	6	8/3/2009
RY006-D	35.9	222	X	X	9.9	21	6	12	8/3/2009
RY007-A	28	196			28	196	0	2	8/4/2009
RY007-A	71	250			71	250	2	6	8/4/2009
RY007-A	25.5	142			25.5	142	6	12	8/4/2009
RY007-A	64	439			64	439	6	12	8/4/2009
RY007-B	3.3	33.5			3.3	33.5	0	2	8/4/2009
RY007-C	2.7	15.1			2.7	15.1	0	2	8/4/2009
RY007-D	50.9	247			50.9	247	0	2	8/4/2009
RY007-D	45.1	272			45.1	272	2	6	8/4/2009
RY007-F	13.6	37.6			13.6	37.6	0	2	8/4/2009
RY008-A	133	274			133	274	0	2	8/4/2009
RY008-B	4.2	36.3			4.2	36.3	0	2	8/4/2009
RY008-C	2.7	14			2.7	14	0	2	8/4/2009
RY008-C	2.8	13.9			2.8	13.9	2	6	8/4/2009
RY008-D	7.2	146			7.2	146	0	2	8/4/2009
RY015-A	4	34.5			4	34.5	0	2	8/4/2009
RY015-B	66.7	71.1			66.7	71.1	6	12	8/4/2009
RY015-C	7.5	62.4			7.5	62.4	0	2	8/4/2009
RY015-D	1.9	6.7			1.9	6.7	0	2	8/4/2009
RY015-E	3.8	14			3.8	14	0	2	8/4/2009
RY015-G	4.3	33.5			4.3	33.5	0	2	8/4/2009
RY015-H	3.9	35.2			3.9	35.2	0	2	8/4/2009
RY018-A	18.5	132			18.5	132	0	2	8/5/2009
RY018-A	42.6	194			42.6	194	2	6	8/5/2009
RY018-A	23.6	117			23.6	117	2	6	8/5/2009
RY018-A	21.7	82.5			21.7	82.5	6	12	8/5/2009
RY018-B	3.5	57.5			3.5	57.5	0	2	8/5/2009
RY018-D	3.4	42.5			3.4	42.5	0	2	8/5/2009
RY021-A	4.8	27.1			4.8	27.1	0	2	8/5/2009

Table 1 continued.

Residential Sample Location	Concentrations prior to the TCRAs		CDM 2011 Target [‡]	URS 2012 Actual [‡]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY021-B	13.9	113			13.9	113	0	2	8/5/2009
RY021-B	11.3	73.1			11.3	73.1	6	12	8/5/2009
RY021-C	4.1	41.9			4.1	41.9	0	2	8/5/2009
RY021-D	15.3	160			15.3	160	2	6	8/5/2009
RY021-D	50.5	1820			50.5	1820	6	12	8/5/2009
RY021-E	26.2	204			26.2	204	0	2	8/5/2009
RY021-E	373	544			373	544	2	6	8/5/2009
RY021-E	26.3	157			26.3	157	6	12	8/5/2009
RY023-A	5.6	523			5.6	523	0	2	8/5/2009
RY023-A	5.8	385			5.8	385	2	6	8/5/2009
RY023-A	5.5	431			5.5	431	6	12	8/5/2009
RY023-B	4.7	71.2			4.7	71.2	0	2	8/5/2009
RY023-B	5.3	258			5.3	258	2	6	8/5/2009
RY023-B	4.7	568			4.7	568	6	12	8/5/2009
RY023-B	5.2	678			5.2	678	6	12	8/5/2009
RY023-C	6.2	212			6.2	212	0	2	8/5/2009
RY023-C	7.2	135			7.2	135	2	6	8/5/2009
RY023-D	7	65.9			7	65.9	2	6	8/5/2009
RY026-A	10	135			10	135	0	2	8/6/2009
RY026-A	0.94	108			0.94	108	0	2	8/6/2009
RY026-A	39.8	172			39.8	172	2	6	8/6/2009
RY026-A	18.1	270			18.1	270	6	12	8/6/2009
RY026-B	5.4	87.6			5.4	87.6	0	2	8/6/2009
RY026-B	7.2	104			7.2	104	2	6	8/6/2009
RY026-C	31.6	279			31.6	279	0	2	8/6/2009
RY026-C	274	317			274	317	2	6	8/6/2009
RY027-D	22.4	221			22.4	221	2	6	8/6/2009
RY030-B	11.5	82			11.5	82	6	12	8/6/2009
RY030-D	115	260	X	X	9.9	21	0	2	8/6/2009
RY030-D	1200	7910	X	X	9.9	21	2	6	8/6/2009
RY030-E	345	1880			345	1880	2	6	8/6/2009
RY030-E	46.8	314			46.8	314	6	12	8/6/2009
RY036-C	4.5	102			4.5	102	0	2	8/10/2009
RY036-D	737	1710			737	1710	0	2	8/10/2009
RY036-D	236	1070			236	1070	2	6	8/10/2009
RY036-D	377	1170			377	1170	6	12	8/10/2009
RY043-B	172	17700	X		172	17700	2	6	8/11/2009
RY043-E	144	1120		X	9.9	21	0	2	8/11/2009

Table 1 continued.

Residential Sample Location	Concentrations prior to the TCRAs		CDM 2011 Target [±]	URS 2012 Actual [±]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY043-E	83.9	403		X	9.9	21	2	6	8/11/2009
RY043-E	111	843		X	9.9	21	6	12	8/11/2009
RY045-A	52.7	143		X	9.9	21	2	6	8/11/2009
RY045-A	18	87.4		X	9.9	21	6	12	8/11/2009
RY045-C	14.5	102			14.5	102	0	2	8/11/2009
RY045-C	17.1	114			17.1	114	2	6	8/11/2009
RY045-C	14.7	94.7			14.7	94.7	6	12	8/11/2009
RY045-D	1190	5470	X	X	9.9	21	0	2	8/11/2009
RY046-D	32.4	174			32.4	174	0	2	8/11/2009
RY046-D	52.7	219			52.7	219	2	6	8/11/2009
RY046-D	30.7	169			30.7	169	6	12	8/11/2009
RY053-C	160	455	X	X	9.9	21	0	2	8/12/2009
RY053-C	1680	7910	X	X	9.9	21	2	6	8/12/2009
RY053-C	520	2940	X	X	9.9	21	6	12	8/12/2009
RY058-C	2.9	46.4			2.9	46.4	0	2	8/12/2009
RY058-D	22.4	177			22.4	177	0	2	8/12/2009
RY061-B	25.6	330			25.6	330	0	2	8/12/2009
RY061-E	20.1	187			20.1	187	2	6	8/12/2009
RY061-E	137	1030			137	1030	6	12	8/12/2009
RY061-F	9.4	122			9.4	122	0	2	8/12/2009
RY061-F	10.5	136			10.5	136	2	6	8/12/2009
RY061-F	14.7	339			14.7	339	6	12	8/12/2009
RY084-C	450	4630	X	X	9.9	21	0	2	8/18/2009
RY084-C	116	1120	X	X	9.9	21	2	6	8/18/2009
RY084-C	273	441	X	X	9.9	21	6	12	8/18/2009
RY086-A	240	1300		X	9.9	21	0	2	8/19/2009
RY086-A	112	657		X	9.9	21	2	6	8/19/2009
RY086-A	234	2050		X	9.9	21	2	6	8/19/2009
RY086-A	46.2	221		X	9.9	21	6	12	8/19/2009
RY086-C	197	1120			197	1120	0	2	8/19/2009
RY086-D	1400	7530	X	X	9.9	21	0	2	8/19/2009
RY086-D	1090	5740	X	X	9.9	21	2	6	8/19/2009
RY086-D	1440	4700	X	X	9.9	21	6	12	8/19/2009
RY089-C	7.8	181			7.8	181	0	2	8/24/2009
RY089-I	4.6	445			4.6	445	0	2	8/24/2009
RY089-I	5.4	383			5.4	383	2	6	8/24/2009
RY091-A	26.4	167		X	9.9	21	2	6	8/19/2009
RY091-A	23.9	144		X	9.9	21	6	12	8/19/2009

Table 1 continued.

Residential Sample Location	Concentrations prior to the TCRAs		CDM 2011 Target [±]	URS 2012 Actual [±]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY091-D	276	3310	X	X	9.9	21	0	2	8/19/2009
RY091-D	182	1110	X	X	9.9	21	2	6	8/19/2009
RY091-D	205	2570	X	X	9.9	21	6	12	8/19/2009
RY091-E	298	1670			298	1670	0	2	8/19/2009
RY091-F	13.7	101		X	9.9	21	0	2	8/19/2009
RY091-F	14.6	134		X	9.9	21	2	6	8/19/2009
RY091-F	9.2	62.6		X	9.9	21	6	12	8/19/2009
RY092-C	121	904		X	9.9	21	0	2	8/19/2009
RY092-C	242	1860		X	9.9	21	2	6	8/19/2009
RY092-C	274	1500		X	9.9	21	6	12	8/19/2009
RY092-D	96.1	617		X	9.9	21	0	2	8/19/2009
RY092-D	51.8	588		X	9.9	21	6	12	8/19/2009
RY092-E	31.8	346			31.8	346	0	2	8/19/2009
RY092-E	25.8	218			25.8	218	2	6	8/19/2009
RY092-E	24.6	203			24.6	203	2	6	8/19/2009
RY092-E	9.7	64.7			9.7	64.7	6	12	8/19/2009
RY094-B	27.7	367		X	9.9	21	0	2	8/18/2009
RY094-B	24.2	287		X	9.9	21	2	6	8/18/2009
RY094-B	31.8	398		X	9.9	21	6	12	8/18/2009
RY094-F	391	7240	X	X	9.9	21	0	2	8/18/2009
RY094-F	311	5690	X	X	9.9	21	2	6	8/18/2009
RY094-F	134	2160	X	X	9.9	21	6	12	8/18/2009
RY095-A	15.7	86.2		X	9.9	21	6	12	8/18/2009
RY095-B	35.8	592			35.8	592	0	2	8/19/2009
RY095-B	60.5	856			60.5	856	2	6	8/18/2009
RY095-B	25.5	311			25.5	311	6	12	8/18/2009
RY095-C	21.4	268	X		21.4	268	2	6	8/18/2009
RY095-C	45.4	673	X		45.4	673	6	12	8/18/2009
RY095-D	15.8	40.4			15.8	40.4	6	12	8/19/2009
RY101-A	95	160	X		95	160	0	2	8/20/2009
RY101-A	19.2	169	X		19.2	169	2	6	8/20/2009
RY101-A	25	216	X		25	216	2	6	8/20/2009
RY101-A	552	3800	X		552	3800	6	12	8/20/2009
RY101-B	12.5	91			12.5	91	0	2	8/20/2009
RY101-B	16.9	73.8			16.9	73.8	6	12	8/20/2009
RY101-C	451	3090	X	X	9.9	21	0	2	8/20/2009
RY101-C	539	2980	X	X	9.9	21	2	6	8/20/2009
RY101-C	264	1020	X	X	9.9	21	6	12	8/20/2009

Table 1 continued.

Residential Sample Location	Concentrations prior to the TCRAs		CDM 2011 Target [±]	URS 2012 Actual [±]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY101-D	524	2600		X	9.9	21	0	2	8/20/2009
RY101-D	90.8	683		X	9.9	21	2	6	8/20/2009
RY101-E	22.8	216			22.8	216	0	2	8/20/2009
RY101-E	53.2	541			53.2	541	2	6	8/20/2009
RY101-E	208	1120			208	1120	6	12	8/20/2009
RY102-A	30.7	250			30.7	250	0	2	8/20/2009
RY102-A	20.9	99.1			20.9	99.1	2	6	8/20/2009
RY102-A	14.8	195			14.8	195	6	12	8/20/2009
RY102-B	25.1	195			25.1	195	0	2	8/20/2009
RY102-B	60.9	410			60.9	410	2	6	8/20/2009
RY102-B	30.4	1020			30.4	1020	6	12	8/20/2009
RY102-C	15	112			15	112	6	12	8/20/2009
RY102-D	732	5140	X	X	9.9	21	0	2	8/20/2009
RY102-D	427	2130	X	X	9.9	21	2	6	8/20/2009
RY102-D	96	557	X	X	9.9	21	6	12	8/20/2009
RY108-B	17.9	81.3			17.9	81.3	2	6	8/20/2009
RY108-B	27	117			27	117	6	12	8/20/2009
RY108-E	85.1	631			85.1	631	2	6	8/20/2009
RY108-E	43.6	325			43.6	325	6	12	8/20/2009
RY109-A	25.6	654			25.6	654	6	12	8/20/2009
RY125-D	127	805	X	X	9.9	21	0	2	8/25/2009
RY125-D	653	3840	X	X	9.9	21	2	6	8/25/2009
RY125-D	678	771	X	X	9.9	21	6	12	8/25/2009
RY130-B	139	1410			139	1410	0	2	8/25/2009
RY139-C	31.5	266			31.5	266	2	6	8/26/2009
RY140-B	815	2880	X	X	9.9	21	2	6	8/26/2009
RY140-B	354	2080	X	X	9.9	21	6	12	8/26/2009
RY140-C	613	3550	X	X	9.9	21	2	6	8/26/2009
RY144-B	16.3	198			16.3	198	2	6	8/26/2009
RY144-B	23.7	250			23.7	250	6	12	8/26/2009
RY144-D	369	637			369	637	2	6	8/26/2009
RY144-D	106	308			106	308	6	12	8/26/2009
RY148-B	1710	4030	X	X	9.9	21	0	2	8/26/2009
RY148-B	695	3420	X	X	9.9	21	2	6	8/26/2009
RY148-B	377	2730	X	X	9.9	21	6	12	8/26/2009
RY148-C	114	476		X	9.9	21	2	6	8/26/2009
RY148-C	17.2	149		X	9.9	21	6	12	8/26/2009
RY160-A	36.4	326			36.4	326	0	2	8/31/2009

Table 1 continued.

Residential Sample Location	Concentrations prior to the TCRAs		CDM 2011 Target [±]	URS 2012 Actual [±]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY160-A	30.8	189			30.8	189	2	6	8/31/2009
RY160-B	180	789			180	789	0	2	8/31/2009
RY176-E	51.7	2190			51.7	2190	2	6	9/1/2009
RY193-C	133	553			133	553	6	12	9/1/2009
RY193-D	47.9	519			47.9	519	0	2	9/1/2009
RY193-D	27.3	167			27.3	167	2	6	9/1/2009
RY198-D	584	4320	X	X	9.9	21	0	2	9/1/2009
RY198-D	302	3940	X	X	9.9	21	2	6	9/1/2009
RY224-D	36.4	261			36.4	261	0	2	9/8/2009
RY224-D	27.7	120			27.7	120	2	6	9/8/2009
RY224-D	44.7	309			44.7	309	6	12	9/8/2009
RY234-D	45.8	30.8			45.8	30.8	2	6	9/9/2009
RY234-D	326	16.3			326	16.3	6	12	9/9/2009
RY240-B	434	4340	X	X	9.9	21	2	6	9/9/2009
RY240-D	212	922	X		212	922	2	6	9/9/2009
RY240-D	813	5540	X		813	5540	6	12	9/9/2009
RY251-D	15.5	143	X	X	9.9	21	0	2	9/10/2009
RY251-D	174	158	X	X	9.9	21	2	6	9/10/2009
RY251-D	53.3	248	X	X	9.9	21	6	12	9/10/2009
RY257-C	296	2660			296	2660	0	2	9/2/2009
RY257-C	9.2	106			9.2	106	2	6	9/2/2009
RY271-D	9.7	119			9.7	119	0	2	9/16/2009
RY271-D	97.2	481			97.2	481	2	6	9/16/2009
RY271-D	221	1030			221	1030	6	12	9/16/2009
RY277-D	22.6	525			22.6	525	2	6	9/15/2009
RY284-A	157	1020			157	1020	0	2	9/15/2009
RY284-A	28.9	506			28.9	506	2	6	9/15/2009
RY284-A	7.3	232			7.3	232	6	12	9/15/2009
RY303-D	1750	6200	X	X	9.9	21	0	2	9/21/2009
RY303-D	122	490	X	X	9.9	21	2	6	9/21/2009
RY303-D	570	4090	X	X	9.9	21	6	12	9/21/2009
RY304-C	15.7	155	X	X	9.9	21	0	2	9/18/2009
RY304-C	474	3810	X	X	9.9	21	2	6	9/18/2009
RY304-C	373	4290	X	X	9.9	21	6	12	9/18/2009
RY312-D	27	225			27	225	2	6	9/21/2009
RY338-C	579	5050	X	X	9.9	21	0	2	9/22/2009
RY338-C	468	4350	X	X	9.9	21	2	6	9/22/2009
RY338-C	327	3190	X	X	9.9	21	6	12	9/22/2009

Table 1 continued.

Residential Sample Location	Concentrations prior to the TCRAs		CDM 2011 Target [±]	URS 2012 Actual [±]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY345-C	40.8	192		X	9.9	21	6	12	9/22/2009
RY352-C	68.2	384			68.2	384	0	2	9/23/2009
RY352-C	76.9	452			76.9	452	2	6	9/23/2009
RY352-C	76.7	488			76.7	488	6	12	9/23/2009
RY361-B	12.9	62.6			12.9	62.6	0	2	7/28/2010
RY361-B	12.7	93.5			12.7	93.5	2	6	7/28/2010
RY361-D	11.6	57			11.6	57	2	6	7/28/2010
RY361-D	10.9	99.7			10.9	99.7	6	12	7/28/2010
RY361-F	21.4	140			21.4	140	0	2	7/28/2010
RY361-F	12.3	71.7			12.3	71.7	2	6	7/28/2010
RY361-F	15	127			15	127	6	12	7/28/2010
RY377-B	3.2	25.4			3.2	25.4	6	12	7/27/2010
RY377-C	6.8	46.3			6.8	46.3	2	6	7/27/2010
RY377-D	21.6	153			21.6	153	0	2	7/27/2010
RY377-D	37.2	201			37.2	201	2	6	7/27/2010
RY377-D	42.3	251			42.3	251	6	12	7/27/2010
RY380-D	29.6	117			29.6	117	6	12	7/14/2010
RY387-A	11.1	91.6			11.1	91.6	2	6	7/29/2010
RY387-D	592	5990	X	X	9.9	21	0	2	7/29/2010
RY387-D	33.3	440	X	X	9.9	21	2	6	7/29/2010
RY387-D	65.7	516	X	X	9.9	21	6	12	7/29/2010
RY387-E	19.5	366			19.5	366	0	2	7/29/2010
RY387-E	21.8	280			21.8	280	2	6	7/29/2010
RY387-E	25.1	384			25.1	384	6	12	7/29/2010
RY395-D	35.6	292			35.6	292	0	2	7/29/2010
RY422-D	229	2110			229	2110	0	2	7/21/2010
RY422-D	95	922			95	922	2	6	7/21/2010
RY422-D	28.6	289			28.6	289	6	12	7/21/2010
RY483-A	5.5	378			5.5	378	0	2	7/22/2010
RY483-A	4.7	296			4.7	296	2	6	7/22/2010
RY483-A	4.1	234			4.1	234	6	12	7/22/2010
RY483-A	4.5	186			4.5	186	6	12	7/22/2010
RY483-B	10.4	502			10.4	502	0	2	7/22/2010
RY483-B	10.5	282			10.5	282	2	6	7/22/2010
RY483-B	9.6	370			9.6	370	6	12	7/22/2010
RY483-C	4.6	143			4.6	143	0	2	7/22/2010
RY483-D	5	577			5	577	6	12	7/22/2010
RY485-E	5.5	371			5.5	371	0	2	7/22/2010

Table 1 continued.

Residential Sample Location	Concentrations prior to the TCRAs		CDM 2011 Target [±]	URS 2012 Actual [±]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY485-F	104	434			104	434	0	2	7/22/2010
RY485-F	19.1	80.1			19.1	80.1	2	6	7/22/2010
RY485-F	25.1	44			25.1	44	6	12	7/22/2010
RY506-A	36.5	469		X	9.9	21	0	2	7/27/2010
RY506-A	22.6	374		X	9.9	21	2	6	7/27/2010
RY506-A	33.7	423		X	9.9	21	6	12	7/27/2010
RY506-C	19.6	295		X	9.9	21	0	2	7/27/2010
RY506-C	26.1	371		X	9.9	21	2	6	7/27/2010
RY506-C	21.4	315		X	9.9	21	6	12	7/27/2010
RY506-C	22.2	305		X	9.9	21	6	12	7/27/2010
RY506-D	72.2	1170		X	9.9	21	0	2	7/27/2010
RY506-D	115	2190		X	9.9	21	2	6	7/27/2010
RY506-D	49.5	760		X	9.9	21	6	12	7/27/2010
RY506-E	12.8	126			12.8	126	0	2	7/27/2010
RY506-E	15.9	179			15.9	179	2	6	7/27/2010
RY506-E	12.1	128			12.1	128	6	12	7/27/2010
RY506-F	220	3790	X	X	9.9	21	0	2	7/27/2010
RY506-F	1880	36800	X	X	9.9	21	2	6	7/27/2010
RY506-F	147	2250	X	X	9.9	21	6	12	7/27/2010
RY506-F	165	2350	X	X	9.9	21	6	12	7/27/2010
RY506-G	9.1	238		X	9.9	21	0	2	7/27/2010
RY506-G	22.2	436		X	9.9	21	2	6	7/27/2010
RY506-G	7.6	143		X	9.9	21	6	12	7/27/2010
RY506-H	6.1	137			6.1	137	0	2	7/27/2010
RY506-H	6.9	147			6.9	147	2	6	7/27/2010
RY506-H	5.8	119			5.8	119	6	12	7/27/2010
RY506-I	13.6	256			13.6	256	0	2	7/27/2010
RY506-I	27	271			27	271	2	6	7/27/2010
RY506-I	17.9	278			17.9	278	6	12	7/27/2010
RY506-J	18	214			18	214	0	2	7/27/2010
RY506-J	17.2	260			17.2	260	2	6	7/27/2010
RY506-J	17.6	234			17.6	234	6	12	7/27/2010
RY506-J	21.3	348			21.3	348	6	12	7/27/2010
RY506-K	12	208			12	208	0	2	7/27/2010
RY506-K	12.1	161			12.1	161	2	6	7/27/2010
RY506-K	12.7	182			12.7	182	6	12	7/27/2010
RY506-L	16	190			16	190	0	2	7/27/2010
RY506-L	19	212			19	212	2	6	7/27/2010

Table 1 continued.

Residential Sample Location	Concentrations prior to the TCRAs		CDM 2011 Target [‡]	URS 2012 Actual [‡]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY506-L	12.8	122			12.8	122	6	12	7/27/2010
RY507-A	0.75	2.8			0.75	2.8	0	2	7/1/2010
RY507-A	0.7	2.7			0.7	2.7	2	6	7/1/2010
RY507-A	0.78	2.2			0.78	2.2	6	12	7/1/2010
RY507-B	1.2	3.3			1.2	3.3	0	2	7/1/2010
RY507-B	23.1	30.6			23.1	30.6	2	6	7/1/2010
RY507-B	1.5	3.6			1.5	3.6	6	12	7/1/2010
RY507-C	1.6	15.3			1.6	15.3	0	2	7/1/2010
RY507-C	1.2	28.2			1.2	28.2	2	6	7/1/2010
RY507-C	0.85	9.5			0.85	9.5	6	12	7/1/2010
RY507-D	1.8	7.4			1.8	7.4	0	2	7/1/2010
RY507-D	3.6	12.5			3.6	12.5	2	6	7/1/2010
RY507-D	3.2	10.3			3.2	10.3	6	12	7/1/2010
RY507-E	5.9	21.4			5.9	21.4	0	2	7/1/2010
RY507-E	5.2	15.6			5.2	15.6	2	6	7/1/2010
RY507-E	4.8	13.5			4.8	13.5	6	12	7/1/2010
RY523-A	17.6	129			17.6	129	0	2	7/1/2010
RY523-A	25.1	168			25.1	168	2	6	7/1/2010
RY523-A	22.2	157			22.2	157	6	12	7/1/2010
RY523-B	18.9	134			18.9	134	0	2	7/1/2010
RY523-B	13.7	129			13.7	129	2	6	7/1/2010
RY523-B	12.5	80.5			12.5	80.5	6	12	7/1/2010
RY523-C	598	6830		X	9.9	21	0	2	7/1/2010
RY523-C	543	2300		X	9.9	21	2	6	7/1/2010
RY523-C	115	721		X	9.9	21	6	12	7/1/2010
RY565-A	9.9	12.2			9.9	12.2	0	2	7/19/2010
RY565-A	10.1	6.36			10.1	6.36	2	6	7/19/2010
RY565-A	10.1	7.03			10.1	7.03	6	12	7/19/2010
RY565-A	9.51	9.12			9.51	9.12	6	12	7/19/2010
RY565-B	9.95	128			9.95	128	0	2	7/19/2010
RY565-B	64.8	1180			64.8	1180	2	6	7/19/2010
RY565-B	28.7	809			28.7	809	6	12	7/19/2010
RY565-C	10	30.1			10	30.1	0	2	7/19/2010
RY565-C	9.89	22.1			9.89	22.1	2	6	7/19/2010
RY565-C	9.99	11.5			9.99	11.5	6	12	7/19/2010
RY565-D	9.4	28.5			9.4	28.5	0	2	7/19/2010
RY565-D	9.87	33.2			9.87	33.2	2	6	7/19/2010
RY565-D	11	46.5			11	46.5	2	6	7/19/2010

Table 1 continued.

Residential Sample Location	Concentrations prior to the TCRAs		CDM 2011 Target [‡]	URS 2012 Actual [‡]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY565-E	10.1	50.9			10.1	50.9	0	2	7/19/2010
RY565-E	10.2	73.6			10.2	73.6	2	6	7/19/2010
RY565-E	18.1	983			18.1	983	6	12	7/19/2010
RY597-D	253	1120			253	1120	2	6	8/10/2010
RY597-D	78.8	238			78.8	238	6	12	8/10/2010
RY600-A	415	3340		X	9.9	21	0	2	8/10/2010
RY600-A	491	1150		X	9.9	21	2	6	8/10/2010
RY600-A	153	17800		X	9.9	21	6	12	8/10/2010
RY616-A	332	867			332	867	2	6	8/12/2010

Data Source: CDM 2011b, URS 2012

- * Arsenic and lead concentrations are provided for those residential properties that had at least one quadrant exceed either the arsenic chronic child environmental media evaluation guide (EMEG) of 15 parts per million (ppm) or the lead soil screening level (SSL) of 400 ppm.
- † Concentrations highlighted in bold either exceed the arsenic chronic child EMEG of 15 ppm or the lead SSL of 400 ppm.
- ‡ The CDM 2011 Target column highlights quadrants (marked with an “X”) that appear in the remedial investigation (RI) report’s Table 5-7 as slated for remediation as part of the 2010/2011 time critical removal action (TCRA) [CDM 2011a]. The URS 2012 actual column highlights quadrants (marked with an “X”) that actually were remediated during the 2010 and 2011 TCRAs. Note that the actual quadrants that were remediated were not listed specifically in the site removal report [URS 2012]; ATSDR used various information sources to match the actual soil removals under the 2010 and 2011 TCRAs to the original CLP laboratory results by quadrant. Information sources included CLP sample field notes for each property contained in Appendix B of the RI, CLP laboratory results, and text descriptions and satellite imagery for each property contained in the site removal report [CDM 2011a, URS 2012]. Documentation in the RI and/or site removal report was not always clear enough to allow a definitive match between the actual soil removal area for a property and the previous RI quadrant delineations and associated CLP results.
- § For quadrants that were cleaned up during the TCRAs (marked with an “X” in the URS 2012 actual column), sample results were replaced with values for arsenic and lead of 9.9 ppm and 21 ppm, respectively. These values correspond to the measured values for the clean topsoil brought in to replace contaminated soil that was removed [URS 2012].

CDM CDM Federal Programs Corporation
 EMEG environmental media evaluation guide
 ppm parts per million
 RI Remedial Investigation
 SSL soil screening level
 TCRA time critical removal effort
 URS URS Operating Services, Inc.

Table 2. Non-Residential Arsenic and Lead Concentrations* prior to and following the 2010/2011 Time-Critical Removal Actions (TCRAs) (5 pages)

Non-Residential Sample Location	Concentrations prior to the TCRA		CDM 2011 Target [‡]	URS 2012 Actual [‡]	Concentrations following the 2010/2011 TCRAs [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY082-A	35.7 [†]	152			35.7	152	0	2	8/19/2009
RY082-A	34.2	177			34.2	177	2	6	8/19/2009
RY082-A	23.6	109			23.6	109	6	12	8/19/2009
RY097-B	17	136			17	136	2	6	8/19/2009
RY097-B	20.3	119			20.3	119	6	12	8/19/2009
RY097-C	27.4	477			27.4	477	0	2	8/19/2009
RY097-C	25.4	353			25.4	353	2	6	8/19/2009
RY097-C	20.1	151			20.1	151	6	12	8/19/2009
RY098-A	125	1160			125	1160	0	2	8/19/2009
RY098-A	151	1260			151	1260	2	6	8/19/2009
RY098-A	131	1350			131	1350	6	12	8/19/2009
RY098-B	97.3	475			97.3	475	0	2	8/19/2009
RY098-C	59.5	392			59.5	392	0	2	8/19/2009
RY098-C	139	1040			139	1040	2	6	8/19/2009
RY098-C	99.1	811			99.1	811	6	12	8/19/2009
RY099-A	12.2	119			12.2	119	0	2	8/19/2009
RY099-A	9.6	103			9.6	103	2	6	8/19/2009
RY099-A	10.5	93.1			10.5	93.1	6	12	8/19/2009
RY099-B	17.6	495			17.6	495	0	2	8/19/2009
RY100-A	66.1	530			66.1	530	0	2	8/19/2009
RY100-A	45.2	437			45.2	437	2	6	9/19/2009
RY100-A	52.3	470			52.3	470	6	12	8/19/2009
RY100-B	23.5	202			23.5	202	0	2	8/19/2009
RY100-B	37.3	297			37.3	297	2	6	8/19/2009
RY100-B	60	532			60	532	2	6	8/19/2009
RY100-B	90.8	715			90.8	715	6	12	8/19/2009
RY100-C	32.9	333			32.9	333	0	2	8/19/2009
RY100-C	26.1	192			26.1	192	2	6	8/19/2009
RY100-C	28.7	240			28.7	240	6	12	8/19/2009
RY106-A	30	237			30	237	0	2	8/20/2009
RY106-A	29.6	158			29.6	158	2	6	8/20/2009
RY106-A	22.1	211			22.1	211	6	12	8/20/2009
RY107-A	22.8	182			22.8	182	0	2	8/20/2009
RY107-A	16.8	133			16.8	133	2	6	8/20/2009
RY107-A	23.5	221			23.5	221	6	12	8/20/2009

Table 2 continued.

Non-Residential Sample Location	Concentrations prior to the TCRA		CDM 2011 Target [‡]	URS 2012 Actual [‡]	Concentrations following the 2010/2011 TCRA [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY111-B	439	1330			439	1330	6	12	9/23/2009
RY112-A	27.8	190	X		27.8	190	2	6	9/24/2009
RY112-A	655	4740	X		655	4740	6	12	8/24/2009
RY112-C	46	319		X	9.9	21	0	2	8/24/2009
RY112-C	102	459		X	9.9	21	2	6	8/24/2009
RY112-E	74.1	383			74.1	383	6	12	8/24/2009
RY115-A	1380	13300	X	X	9.9	21	0	2	9/24/2009
RY115-A	1210	6690	X	X	9.9	21	2	6	9/24/2009
RY115-A	754	20400	X	X	9.9	21	6	12	9/24/2009
RY115-D	38.3	202			38.3	202	6	12	9/24/2009
RY115-E	129	706	X	X	9.9	21	0	2	9/24/2009
RY115-E	465	2930	X	X	9.9	21	2	6	9/24/2009
RY115-E	287	873	X	X	9.9	21	6	12	9/24/2009
RY118-E	5.4	64.3			5.4	64.3	6	12	7/13/2010
RY118-G	6.1	123			6.1	123	0	2	7/13/2010
RY118-G	6.1	111			6.1	111	2	6	7/13/2010
RY118-O	619	3430	X		619	3430	0	2	7/13/2010
RY118-O	172	913	X		172	913	2	6	7/13/2010
RY118-O	404	1180	X		404	1180	6	12	7/13/2010
RY118-P	1750	13800	X	X	9.9	21	0	2	7/13/2010
RY118-P	681	3250	X	X	9.9	21	2	6	7/13/2010
RY118-P	3370	5740	X	X	9.9	21	6	12	7/13/2010
RY136-B	91	434			91	434	2	6	8/25/2009
RY136-B	70.4	608			70.4	608	6	12	8/25/2009
RY136-C	12.4	80.8			12.4	80.8	6	12	8/25/2009
RY146-B	40.5	375			40.5	375	2	6	8/26/2009
RY146-B	425	275			425	275	6	12	8/26/2009
RY213-B	119	717			119	717	0	2	9/3/2009
RY213-B	144	1190			144	1190	2	6	9/3/2009
RY213-B	169	1960			169	1960	6	12	9/3/2009
RY213-C	144	760			144	760	2	6	9/3/2009
RY221-D	25.1	268			25.1	268	2	6	9/3/2009
RY289-F	65.3	677			65.3	677	0	2	9/16/2009
RY289-F	287	763			287	763	2	6	9/16/2009
RY289-G	1340	2750	X		1340	2750	0	2	9/16/2009
RY289-G	1500	7080	X		1500	7080	2	6	9/16/2009
RY289-I	19.7	145			19.7	145	2	6	9/16/2009

Table 2 continued.

Non-Residential Sample Location	Concentrations prior to the TCRA		CDM 2011 Target [‡]	URS 2012 Actual [‡]	Concentrations following the 2010/2011 TCRA [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY289-I	25	148			25	148	6	12	9/16/2009
RY332-A	25.1	406		X	9.9	21	0	2	9/16/2009
RY332-A	34.6	578		X	9.9	21	2	6	9/16/2009
RY332-B	64.1	633	X	X	9.9	21	2	6	9/16/2009
RY332-B	350	4150	X	X	9.9	21	6	12	9/16/2009
RY332-D	22.6	311		X	9.9	21	0	2	9/16/2009
RY332-D	24	258		X	9.9	21	2	6	9/16/2009
RY332-D	57.8	755		X	9.9	21	6	12	9/16/2009
RY366-A	33.8	280			33.8	280	0	2	7/28/2010
RY366-A	26.4	319			26.4	319	2	6	7/28/2010
RY366-A	43.7	592			43.7	592	6	12	7/28/2010
RY366-B	11.9	141			11.9	141	0	2	7/28/2010
RY366-B	12.2	273			12.2	273	2	6	7/28/2010
RY366-C	16.5	119			16.5	119	2	6	7/28/2010
RY366-C	19.4	138			19.4	138	6	12	7/28/2010
RY366-D	23.8	230			23.8	230	0	2	7/28/2010
RY366-D	48.1	331			48.1	331	2	6	7/28/2010
RY366-D	167	495			167	495	6	12	7/28/2010
RY366-E	28	289			28	289	0	2	7/28/2010
RY366-E	25.8	192			25.8	192	2	6	7/28/2010
RY366-E	19.1	146			19.1	146	6	12	7/28/2010
RY369-B	26	343			26	343	0	2	9/24/2009
RY369-B	44.5	1160			44.5	1160	2	6	9/24/2009
RY369-B	25.1	315			25.1	315	6	12	9/24/2009
RY369-E	29.3	135			29.3	135	6	12	9/24/2009
RY386-A	31.2	475			31.2	475	0	2	7/29/2010
RY386-A	98.6	169			98.6	169	2	6	7/29/2010
RY386-A	111	705			111	705	6	12	7/29/2010
RY386-B	191	328			191	328	0	2	7/29/2010
RY386-B	69.5	564			69.5	564	2	6	7/29/2010
RY386-C	52.2	306			52.2	306	0	2	7/29/2010
RY386-C	24.2	142			24.2	142	2	6	7/29/2010
RY386-C	25.6	127			25.6	127	6	12	7/29/2010
RY386-D	78.7	452			78.7	452	0	2	7/29/2010
RY386-D	16.1	106			16.1	106	6	12	
RY392-A	2.8	17.9			2.8	17.9	0	2	7/6/2010
RY392-A	2.9	21.8			2.9	21.8	2	6	7/6/2010

Table 2 continued.

Non-Residential Sample Location	Concentrations prior to the TCRA		CDM 2011 Target [‡]	URS 2012 Actual [‡]	Concentrations following the 2010/2011 TCRA [§]		Start Depth	End Depth	Sample Date
	Arsenic (ppm)	Lead (ppm)			Arsenic (ppm)	Lead (ppm)			
RY392-A	3.6	12.8			3.6	12.8	6	12	7/6/2010
RY392-B	13.4	51.3			13.4	51.3	0	2	7/6/2010
RY392-B	18.4	159			18.4	159	2	6	7/6/2010
RY392-B	29.5	343			29.5	343	6	12	7/6/2010
RY392-C	3.3	29.3			3.3	29.3	0	2	7/6/2010
RY392-C	3	16.8			3	16.8	2	6	7/6/2010
RY392-C	2.5	14			2.5	14	6	12	7/6/2010
RY398-A	53.1	932		X	9.9	21	0	2	7/29/2010
RY398-A	75.3	1250		X	9.9	21	2	6	7/29/2010
RY398-A	66.1	1310		X	9.9	21	6	12	7/29/2010
RY398-B	50.8	451			50.8	451	0	2	7/29/2010
RY398-B	462	2480			462	2480	2	6	7/29/2010
RY398-B	201	1150			201	1150	6	12	7/29/2010
RY398-E	10.4	66			10.4	66	6	12	7/29/2010
RY402-A	65.7	13900			65.7	13900	0	2	7/29/2010
RY403-A	30.3	208			30.3	208	0	2	7/29/2010
RY403-A	15.9	197			15.9	197	6	12	7/29/2010
RY407-A	41.4	215			41.4	215	6	12	7/29/2010
RY407-C	17.3	138			17.3	138	6	12	7/29/2010
RY598-B	30.8	191			30.8	191	2	6	8/10/2010
RY627-B	2620	6700			2620	6700	0	2	8/9/2010
RY627-B	985	3690			985	3690	2	6	8/9/2010
RY627-B	311	1460			311	1460	6	12	8/9/2010
RY627-C	269	1270			269	1270	0	2	8/9/2010
RY627-C	1240	5810			1240	5810	2	6	8/9/2010
RY627-C	555	2790			555	2790	6	12	8/9/2010
RY627-D	34.4	174			34.4	174	0	2	8/9/2010
RY627-D	933	6000			933	6000	2	6	8/9/2010
RY627-D	376	1980			376	1980	6	12	8/9/2010
RY627-E	16	117			16	117	0	2	8/9/2010
RY627-E	11.2	71.1			11.2	71.1	2	6	8/9/2010

Data Source: CDM 2011b, URS 2012

* Arsenic and lead concentrations are provided for those non-residential properties that had at least one quadrant exceed either the arsenic chronic child environmental media evaluation guide (EMEG) of 15 parts per million (ppm) or the lead soil screening level (SSL) of 400 ppm.

† Concentrations highlighted in bold either exceed the arsenic chronic child EMEG of 15 ppm or the lead SSL of 400 ppm.

‡ The CDM 2011 Target column highlights quadrants (marked with an "X") that appear in the remedial investigation (RI) report's Table 5-7 as slated for remediation as part of the 2010/2011 time critical removal action (TCRA) [CDM 2011a]. The URS 2012 actual column highlights quadrants (marked with an "X") that were remediated during the 2010 and 2011 TCRA's. Note that the actual quadrants that were remediated were not listed specifically in the site removal report [URS 2012]; ATSDR used various information sources to match the actual soil removals under the 2010 and 2011 TCRA's to the original CLP laboratory results by quadrant.

Table 2 continued.

Information sources included CLP sample field notes for each property contained in Appendix B of the RI, CLP laboratory results, and text descriptions and satellite imagery for each property contained in the site removal report [CDM 2011a, URS 2012]. Documentation in the RI and/or site removal report was not always clear enough to allow a definitive match between the actual soil removal area for a property and the previous RI quadrant delineations and associated CLP results.

§ For quadrants that were cleaned up during the TCRA's (marked with an "X" in the URS 2012 actual column), sample results were replaced with values for arsenic and lead of 9.9 ppm and 21 ppm, respectively. These values correspond to the measured values for the clean topsoil brought in to replace contaminated soil that was removed [URS 2012].

CDM	CDM Federal Programs Corporation
EMEG	environmental media evaluation guide
ppm	parts per million
RI	Remedial Investigation
SSL	soil screening level
TCRA	time critical removal effort
URS	URS Operating Services, Inc.

Table 3A. Quadrants to be Remediated*

Residential Quadrants				Non-Residential Quadrants	
RY007-A	RY089-I	RY257-C	RY565-E	RY097-C	RY213-C
RY008-A	RY108-E	RY271-D	RY597-D	RY098-A	RY366-A
RY021-D	RY109-A	RY277-D	RY616-A	RY098-B	RY366-D
RY021-E	RY130-B	RY284-A		RY098-C	RY369-B
RY023-A	RY144-D	RY352-C		RY099-B	RY386-A
RY023-B	RY160-B	RY422-D		RY100-A	RY386-B
RY026-C	RY176-E	RY483-B		RY100-B	RY386-D
RY036-C	RY193-C	RY483-D		RY111-B	RY402-A
RY036-D	RY193-D	RY485-F		RY136-B	
RY061-E	RY234-D	RY565-B		RY213-B	

Data Source: EPA 2012a

* ATSDR obtained this list of quadrants from Exhibit 7-7 (Properties Identified for Remediation) in the record of decision for the site [EPA 2012a].

Table 3B. Quadrants that Require Confirmation Sampling*

Residential Quadrants		Non-Residential Quadrants	
RY030-E	RY095-C	RY112-A	RY398-B
RY043-B	RY101-A	RY118-O	
RY086-C	RY101-E	RY146-B [‡]	
RY091-E	RY102-B	RY289-F [†]	
RY095-B	RY240-D	RY289-G [†]	

Data Source: CDM 2011b, EPA 2012a, URS 2012

* ATSDR recommends follow up sampling, preferably using laboratory analysis, to confirm that soil levels are not elevated in these quadrants. Uncertainty exists for these quadrants because (1) previous CLP results were elevated but field XRF results could not replicate the CLP results and therefore no removal occurred during TCRA events, (2) report documentation was not clear enough to allow a definitive match between the actual soil removal area and the previous RI quadrant delineations and associated CLP results, or (3) site documentation indicates discrepancies, such as one document listing the quadrant for potential remediation and another indicating remediation already occurred.

† Although the remedial investigation indicates a small area of RY289-G was remediated, the feasibility study lists both of these quadrants (RY289-F and RY289-G) for potential remediation [CDM 2011a, CDM 2011d].

‡ Quadrant RY146-B is not identified in Exhibit 7-7 (Properties Identified for Remediation) in the record of decision (ROD) for the site [EPA 2012a]. However, the arsenic CLP results for this quadrant (425 parts per million (ppm)) exceed the remediation action level of 100 ppm set forth in the ROD.

Table 4. Estimated Residential Arsenic and Lead Concentrations* following Proposed Remedial Efforts[†] (2 pages)

Residential Sample Location	Arsenic (ppm)	Lead (ppm)	Start Depth	End Depth	Sample Date
RY006-A	27.9	194	6	12	8/3/2009
RY007-D	50.9	247	0	2	8/4/2009
RY007-D	45.1	272	2	6	8/4/2009
RY015-B	66.7	71.1	6	12	8/4/2009
RY018-A	18.5	132	0	2	8/5/2009
RY018-A	42.6	194	2	6	8/5/2009
RY018-A	23.6	117	2	6	8/5/2009
RY018-A	21.7	82.5	6	12	8/5/2009
RY026-A	39.8	172	2	6	8/6/2009
RY026-A	18.1	270	6	12	8/6/2009
RY027-D	22.4	221	2	6	8/6/2009
RY045-C	17.1	114	2	6	8/11/2009
RY046-D	32.4	174	0	2	8/11/2009
RY046-D	52.7	219	2	6	8/11/2009
RY046-D	30.7	169	6	12	8/11/2009
RY058-D	22.4	177	0	2	8/12/2009
RY061-B	25.6	330	0	2	8/12/2009
RY092-E	31.8	346	0	2	8/19/2009
RY092-E	25.8	218	2	6	8/19/2009
RY092-E	24.6	203	2	6	8/19/2009
RY095-D	15.8	40.4	6	12	8/19/2009
RY101-B	16.9	73.8	6	12	8/20/2009
RY102-A	30.7	250	0	2	8/20/2009
RY102-A	20.9	99.1	2	6	8/20/2009
RY102-C	15	112	6	12	8/20/2009
RY108-B	17.9	81.3	2	6	8/20/2009
RY108-B	27	117	6	12	8/20/2009
RY139-C	31.5	266	2	6	8/26/2009
RY144-B	16.3	198	2	6	8/26/2009
RY144-B	23.7	250	6	12	8/26/2009
RY160-A	36.4	326	0	2	8/31/2009
RY160-A	30.8	189	2	6	8/31/2009
RY224-D	36.4	261	0	2	9/8/2009
RY224-D	27.7	120	2	6	9/8/2009
RY224-D	44.7	309	6	12	9/8/2009

Table 4 continued.

Residential Sample Location	Arsenic (ppm)	Lead (ppm)	Start Depth	End Depth	Sample Date
RY312-D	27	225	2	6	9/21/2009
RY361-F	21.4	140	0	2	7/28/2010
RY361-F	15	127	6	12	7/28/2010
RY377-D	21.6	153	0	2	7/27/2010
RY377-D	37.2	201	2	6	7/27/2010
RY377-D	42.3	251	6	12	7/27/2010
RY380-D	29.6	117	6	12	7/14/2010
RY387-E	19.5	366	0	2	7/29/2010
RY387-E	21.8	280	2	6	7/29/2010
RY387-E	25.1	384	6	12	7/29/2010
RY395-D	35.6	292	0	2	7/29/2010
RY506-E	15.9	179	2	6	7/27/2010
RY506-I	27	271	2	6	7/27/2010
RY506-I	17.9	278	6	12	7/27/2010
RY506-J	18	214	0	2	7/27/2010
RY506-J	17.2	260	2	6	7/27/2010
RY506-J	17.6	234	6	12	7/27/2010
RY506-J	21.3	348	6	12	7/27/2010
RY506-L	16	190	0	2	7/27/2010
RY506-L	19	212	2	6	7/27/2010
RY507-B	23.1	30.6	2	6	7/1/2010
RY523-A	17.6	129	0	2	7/1/2010
RY523-A	25.1	168	2	6	7/1/2010
RY523-A	22.2	157	6	12	7/1/2010
RY523-B	18.9	134	0	2	7/1/2010

Data Source: CDM 2011b, URS 2012

- * Arsenic and lead concentrations are provided for those residential properties that had at least one quadrant exceed either the arsenic chronic child environmental media evaluation guide (EMEG) of 15 parts per million (ppm) or the lead soil screening level (SSL) of 400 ppm.
- † Sampling data for those quadrants provided in Tables 3A and 3B, Appendix B, were removed from the data set because for the future scenario, ATSDR assumes those quadrants in Table 3A will be remediated and in Table 3B will be sampled and then remediated, if needed.

EMEG environmental media evaluation guide
 ppm parts per million
 SSL soil screening level

Table 5. Estimated Non-Residential Arsenic and Lead Concentrations* following Proposed Remedial Efforts[†] (2 pages)

Non-Residential Sample Location	Arsenic (ppm)	Lead (ppm)	Start Depth	End Depth	Sample Date
RY082-A	35.7	152	0	2	8/19/2009
RY082-A	34.2	177	2	6	8/19/2009
RY082-A	23.6	109	6	12	8/19/2009
RY097-B	17	136	2	6	8/19/2009
RY097-B	20.3	119	6	12	8/19/2009
RY100-C	32.9	333	0	2	8/19/2009
RY100-C	26.1	192	2	6	8/19/2009
RY100-C	28.7	240	6	12	8/19/2009
RY106-A	30	237	0	2	8/20/2009
RY106-A	29.6	158	2	6	8/20/2009
RY106-A	22.1	211	6	12	8/20/2009
RY107-A	22.8	182	0	2	8/20/2009
RY107-A	16.8	133	2	6	8/20/2009
RY107-A	23.5	221	6	12	8/20/2009
RY112-E	74.1	383	6	12	8/24/2009
RY115-D	38.3	202	6	12	9/24/2009
RY221-D	25.1	268	2	6	9/3/2009
RY289-I	19.7	145	2	6	9/16/2009
RY289-I	25	148	6	12	9/16/2009
RY366-C	16.5	119	2	6	7/28/2010
RY366-C	19.4	138	6	12	7/28/2010
RY366-E	28	289	0	2	7/28/2010
RY366-E	25.8	192	2	6	7/28/2010
RY366-E	19.1	146	6	12	7/28/2010
RY369-E	29.3	135	6	12	9/24/2009
RY386-C	52.2	306	0	2	7/29/2010
RY386-C	24.2	142	2	6	7/29/2010
RY386-C	25.6	127	6	12	7/29/2010
RY392-B	18.4	159	2	6	7/6/2010
RY392-B	29.5	343	6	12	7/6/2010
RY403-A	30.3	208	0	2	7/29/2010
RY403-A	15.9	197	6	12	7/29/2010
RY407-A	41.4	215	6	12	7/29/2010
RY407-C	17.3	138	6	12	7/29/2010

Table 5 continued.

Non-Residential Sample Location	Arsenic (ppm)	Lead (ppm)	Start Depth	End Depth	Sample Date
RY598-B	30.8	191	2	6	8/10/2010
RY627-B	2620	6700	0	2	8/9/2010
RY627-B	985	3690	2	6	8/9/2010
RY627-B	311	1460	6	12	8/9/2010
RY627-C	269	1270	0	2	8/9/2010
RY627-C	1240	5810	2	6	8/9/2010
RY627-C	555	2790	6	12	8/9/2010
RY627-D	34.4	174	0	2	8/9/2010
RY627-D	933	6000	2	6	8/9/2010
RY627-D	376	1980	6	12	8/9/2010
RY627-E	16	117	0	2	8/9/2010

Data Source: CDM 2011b, URS 2012

* Arsenic and lead concentrations are provided for those residential properties that had at least one quadrant exceed either the arsenic chronic child environmental media evaluation guide (EMEG) of 15 parts per million (ppm) or the lead soil screening level (SSL) of 400 ppm.

† Sampling data for those quadrants provided in Tables 3A and 3B, Appendix B, were removed from the data set because for the future scenario, ATSDR assumes those quadrants in Table 3A will be remediated and in Table 3B will be sampled and then remediated, if needed. Also of note, the ROD for the site acknowledges that high levels of arsenic and lead will remain at property RY627 and that institutional controls are needed to protect human health [EPA 2012a].

EMEG environmental media evaluation guide

ppm parts per million

SSL soil screening level

Table 6. Definition of statistical terms*

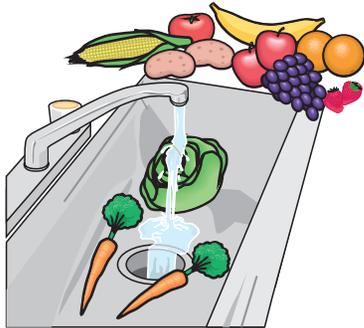
Term	Definition
Minimum	The minimum is the lowest value in the data set.
Maximum	The maximum is the highest value in the data set.
Mean	The mean, also called the average, is a measure of the center of the data. The mean is obtained by adding all of the data values together and dividing the total by the number of data values.
Median	The median, also known as the 50th percentile, is another measure of the center of the data. If the data are ordered from highest to lowest, the median is the value that is in the middle of the data. For any given data set, 50% of the data will be above the median and 50% of the data will be below the median. Because the median is less affected by extreme values in the data, it can be a better—or more robust—central measure than the average.
25 th percentile	The 25 th percentile is the value that delineates the lowest 25% of the data values from the upper 75% of the data values.
75 th percentile	The 75 th percentile is the value that delineates the highest 25% of the data values from the lowest 75% of the data values.
Interquartile range	The interquartile range (IQR) is the range between the first and third quartiles (Q3-Q1), which corresponds to the data within the 25 th and 75 th percentiles. The range represents 50% of the data.
Standard deviation	The standard deviation of a data set is a measure of how much the data values vary from the mean, or average value. The larger the standard deviation, the more the data values are spread out in a range around the mean.
Confidence interval	A confidence interval is a range of values that will likely contain the value of the parameter of interest—the mean for example. A confidence interval typically has a percentage level associated with it that indicates how often the interval will contain the true value of the parameter of interest. Common levels for the confidence interval are 90%, 95%, and 99%.

* Reference Exhibit 2 for application of these terms to the site-related arsenic and lead data.

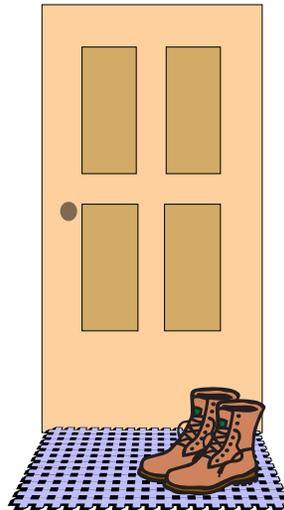
Appendix C: Ways to Protect your Health

Ways to protect your health

By keeping dirt from getting into your house and into your body



Wash and peel all fruits, vegetables, and root crops



Wipe shoes on doormat or remove shoes



Don't eat food, chew gum, or smoke when working in the yard



Damp mop floors and damp dust counters and furniture regularly



Wash dogs regularly



Wash children's toys regularly



Wash children's hands and feet after they have been playing outside

Appendix D: Record of Decision, Alternative 4

Record of Decision, Alternative 4

In July 2012, the U.S. Environmental Protection Agency (EPA) released its record of decision (ROD) for the Flat Creek IMM site [EPA 2012a]. The ROD documented Alternative 4 as the selected remedy [EPA 2012a]. The following text provides a brief description of Alternative 4 as outlined in the ROD.

Alternative 4: Excavation and Disposal of Contaminated Soils at the Mine Waste Joint Repository

Excavation of Contaminated Soils

All contaminated soils above remedial action levels (RALs) on individual properties would be excavated. Confirmation that soils remaining in excavations are below RALs for lead, arsenic, and antimony would be made by visual inspections for mine waste as well as sample collection and analysis. Soils failing confirmation sampling will be removed until RALs are achieved. The repository at the Mineral County Airport would also be completely excavated.

Health and safety precautions, dust suppression, personal protective equipment, and monitoring, would be used during excavation of contaminated soils to reduce risks to workers. Water- or chemical-based dust suppression would prevent inhalation exposure of contaminants.

Excavation of contaminated surface material would be conducted to the extent practicable. However, it may not be possible to excavate contaminated soils underneath or adjacent to structures or obstructions. Thus, residual contaminated soils may be left in place in some locations. A geotextile barrier or another barrier material placed in the sidewalls of these excavations coupled with land use controls (LUCs) may be used to address these situations, and will be determined on a property-by-property basis during remedial design.

Disposal

The excavated contaminated soils would be disposed of at the newly-constructed Wood Gulch Repository, north of Superior on Flat Creek Road, within lands currently owned by the State of Montana, Department of Natural Resources and Conservation. Health and safety precautions would be used during placement of contaminated soils to reduce risks to workers. The repository would be operated and maintained under OU2.

Excavation Backfill

Excavations would be backfilled to existing grade. Clean soil would be transported from offsite borrow areas. Backfilled areas would be covered with topsoil and revegetated or otherwise restored to match the surface conditions that previously existed, such as structural fill and gravel for a driveway.

Land Use Controls

LUCs would consist of a combination of institutional controls (ICs) and community awareness activities to restrict use of contaminated areas and provide awareness of risks from exposure. LUCs would be tailored for each property, based on the type and extent of contaminated soils and type of ownership.

- ICs would consist of governmental controls, proprietary controls and/or informational devices selected on a per property basis depending on ownership status and degree of contamination. ICs would be layered to enhance protectiveness. Issuance and periodic review and update of a detailed ICs plan likely would be required to track the ICs at each property where contamination is left in place.
- ICs may also include community awareness activities such as informational and educational programs to inform the public about site risks and risk reduction activities. Information could be provided using electronic (e-mails and web site updates), printed (flyers, facts sheets, newspaper articles, or signs), and/or personal communication methods (public meetings or personal visits). These activities would occur throughout the remedial process, especially during implementation of remedial action and annually thereafter.

Monitoring

Monitoring during construction would consist of borrow source testing for lead, arsenic, and antimony (at a minimum) to determine if the proposed offsite borrow area materials were suitable for use in construction.

Five-year site reviews would be performed at those properties where contaminated soils would or might remain at concentrations that do not allow for unlimited use and unrestricted exposure. This would include non-intrusive visual inspections. Annual monitoring of ICs would be required.