Public Health Assessment

WASHINGTON COUNTY LEAD DISTRICT – FURNACE CREEK AREA

WASHINGTON COUNTY, MISSOURI

EPA FACILITY ID: MON000705842

Prepared by
Missouri Department of Health and Senior Services

FEBRUARY 11, 2016

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR's Cooperative Agreement Partner pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR's Cooperative Agreement Partner which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Section for Environmental Public Health
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SUMMARY

INTRODUCTION

The Missouri Department of Health and Senior Services (DHSS), in cooperation with the Federal Agency for Toxic Substances and Disease Registry (ATSDR), has developed this public health assessment to evaluate the public health impacts of exposure to lead and other metals found in soil and well water at the Washington County Lead District – Furnace Creek Area site, which was listed on the United States Environmental Protection Agency's (EPA's) National Priorities List (NPL) in 2011. Lead contamination of residential soils and well water at the site is a result of former lead mining, milling, and smelting activities in the area and use of lead mining wastes as landscaping and fill material. There are also concerns about the physical hazards associated with past mining activities, including abandoned diggings and shafts.

CONCLUSIONS

DHSS has reached four important conclusions in this public health assessment:

Conclusion 1
Soil

Exposure to lead-contaminated soil or mine tailings found in many of the residential yards and driveways within the Furnace Creek Area could harm individuals' health and presents a public health hazard. This conclusion applies to past incidental or intentional ingestion (swallowing) of lead at some residences at this site. This conclusion may also apply to present and future ingestion of lead at some residences that have not been sampled and/or remediated. Exposure to cadmium, which was also found to contaminate some residential soils, is not expected to harm people's health.

Basis for Decision

Soils in residential yards/driveways and mining areas throughout the Furnace Creek Area have been found by EPA to contain elevated levels of lead. Lead exposure can adversely affect the nervous system, especially in fetuses and children less than 72 months of age. Individuals, especially children and women of child-bearing age, can be directly exposed to dangerous levels of lead in this contaminated soil by incidentally ingesting the soil while working, playing, gardening, or spending time in the yard. This contaminated soil can be tracked indoors on shoes, pets, and other routes and accumulate in the home. Individuals, especially children, can incidentally ingest this contaminated soil in the home. Although not a major route of exposure, individuals can also be exposed by inhalation to contaminated dust in the yard and contaminated dust in the home. When this soil or dust is stirred up

and becomes airborne, individuals, especially children, may breathe it in and then clear it from their lungs and swallow it.

Some residential soils were also found to contain elevated concentrations of cadmium. However, estimated doses of cadmium exposure were below levels shown to have an adverse health effect.

EPA has removed soil from several residential yards/driveways found to contain lead concentrations above EPA's Removal Action criteria. The removal criteria include lead concentrations in yard soil at or above 1,200 parts per million (ppm) or, where sensitive individuals (e.g., children less than 72 months of age; pregnant women) are living, lead concentrations at or above 400 ppm. After EPA has completed its Removal Action and later Remedial Action to replace lead contaminated soils with clean soil, the possibility of future exposures to lead and other metals in those yards is likely to be reduced.

EPA has not sampled and/or remediated all residences in the Furnace Creek Area. Properties that have not been sampled and/or remediated could contain lead contaminated soil above EPA criteria and may continue to pose exposure risks.

Conclusion 2
Groundwater

Drinking untreated private well water contaminated with lead and/or cadmium may harm individuals' health and presents a public health hazard. This conclusion applies to past, current, and future ingestion of lead and/or cadmium in well water at some residences at this site, unless a water treatment system has been installed.

Basis for Decision

A number of private drinking water wells in the Furnace Creek Area were found to contain lead concentrations greater than EPA's action level of 15 parts per billion (ppb) for public water systems. Some wells contained cadmium above ATSDR's Environmental Media Evaluation Guide (EMEG) of 1 ppb for long-term drinking water exposure. Lead exposure can adversely affect the nervous system, especially in fetuses and children less than 72 months of age. Long-term exposure to low levels of cadmium in water may lead to a buildup of cadmium in the kidneys and possible kidney disease, especially in young children.

EPA's current site-specific action levels for lead and cadmium in private well water in Washington County are 15 ppb and 5 ppb, respectively. If lead or cadmium in private well water exceeds

those values, EPA has provided residents with alternative sources of drinking water. Residents with private wells containing less than 15 ppb lead or 5 ppb cadmium should also consider using a treatment system or an alternative water supply due to the health risks posed by exposure to even low levels. This may be especially important due to the elevated risks of exposure to lead in soil in the Furnace Creek Area.

Individuals who have refused EPA's temporary alternative sources of water or have not had their well tested may still be drinking water from a contaminated private well. If those individuals are not drinking water from an alternative source or are not effectively filtering their well water, they may continue to be exposed to contaminants at levels that may harm their health or their unborn child's health.

Conclusion 3
Other lead sources

Past, present, and future exposure to lead contaminated paint and a number of other lead sources may harm individuals' health, especially the health of children and fetuses.

Basis for Decision

The Furnace Creek area was the site of lead mining, processing, and smelting since the early 1700s, and remnants of those activities remain in the environment. Besides the lead mining, 61% of the homes in Washington County were built before 1979 when lead-based paint was used. Lead paint remediation should be done using EPA guidelines or a certified lead abatement contractor.

Conclusion 4
Other pathways

DHSS cannot currently conclude whether exposure to lead and other metals in sediment, surface water, fish, and edible plants in the Furnace Creek Area could harm individuals' health. High concentrations of lead and other metals in soils, as well as physical hazards, are also expected to exist in the past mining areas. The information needed to make decisions on these exposures is very limited.

Basis for Decision

Concentrations of lead and other metals in other environmental media (e.g., sediment, surface water, fish, and edible plants) may vary greatly between mining areas. Limited sampling has been done in water bodies (streams, lakes, and impoundments), sediment, and fish associated with the mining areas in the Furnace Creek. EPA and other agencies are currently investigating the risks of other routes of metal exposure in lead mining areas in Missouri.

NEXT STEPS

To protect residents:

1. During the Remedial Action phase, EPA are expected to continue to sample untested residential soil and private well water and offer remedial action at residences where elevated concentrations of lead or other metals may harm individuals' health.

2. DHSS recommends that EPA, the Missouri Department of Natural Resources (MDNR), and other agencies continue to sample other media, such as sediment, surface water, fish, and edible plants, so it can be determined if exposure to lead and other metals in these media may harm individuals' health.

3. DHSS recommends that EPA consider removal of contaminated soils and eliminate physical hazards left from past mining activities, as appropriate when found.

4. DHSS will coordinate with the Washington County Health Department, MDNR, and EPA to address community health concerns and questions as they arise by providing health professional and community education.

5. DHSS will continue to coordinate with the Washington County Health Department to provide health education to the residents of Washington County and encourage them to have their residential yard soils and private drinking water tested for lead and cadmium and remediated when elevated levels are found.

6. DHSS will assist the Washington County Health Department in educating the public on the various pathways of exposure to lead and cadmium and continue to promote prevention of lead exposure from all sources. We will also encourage residents of Washington County to have their blood lead levels tested. Children less than 72 months of age and women of child-bearing age are encouraged to have their blood lead levels tested on a yearly basis. Since 2004, between 16% and 27% of children less than 72 months of age in Washington County were tested.

7. DHSS will coordinate with the Washington County Health Department, MDNR, and EPA to implement the recommendations in this public health assessment.

8. DHSS will review and comment on any additional data from environmental samples collected by EPA, MDNR, or other agencies as they become available.

FOR MORE INFORMATION

If you have concerns about this Washington County Lead District – Furnace Creek Area Public Health Assessment, you can contact the Missouri Department of Health and Senior Services at (573) 751-6102 or, toll free, at (866) 628-9891

PURPOSE AND HEALTH ISSUES

The Missouri Department of Health and Senior Services (DHSS), in cooperation with the Federal Agency for Toxic Substances and Disease Registry (ATSDR), has developed this public health assessment to evaluate the public health impacts of the Washington County Lead District – Furnace Creek Area site. ATSDR, located in Atlanta, Georgia, is a Federal agency within the United States (U.S.) Department of Health and Human Services and is authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) to conduct public health assessments at hazardous waste sites.

The primary contaminant of concern in the Washington County Lead District – Furnace Creek Area is lead in soil and drinking water that were contaminated as a result of former lead mining, milling, and smelting activities in the area. Elevated concentrations of lead have been found in soils at several former mining sites and in soil, sediment, and lead mining waste materials used for residential landscaping purposes in driveways and yards. To a lesser extent, cadmium infrequently detected in private drinking water is also a contaminant of concern in the area. Physical hazards may also be present at some of the mining sites.

This public health assessment will determine if exposures to site related contaminants have occurred in the past, are presently occurring, or are likely to occur in the future at a level of health concern and recommend actions to reduce or prevent exposures and possible adverse health effects.

BACKGROUND

Site Description and History

The Washington County Lead District – Furnace Creek Area encompasses approximately 175 square miles, covering the whole southeast corner of Washington County (see Figure 1 in Appendix A). The Furnace Creek Area lies directly south of Potosi, Missouri and includes the towns of Caledonia, Irondale, and Belgrade. Potosi is located approximately 60 miles southwest of St. Louis, Missouri. The U.S. Environmental Protection Agency (EPA) proposed adding the Washington County Lead District – Furnace Creek Area to their National Priorities List (NPL) on October 19, 2010 and added the site to the NPL on March 10, 2011.

Washington County is part of the Old Lead Belt where lead mining, milling, and smelting activities occurred for over 200 years [TetraTech EM Inc. 2010a; TetraTech EM Inc. 2010b]. Lead was originally found on or near the ground surface and was later mined from shafts less than 10 feet deep in the red clay residuum and fractured bedrock by the pick and shovel method. Mechanization was first introduced in 1819 when a drill was used for blasting. By the late 1800s, a number of mines had penetrated the bedrock at

depths of 100 feet or more. Past mining has left large and small areas of disturbed land along with associated water retention ponds or pits. These disturbed areas and diggings are situated throughout the Furnace Creek Area. Five areas of concentrated mining and diggings have been delineated by EPA as potential study areas [TetraTech EM Inc. 2009a; TetraTech EM Inc. 2010b]. One of those study areas is the 72-acre site known as the Furnace Creek Tailings Pond and associated disturbed area. The Furnace Creek Area is also part of the barite mineralization area that was the world's leading producer of barite before declining in the 1980s.

Land Use, Natural Resources, and Geology

Except for the small communities of Caledonia, Belgrade, and Irondale, the Furnace Creek Area is primarily rural residential with some businesses located mostly along state highways in the wooded northern portion of the site. The Furnace Creek Area consists of approximately 175 square miles of wooded rolling hills that becomes flatter and less wooded with more pasture and some cropland in the southwestern portion of the site. In the southwestern portion, residences are still scattered and consist of single family housing areas on small to large acreage with private wells.

Historical mining in the area consisted of past lead and some barite mining in certain areas listed as potential study areas shown in Figures 2 and 3 in Appendix A [TetraTech EM Inc. 2009a; TetraTech EM Inc. 2010b]. Other natural resources include forest land, which was and is still being harvested to an extent, and the pasture and farmland of the southwestern part of the site. The Big River and smaller streams as well as small impoundments provide some recreation areas and places to fish.

Bedrock within the site area is dolomite (carbonate rock) that is susceptible to being dissolved or undergoing karstification. These carbonate formations in and near the study areas contain sinkholes, springs, losing streams, and caves. The site area is structurally complex with numerous faults present in the areas. The Ozark aquifer is the most important aquifer for water production. Underlying the Ozark aquifer is the St. Francois confining layer that hydrologically separates the Ozark aquifer from the deeper St. Francois aquifer. The St. Francois aquifer is a significant source of groundwater in the southern portion of the Furnace Creek site. Besides the fracturing between the aquifers, numerous exploration drill holes may also penetrate the confining layer and allow circulation between the aquifers. [TetraTech EM Inc. 2009a; TetraTech EM Inc. 2010b]

Demographics

A demographic statistics map developed by ATSDR (Figure 1, Appendix A) shows the population of the Furnace Creek area. The total population of the site within a one mile buffer zone is 9,080. The population of this area is 97.6% white, 0.29% black, 0.75% American Indian and Alaska Native, 0.1% Asian, less than 0.1% Native Hawaiian and other races, 1% two or more races, and 0.7% Hispanic or Latino. The percentage of children aged six and younger is 9.2%, and the percentage of adults aged 65 and older is 12.8%. The percentage of females aged 15 to 44 is 20.2%. According to the 2000 U.S.

Census, the percentage of families below the poverty level for 1999 in Washington County was 17.1% [ATSDR 2011]. The percentage of homes that were built before 1979 was 61% [ATSDR 2011].

Site Investigations

EPA began a removal assessment of the Furnace Creek Area after lead levels in other former mining areas of Washington County were found to be elevated and required remediation work to protect public health. From May 2008 to January 2009, EPA collected initial soil and well water samples to determine if the Furnace Creek Area had similar levels of contamination. EPA screened 428 residences and sampled 207 private drinking water wells [EPA 2010]. In that sampling effort, 145 properties were found to have surface (0-1 inch) soil that contained lead concentrations above EPA's Removal Action Levels (RALs). A total of 112 residences had lead concentrations greater than 400 parts per million (ppm), the RAL for the protection of sensitive residents (i.e., children less than 72 months of age; pregnant women). EPA's RAL of 400 ppm is based on the results of their Integrated Exposure Uptake Biokinetic (IEUBK) model that predicts blood lead concentrations of children up to 72 months of age exposed to environmental lead contamination. A total of 33 residences had lead concentrations in soil greater than 1,200 ppm [EPA 2010], the RAL for protection of all members of the public. Of the 207 private wells sampled, three contained lead concentrations that exceeded EPA's action level of 15 parts per billion (ppb) for lead in public drinking water systems. Exceedances ranged from 17.7 to 82.2 ppb [TetraTech 2009a].

Based on their findings, EPA initiated actions to remove residential soils with lead concentrations above RALs and provide a temporary alternative water source to residents with lead concentrations in private drinking water above the action level. EPA also made plans to continue sampling residential properties in the Furnace Creek Area for lead, cadmium, and barium contamination.

As of February 2013, over 1,500 properties had been sampled [Black & Veatch 2013]. A total of 497 of those properties contained lead in soil above 400 ppm. EPA had conducted removal activities at 160 properties because they (a) contained lead in soil above 1,200 ppm or (b) contained lead in soil above 400 ppm and were properties where sensitive individuals resided [Black & Veatch 2013]. It was estimated that, with continued remedial action and additional sampling, 485 additional properties would be assigned to the Non-Time Critical Action category to be cleaned up under future remedial action [Black & Veatch 2013]. Non-time critical properties are properties where sensitive individuals did not reside and where lead in soil was found to exceed the action level of 400 ppm but not 1,200 ppm.

A total of 147 residential properties contained cadmium in soil above ATSDR's screening level of 5 ppm for child exposure. One residential property contained barium in soil above ATSDR's screening level of 10,000 ppm for child exposure. All but ten of those properties also contained elevated concentrations of lead in soil and were scheduled

for remediation. Cadmium concentrations at the other ten residences were less than 10 ppm.

As of February 2013, over 1,100 private wells were sampled [Black & Veatch 2013]. Of those, 14 purged spigot and/or kitchen faucet samples were found to contain lead above the EPA's action level of 15 ppb. Sampling at kitchen faucets found only eight residences with lead levels above the EPA's action level. Unless residences had some sort of water treatment device that lowers the lead concentration to below the action level, EPA provided a temporary source of safe drinking water until a permanent solution could be found.

At five additional residential properties, purged spigot and/or kitchen faucet samples were found to contain cadmium above ATSDR's screening levels of 1 ppb and 3.5 ppb for chronic exposures in children and adults, respectively. Only three samples at kitchen faucets contained cadmium levels above ATSDR's screening levels. None of the samples contained cadmium concentrations exceeding EPA's action level.

See Table 1 for a summary of contaminant levels in residential soils and private well water. The health risks of exposure the lead and cadmium are further addressed in the *Discussion* section.

Table 1
Summary of Metal Contaminants in the Washington County Lead District—Furnace Creek Area Soil and Private Well Water, May 2008 - November 2011[a]

Contaminant	Locations	Media	Maximum Concentration	Screening Value & Source
Lead	Residences	Yard Soil Driveways	144,300 ppm	400 (implemented) 430 ppm (calculated) EPA[b]
Cadmium	Residences	Yard Soil Driveways	96.8 ppm	5 ppm ATSDR EMEG 70 ppm EPA RSL†
Barium	Residences	Yard Soil Driveways	15,200 ppm	10,000 ppm ATSDR EMEG 15,000 ppm EPA RSL†
Lead	Private Drinking Water Wells	Water	378 ppb	15 ppb EPA PDW Action Level[b]
Cadmium	Private Drinking Water Wells	Water	4.66 ppb	1 ppb, 3.5 ppb ATSDR EMEGs 5 ppb EPA MCL†
Barium	Private Drinking Water Wells	Water	1,870 ppb	2,000 ppb ATSDR EMEG and EPA MCL

[a]Black &Veatch 2013; surface soil samples and purged spigot or kitchen faucet water samples
[b]ATSDR has not developed a screening value
ppm = parts per million
ppb = parts per billion
ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide
EPA RSL = Environmental Protection Agency Regional Screening Level
EPA PDW Action Level = Environmental Protection Agency Public Drinking Water Action Level
EPA MCL = Environmental Protection Agency Maximum Contaminant Level for Public Water Supplies
†EPA's action level for remediating soil or providing alternative drinking water

Source Areas/Study Areas

In the assessment of the Furnace Creek Area, EPA also investigated and sampled areas where the Missouri Department of Natural Resources (MDNR) Inventory of Mines Occurrences and Prospects (IMOP) database had identified historical mining operations. EPA identified five study areas where mining and disturbed land were present (see

Figures 2 and 3 in Appendix A). Soil, tailings ponds, drainage water ways, and sediment were sampled in February and April of 2010 [TetraTech EM Inc. 2009a; TetraTech EM Inc. 2010b]. Concentrations of metals found during those sampling events are listed in Table 2.

Most of the source sites are not easily accessible. During a site visit on June 23, 2011, a DHSS employee and the EPA On-Site Coordinator visited the Furnace Creek Tailing Area and Pond (Area 22). Although the site was isolated and access was difficult, there were visible signs of some activities at the site, such as all-terrain vehicle riding, partying, and possibly fishing in the impoundment. Some foundation structures were also seen that could be a safety hazard.

On the MDNR's IMOP, there are listings of some zinc mines. During the June 23, 2011 site visit, the DHSS and EPA personnel also visited one of those mines and found it to be on private property with limited access. In EPA's investigation of that site, no elevated levels of lead were detected. Although public exposure is not expected to occur, if more information or concern arises, EPA will consider further evaluation of the site.

Table 2

Summary of Contaminant Concentrations[a]
at Source Areas and Associated Drainage Streams
Washington County Lead District – Furnace Creek Area

Source Area	Media and Range of Concentrations In parts per million (ppm) unless otherwise noted			Screening Value
	Media	Lead	Arsenic	ATSDR has no screening values for lead in soil. EPA calculated a screening value of 430 ppm for the Furnace Creek Area but is remediating residential yards with over 400 ppm of lead in soil. Arsenic in soil - 15 ppm ATSDR EMEG – child ATSDR has no screening value for lead in water. EPA's Action Level for lead in public drinking water is 15 ppb.
Furnace Creek Mine	Soil/ Tailings	88.3 – 67,000	3.15 – 133	
Irondale Mine	Soil/ Tailings	223 – 195,000	7.32 – 42.8	
Forker Diggings	Soil/ Tailings	73.1 – 1,284	3.21 – 23.8	
Drainage Streams	Sediment	6.27J – 120,000	2.38 – 27.1	
Drainage Streams	Water	ND – 5.73 ppb (J)	ND	

[a]TetraTech EM Inc. 2010b
ATSDR EMEG = ATSDR Environmental Media Evaluation Guide
ppb = parts per billion
ND = not detected
J = The identification of the analyte is acceptable; the reported value is an estimate

Remedial Action

Removal Actions have been completed at all residences in the Furnace Creek Area, except remediated locations that require repair and properties where access was not granted or no contact was made. To address those properties found to meet Non Time-Critical Removal Action criteria, EPA will undertake Remedial Action on contaminated soil/driveways and provide a permanent solution to the lead contaminated well problems. Because the site is so large and complicated, EPA will separate the Remedial Action areas into four Operable Units [EPA 2011]. The Operable Units (OUs) for the Furnace Creek Remedial Action are:

OU-01	Residential Soils
OU-02	Groundwater
OU-03	Mine waste and railroad grades
OU-04	Surface water and sediment

Other Sources of Exposure to Contamination

Another source of lead exposure is lead-based paint, since a large percentage of homes in Washington County were built before 1979. The use of lead-based paint in residential buildings was not restricted until 1978. In Washington County, 61% of the homes were built before 1979. Areas of deteriorating and cracking lead paint and areas of friction where the lead paint is ground to dust are areas where children can easily be exposed to lead contamination through their high hand-to-mouth activity [CDC 2005].

Air sampling for lead has not been done and is not considered a major pathway of exposure unless the lead-contaminated material is disturbed. Considering that the mine tailings areas are mostly located in rural areas with some vegetation being present and not like the large tailings pile areas of St. Francois and Madison Counties, wind doesn't seem to affect and move the lead contaminated materials like it does at the large tailings piles. However, airborne lead in soil or dust could potentially be a concern, especially for residents who live on or near unpaved roads where the lead contaminated materials were used as surface materials.

Quality Assurance and Quality Control

Various people, organizations, and contractors have been involved in the sampling, research, and analyses at this site, resulting in Quality Assurance and Quality Control (QA/QC) information of varying degrees of accuracy and precision. In preparing this public health assessment, DHSS and ATSDR have relied on the information provided in the referenced documents and have assumed that adequate quality assurance and quality control measures were followed with regard to chain-of-custody, laboratory procedures, and data reporting. The validity of the analysis and, therefore, the conclusions in this public health assessment are valid only if the referenced information is complete and reliable.

Results of Blood Lead Testing of Children in Washington County

DHSS reviewed the data on blood lead levels collected by Missouri counties as part of the U.S. Centers for Disease Control and Prevention's (CDC's) nationwide lead surveillance program to understand the general prevalence of elevated blood lead levels in children in Washington County. According to CDC, children less than 72 months of age are at greatest risk of the adverse effects of lead exposure. In the past, CDC used 10 microgram per deciliter (µg/dL) as the blood-lead level at which public health actions should be initiated [CDC 2005]. In cases where children's blood-lead levels were found to exceed 10 µg/dL, follow-up and intervention activities have taken place to lower those levels.

In 2004, prior to the Washington County Lead District – Furnace Creek Area being listed as a NPL site, approximately 19% of children in Washington County less than 72 months of age (i.e., 348 children of the 2000 U. S. Census population of 1,844 children) had their blood-lead levels tested. Of those tested, 5% (16 children) were found to have blood-lead levels above 10 µg/dL.

Since that time, the percentage of children in Washington County with elevated blood-lead levels has gradually decreased. In 2007, approximately 27% of children less than 72 months of age (i.e., 494 children of a population of 1,844 children) were tested. Of those tested, 3% were found to have blood-lead levels above 10 µg/dL. In 2011, approximately 16% of children less than 72 months of age (i.e., 301 children of a population of 1,844 children) were tested. Of those tested, 1% were found to have blood-lead levels above 10 µg/dL.

Several factors have contributed to the increased blood-lead testing numbers, and decreased percentages of children with blood-lead levels over 10 µg/dL: increased provider (doctor, nurse, etc.) education, patient and community education about lead poisoning, increased effort by the Washington County Health Department (WCHD) to sample more children, and increased Medicaid funding and outreach for testing of children in low income families. EPA remediation of yards with high lead contamination at other NPL sites in Washington County has also likely contributed to the lower percentage of elevated blood-lead children on a county wide basis.

In 2012, in response to studies showing health effects from blood-lead levels below 10 µg/dL and under the recommendation from its former Advisory Committee on Childhood Lead Poisoning, CDC began using a blood lead reference value of 5 µg/dL. For a complete explanation of the new reference value, see the *Toxicological Evaluation* section of this public health assessment. In 2012, 7.8% of children tested in Washington County had blood-lead levels greater than 5 µg/dL. In 2013, 12.8 % of children tested in Washington County had blood-lead levels greater than 5 µg/dL. Continued public health actions such as health education and blood-lead testing in Washington County should assist in implementing this new recommendation.

Elevated Blood-Lead Risk Assessment in Washington County

WCHD and other health care providers offer blood-lead testing to the residents of Washington County, as part of well-child checkups and in response to the health concerns associated with the site. When a child is found to have an elevated blood-lead level, their health care provider, local county health department, and/or managed health care agency typically educates the family on ways to reduce the child's blood-lead level. In the past, when WCHD or a health care provider identified a child with a blood-lead level above 10 µg/dL, the child was said to have an elevated blood-lead level. In response to CDC's current reference value of 5 µg/dL, health education is usually provided to families if a child's blood-lead level is greater than 5 µg/dL.

If a child's blood lead level exceeds 15 µg/dL, the DHSS Bureau of Environmental Epidemiology's Childhood Lead Program conducts an Elevated Blood Level Risk Assessment to find what is causing the child to have elevated levels of lead in his/her blood. These Risk Assessments typically include testing for lead in drinking water, yard soil, dust, lead-based paint, or other interior sources such as doorways, windowsills, window troughs, walls, and toys, along with other areas where the child may come into contact with lead.

DISCUSSION

Pathways Analysis

Lead is the primary contaminant of concern at the Washington County Lead District – Furnace Creek Area and has contributed to elevated blood-lead levels in some children less than 72 months of age. Other metals may also be a concern. The five elements of the completed exposure pathway at the Washington County Lead District – Furnace Creek Area are:

1. **Contaminant source –** mine tailings, soils, and other materials
2. **Environmental medium and transport –** soil, groundwater, and dust
3. **Point of exposure –** areas where exposure to lead and other metal contamination is taking place
4. **Route of exposure** – ingestion
5. **Receptor population –** residents and visitors

Completed Exposure Pathways

Completed exposure pathways at the Washington County Lead District – Furnace Creek Area have existed in the past, are presently occurring, and will continue to occur in the future, until exposure to lead and other metals in soil and groundwater are reduced or eliminated (Table B-1, Appendix B).

Exposure to lead or other metals in soil can occur through ingestion of soil while working, playing, gardening, or spending time in the yard. The contaminated soil can also be tracked indoors on shoes, by pets, and other methods and may accumulate in the home. Individuals, especially children, can incidentally ingest this contaminated dirt/dust in the home. Children are more likely to be exposed to household dust and other forms of contaminated media because of their more frequent hand-to-mouth activity.

Individuals may also be exposed to some contaminated soil and dust in the yard and home that can be stirred up and becomes airborne, breathed in, coughed up, and inadvertently swallowed. Lead and other metals on dust particles are likely to be coughed up rather than absorbed through the lungs, so inhalation of lead is not a significant route of exposure. Lead and other metals are also not readily absorbed through the skin, so dermal contact with contaminated soil is not a significant route of exposure.

Individuals can be exposed to the lead and other metals in water through ingestion while drinking and cooking with contaminated water. Individuals may incidentally ingest contaminated water while bathing. Dermal contact to lead and other metals in water is not a significant route of exposure.

In addition to exposure to lead and other metals by ingestion of soil and groundwater, individuals may ingest high levels of lead and other metals in paint chips or dust from lead based paint in the home or other sources. The DHSS Childhood Lead Program in collaboration with WCHD and other healthcare providers have identified children in the area with elevated blood-lead levels whose homes had elevated levels of lead in the indoor dust and/or lead-based paint.

Potential Exposure Pathways

Exposure to lead and other metals in the Furnace Creek area by other exposure pathways could also pose increased health risks. Limited sampling has shown that elevated levels of lead or other contaminants are present in the water and sediment in ponds and streams, particularly near the source areas. Fish in contaminated streams, garden produce grown in lead contaminated soil, and wild edible plants growing in mining disturbed soils could also be a potential source of exposure. Additional sampling is needed to determine if the water bodies, fish, and edible plant are being affected and contain contaminants at a level of health concern. DHSS recommends that EPA, MDNR, and/or other agencies continue to expand their sampling efforts so that these potential pathways can be assessed.

TOXICOLOGICAL EVALUATION

Introduction

This section will discuss the health effects of exposure to specific contaminants found at the site. A discussion of non-cancerous health effects and the possibility of the contaminants causing cancer are evaluated in this section.

ATSDR and other agencies have developed comparison values (CVs) that are media-specific concentrations used by health assessors to select environmental contaminants of concern. Contaminant concentrations that are less than the CV are unlikely to pose a health threat. Contamination levels above the CV do not necessarily indicate that a health threat is present, but they may indicate that further evaluation of the chemical and pathways is needed. CVs are usually developed for chronic (more than 365 days) exposure, intermediate (15 days to 365 days) exposure, and acute (14 days and less) exposure. CVs include ATSDR's Environmental Media Evaluation Guides (EMEGs) and Minimum Risk Levels (MRLs) that have been derived for a variety of chemicals in various media.

Lead and, to a lesser extent, cadmium have been found in elevated concentrations in soils and groundwater in the Washington County Lead District – Furnace Creek Area. Although lead and cadmium are naturally occurring, the practice of depositing mine tailings above ground has made a large volume of contaminated materials more accessible to people. From natural processes and human intervention, the contaminated tailings have moved throughout the community in different media where exposure has occurred. Other sources of lead exposure are also possible in older homes containing lead-based paint, lead pipes, and lead-containing solder.

Lead

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. It is mined and processed for use in various industries. It is used in some types of batteries, ammunition, ceramic glazes, medical equipment, scientific equipment, and military equipment. At one time, lead was used as an additive in gasoline and paint [ATSDR 2007]. Paint containing lead may still be present in older homes and becomes more available for uptake into the body if it is deteriorated or flaking. Mine tailings contaminated with lead have been deposited on the ground surface in tailings piles and also moved by nature and man into areas where exposure can easily occur, such as yards and driveways.

ATSDR has not developed a CV for lead, because a safe blood lead level in children has not been determined. Instead, exposure to lead is evaluated by using an EPA biological model that predicts blood-lead concentrations that would result from exposure to lead levels found in the environment. The correlation between lead-contaminated soil and blood lead levels is influenced by many factors, including access to soil, presence of ground cover, levels of lead in soil, lead bioavailability, the size and composition of the lead particles, behavior patterns (especially of children), seasonal variation of exposure conditions, and the route of exposure [EPA 2003]. Until recently, children were identified as having a blood lead level of concern (i.e., an elevated blood lead level) if the blood lead level was 10 µg/dL or greater (CDC 2005; ATSDR 2007). CDC recently began using a reference value of 5 µg/dL, which is currently the 97.5th percentile of blood lead in a representative sample of children in the U.S. 1-5 years of age. In other words, 2.5% of the children tested had blood-lead levels at or above 5 µg/dL. As recommended in the report of the Advisory Committee on Childhood Lead Poisoning Prevention: *Low*

Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention, children identified with blood lead levels greater than or equal to 5 µg/dL should prompt public health actions, and agencies should shift priorities to primary prevention and provide guidance to respond to blood lead levels above the reference value [CDC 2012].

Lead has no nutritional benefits for humans and has its greatest adverse effect on the nervous system, especially in children. Health effects of elevated blood lead levels include decreased attention span, hyperactivity, and lower IQ scores. Lanphear et al. [2005] report that children's IQ scores are inversely related to blood lead levels. Several studies provide sufficient evidence that children's mental process or the faculty by which knowledge is acquired is adversely affected by lead [ATSDR 1992].

An unborn child can also be exposed to elevated blood lead levels if his/her mother has an elevated blood lead level in her body. This exposure can cause problems such as premature births, low birth weight, decreased mental ability, learning difficulties, and reduced growth as young children [ATSDR 2007]. Young children can also be exposed to lead through their mother's breast milk if the mother has elevated blood lead levels in her system [ATSDR 2007].

The biologic fate of inorganic lead in the human body is well known. Inorganic lead is not metabolized but is directly absorbed, distributed, and excreted. Once in the blood, lead is disturbed primarily among three compartments – blood, soft tissue (kidney, bone marrow, liver, and brain), and mineralizing tissue (bones and teeth) [ATSDR 2007]. Mineralizing tissue contains about 95% of the total body burden of lead in adults [ATSDR 2007].

Cadmium

Cadmium is a soft, silver-white metal that occurs naturally in the earth's crust. Cadmium is not usually present in the environment as a pure metal, but rather as a mineral combined with other elements. It is most often present in nature as complex oxides, sulfides, and carbonates in zinc, lead, and copper ores. Cadmium has many industrial uses and is used in consumer products including batteries, pigments, metal coatings, plastics, and some metal alloys [ATSDR 2012]. Cigarette smoke also contains cadmium and can double an individual's daily intake [ATSDR 2012].

Low levels of cadmium are present in most foods with the highest levels present in shellfish, liver, and kidney meats [ATSDR 2012]. Ingestion of high levels of cadmium in contaminated food or water can severely irritate the stomach, leading to vomiting and diarrhea, and sometimes death [ATSDR 2012]. Cadmium is a cumulative toxicant and ingestion of lower levels for a long period of time can lead to a buildup of cadmium in the kidneys and, possibly, kidney damage [ATSDR 2012]. The kidney is the main target organ for cadmium toxicity following chronic-duration exposure by oral routes. Chronic exposure to cadmium can also lead to bone fragility due to loss of bone density.

The levels of cadmium detected in residential soils/driveways in the Furnace Creek area were as high as 96.8 ppm. As shown in Table 3, incidental ingestion of 96.8 ppm cadmium in soil corresponds to an estimated maximum dose of 0.002 mg/kg-day in children[1]. While the maximum dose exceeds the MRL for intermediate exposure (0.0005 mg/kg-day), it is below the level at which health effects have been observed (0.05 mg/kg-day). Because maximum cadmium concentrations are below observed effect levels, and because elevated levels of cadmium are generally associated with elevated lead in soils that are being remediated, MDHSS concludes that cadmium found in residential soil at the site is unlikely to pose health risks.

Cadmium was mostly non-detectable in the private wells that were sampled, although five wells had detectable levels of cadmium of 2 ppb to 4.66 ppb. As shown in Table 3, ingestion of 2 to 4.66 ppb cadmium in drinking water corresponds to estimated doses[2] in children of 0.00027 to 0.0006 mg/kg-day and estimated doses in adults of 0.00005 to 0.00011 mg/kg-day. The ingestion doses in children approach or exceed the level at which health effects may be observed (0.0003 mg/kg-day). Thus, DHSS expects that chronic exposure to cadmium in drinking water may cause adverse health effects, especially in children exposed to cadmium in drinking water at a young age. Chronic exposure to low levels of cadmium in water may lead to accumulation of cadmium in the kidneys and possible kidney disease. Estimated exposure doses in adults approach or exceed the MRL for chronic exposure (0.0001 mg/kg-day) but not the observed effect level for chronic exposure. Thus, chronic exposure to cadmium in drinking water during adulthood is not expected to cause adverse health effects.

Table 3

Comparison to Estimated Cadmium Doses to Observed Effect Levels

Media	Cadmium Concentration[a]	Estimated Dose (mg/kg-day)	Minimum Risk Level[b] (mg/kg-day)	Observed Effect Level (mg/kg-day)
Soil	96.8 ppm	0.002 *children*	0.0005 *intermediate*	0.05 *bone*
Private Drinking Water Wells	2 ppb-4.66 ppb	0.00027-0.0006 *children* 0.00005-0.00011 *adults*	0.0001 *chronic*	0.0003 *kidney*

[a]Maximum concentration detected in surface soil; minimum and maximum concentrations detected in purged kitchen faucet water from private wells
[b]Minimum Risk Levels derived from Observed Effect Levels using uncertainty factors associated with animal studies and human variability
ppm = parts per million
ppb = parts per billion
mg/kg-day = milligrams per kilogram-day

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[1] Dose (children aged 1-<2 years) = C × IR × CF / BW, where C (concentration) = 96.8 mg/kg, IR (intake rate) = 200 mg/day, CF (conversion factor) = 10^{-6} kg/mg, and BW (body weight) = 11.4 kg
[2] Dose = C × IR × EF / BW, where C (concentration) = 2 to 4.66 ppb, IR (intake rate) = 1.113 L/day (children aged <1 year) or 2 L/day (adults), EF (exposure factor) = 1, and BW (body weight) = 7.8 kg (children aged <1 year) or 80 kg (adults).

Cancer

The American Cancer Society estimates that in the United States, slightly less than half of all men and slightly more than one-third of all women will develop some form of cancer in their lifetime [American Cancer Society 2007]. Of the chemicals of concern on site, lead, cadmium, and arsenic have some association with cancer. However, due to the types of exposure at this site, cancerous effects are not expected to occur. Increased cancer risks have not been associated with residential ingestion of lead- or cadmium-contaminated soil or drinking water. Since arsenic was detected only in some source areas, chronic exposure to arsenic is not likely and carcinogenic health effects are not expected.

Mixtures

Although lead's greatest damaging effect on the human body is to the nervous system, high levels of exposure can also damage the kidneys. Cadmium can also affect the kidneys after long-term exposure to low levels. Although both lead and cadmium can affect the kidneys, given the low levels of exposures, no expected synergistic (i.e., more than just additive) health impacts are expected [ATSDR 2007; ATSDR 2012]. EPA's efforts to clean up contaminated residential yards and provide an alternative drinking water source to residents with contaminated private wells should reduce exposure.

Children's Health Considerations

Children are more susceptible to the adverse effects of lead and other metals than adults. They are more likely to be exposed to contaminated soil, as infants and young children may swallow more lead in dirt, dust, or sand while they play on the floor or ground. In their daily activities, children have a tendency for frequent hand-to-mouth contact and often introduce non-food items into their mouths. Also, it usually takes less of a contaminant to cause adverse health effects in children than adults. They can also be exposed to lead and other metals through breast milk if the mother has elevated levels in her system. Studies indicate that larger proportions of ingested lead or cadmium will enter the bloodstream in children [ATSDR 2007; ATSDR 2012]. While about 99% of the amount of lead entering the body of an adult will leave as waste within a few weeks, only about 32% of lead taken into the body of a child will be excreted [ATSDR 2007]. Children who exhibit pica behavior may be at an even greater risk of exposure to contaminants in soil than other children [ATSDR 2007].

When children are exposed to lead-contaminated materials, a variety of adverse health effects can occur depending on the level of lead to which they are exposed and the duration of exposure. These effects include learning disabilities, slowed growth, hyperactivity, impaired hearing, and, at very high exposure levels, even brain damage [ATSDR 2007]. Unborn children can also be exposed to lead through their mothers and are at risk of premature birth, low birth weight, decreased mental ability, learning difficulties, and reduced growth as young children [ATSDR 2007].

The CDC considers lead poisoning to be the number one preventable environmental health problem facing children in the United States [CDC 2005]. Eliminating exposure pathways by controlling contamination sources, practicing good personal hygiene, and eating a proper diet high in calcium, iron, and vitamin C can lessen the risk of lead poisoning [CDC 2005].

Some studies suggest that children exposed to cadmium may be more susceptible than adults to kidney disease and loss of bone strength [ATSDR 2012]. As with lead, eliminating exposure pathways and eating a balanced diet can reduce the health risks of cadmium exposure.

COMMUNITY HEALTH CONCERNS

Starting in 2008, EPA began collecting soil and water samples from residential properties to determine if the Furnace Creek area of Washington County has been affected from past mining activities similar to the northeast portion of Washington County. EPA held a public availability session on May 28, 2008 to notify the public of their planned activities to sample residential yards and source areas. DHSS provided health education information at the availability session, but no community health concerns were expressed. On May 29, 2009, EPA conducted a public meeting to inform the public of the results of their sampling activities, follow-up activities, and encourage others to have their properties sampled for contamination. As part of the public meeting, DHSS in cooperation with the WCHD and ATSDR offered free blood-lead screening for those interested. None of the blood-lead levels of the 14 sampled were found to be above the new CDC reference value of 5 μg/dL. Few public health concerns were expressed during the meeting. Residents found to have elevated levels of lead in their yards were usually willing to have their yard remediated. However, some residents will not permit their property to be sampled, and EPA has not been able to make contact with all of the residents to offer screening of their property.

According to personnel from the WCHD who interact with the public on a daily basis, health concerns about the lead contamination are not generally expressed by the public, unless a parent's child is found to have an elevated blood-lead level.

A Public Comment Version of the Washington County Lead District-Furnace Creek Area Public Health Assessment was available for public comments from June 23, 2014 to July 23, 2014. The document was placed in several repositories including the Washington County Library and Washington County Health Department. Ads were placed in the local newspaper announcing the availability of document for comments. No comments were received by mail or email.

CONCLUSIONS

There are several known lead exposure risk factors in this community. DHSS has reached four important conclusions in this public health assessment:

1. Exposure to lead contaminated soil or mine tailings found in many of the residential yards and driveways within the Furnace Creek Area may harm individuals' health and is considered a public health hazard. This conclusion applies to past incidental or intentional ingestion (swallowing) of lead at some residences at this site. This conclusion may also apply to present and future ingestion of lead at some residences that have not been sampled and/or remediated. Exposure to cadmium, which was also found to contaminate some residential soils, is not expected to harm people's health.

2. Drinking untreated private well water contaminated with lead and/or cadmium may harm people's health and is considered a public health hazard. This conclusion applies to past, current, and future ingestion of lead and/or cadmium in well water at some residences at this site, unless a water treatment system has been installed.

3. Past, present, and future exposure to lead-contaminated paint and a number of other lead sources may harm people's health, especially the health of children and fetuses.

4. DHSS cannot currently conclude whether exposure to lead and other metals in sediment, surface water, fish, and edible plants in the Furnace Creek Area could harm individuals' health. High concentrations of lead and other metals in soils, as well as physical hazards, are also expected to exist in the past mining areas. The information needed to make decisions on these exposures is very limited.

RECOMMENDATIONS

1. DHSS recommends that EPA continues investigation and remediation of residential yards, driveways, and other areas where individuals, especially children and expectant mothers, might be exposed to elevated concentrations of lead and possibly other contaminants.

2. DHSS recommends that EPA continues sampling of private wells in the area to find contaminated drinking water sources and take permanent actions to prevent exposure to lead and other metals in drinking water. Residents with lead contamination below EPA action levels can decrease exposures by adding a household filter system or by flushing their water taps before using the water for drinking, cooking, making baby formula, or brushing their teeth.

3. Indoor dust may contain lead from a variety of sources, including lead based paint. Therefore, DHSS recommends that all agencies involved in remediation efforts in Washington County work toward educating the public on how to reduce or eliminate their exposure to all sources of lead, including lead dust which often comes from lead-based paints. Lead paint remediation should be done using EPA guidelines or a certified lead abatement contractor.

4. DHSS recommends that EPA, MDNR, and other agencies continue to sample other media, such as air, sediment, surface water, fish, and edible plants, so it can be determined if exposure to lead and other metals in these media may harm individuals' health.

5. DHSS recommends that EPA considers removal of contaminated soils and physicals hazards left from past mining activities, as appropriate when found.

PUBLIC HEALTH ACTION PLAN

This Public Health Action Plan (PHAP) for the Washington County Lead District – Furnace Creek Area contains a description of actions underway and planned by the Missouri DHSS, ATSDR, and other stakeholders. The purpose of the PHAP is to ensure that this public health assessment not only identifies hazards that may harm health, but provides an action plan to mitigate and prevent adverse human health effects resulting from past, present, and future exposures to hazardous substances at or near the site. Below is a list of commitments of public health actions by DHSS, ATSDR, or other site stakeholders.

Actions undertaken:

1. EPA conducted a public availability session in 2008 to inform the public of their investigation process and DHSS, ATSDR, and WCHD provided health education materials and answered health questions.

2. EPA conducted a public meeting in 2009 to inform residents of their findings, follow-up activities, and to encourage other residents to have their property tested while DHSS, ATSDR and WCHD provided free blood-lead testing, health information, and answered health questions.

3. EPA has removed soils from residential yards/driveways containing lead concentrations that exceed their Removal Action levels. These yards contained soil with lead contamination at concentrations at or above 1,200 ppm or lead concentrations at or above 400 ppm with sensitive individuals (i.e., children less than 72 months of age or pregnant women) in the residence.

4. EPA has provided, as a temporary measure, an alternative source of drinking water to residents who have elevated levels of lead in their private drinking water wells.

Actions planned:

1. During the Remedial Action phase, EPA are expected to continue to sample residential yards/driveways and private wells and remediate as necessary to prevent exposure.

2. EPA and other agencies are expected to further sample other media, such as sediment, surface water, fish, and edible plants, so it can be determined if exposure to these media can harm people's health.

3. DHSS will work with the WCHD and EPA to provide health education for the residents of the Furnace Creek area so they can help reduce or eliminate their exposure to all sources of lead and cadmium.

4. DHSS will continue to coordinate with the WCHD, MDNR, and EPA to address community health concerns and questions as they arise by providing health professionals and community health education.

5. DHSS will work with the WCHD to promote prevention of lead and cadmium exposure from all sources and encourage yearly blood-lead testing of children less than 72 months of age and women of child-bearing age.

6. DHSS will work with the WCHD to encourage residents of Washington County to have their yard soils and private drinking water wells tested for lead and cadmium and remediated if elevated levels are found.

7. DHSS will coordinate with the WCHD, MDNR, and EPA to implement the recommendations in this public health assessment.

8. DHSS will review additional sampling data from further investigations and provide guidance regarding possible health risks, as requested.

9. DHSS will update this public health assessment as needed.

REPORT PREPARATION

This Public Health Assessment for the Washington County Lead District – Furnace Creek Area site was prepared by the Missouri Department of Health and Senior Services under a cooperative agreement with the Federal Agency for Toxic Substances and Disease Registry (ATSDR).

Authors

Arthur Busch
Environmental Specialist
Bureau of Environmental Epidemiology
Missouri Department of Health and Senior Services

Elizabeth Semkiw
Environmental Specialist
Bureau of Environmental Epidemiology
Missouri Department of Health and Senior Services

State Reviewers

Dennis Wambuguh
Health & Risk Assessment Unit Chief
Bureau of Environmental Epidemiology
Missouri Department of Health and Senior Services

Jonathan Garoutte, Chief
Bureau of Environmental Epidemiology
Missouri Department of Health and Senior Services

ATSDR Reviewers

Division of Community Health Investigations

Trent LeCoultre, Technical Project Officer
Greg Zarus, Western Branch Headquarters Team Lead
Kai Elgethun, Western Branch Associate Director for Science
Lynn Wilder, Division Associate Director for Science
Tina Forrester, Deputy Director

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APPENDICES

Appendix A

Figures:

Figure 1: Washington County Lead District – Furnace Creek Area Sampling Points and Surface Water Pathways Segments
Figure 2: Washington County Lead District – Furnace Creek Area Field Screening Results for Residential and School Properties
Figure 3: Washington County–Furnace Creek Area Location and Demographic Statistics

Appendix B

Tables:

Table B-1: Washington County Lead District – Furnace Creek Area Exposure Pathways

Figure 1
Washington County Lead District – Furnace Creek Area
Location Map and Demographic Statistics

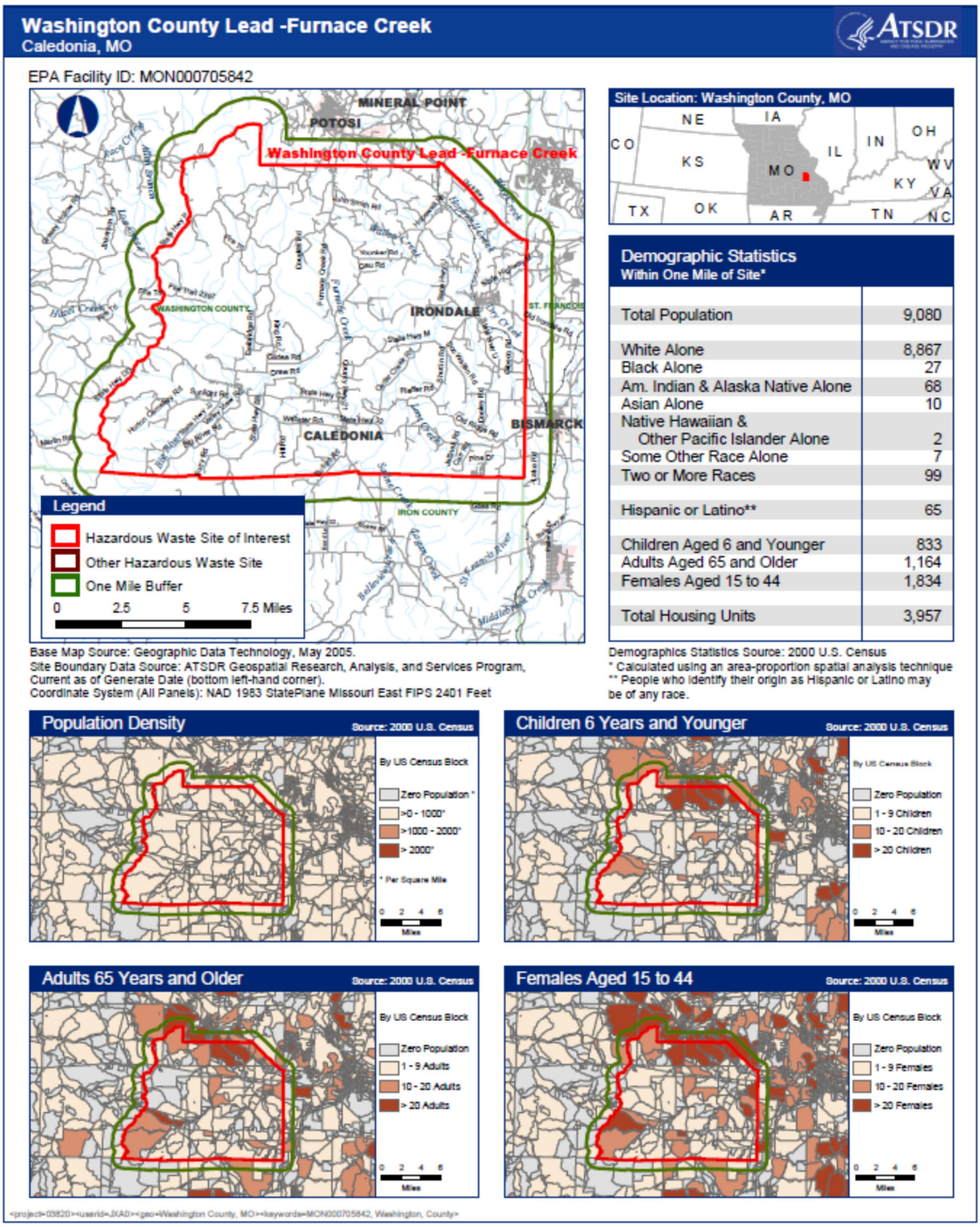
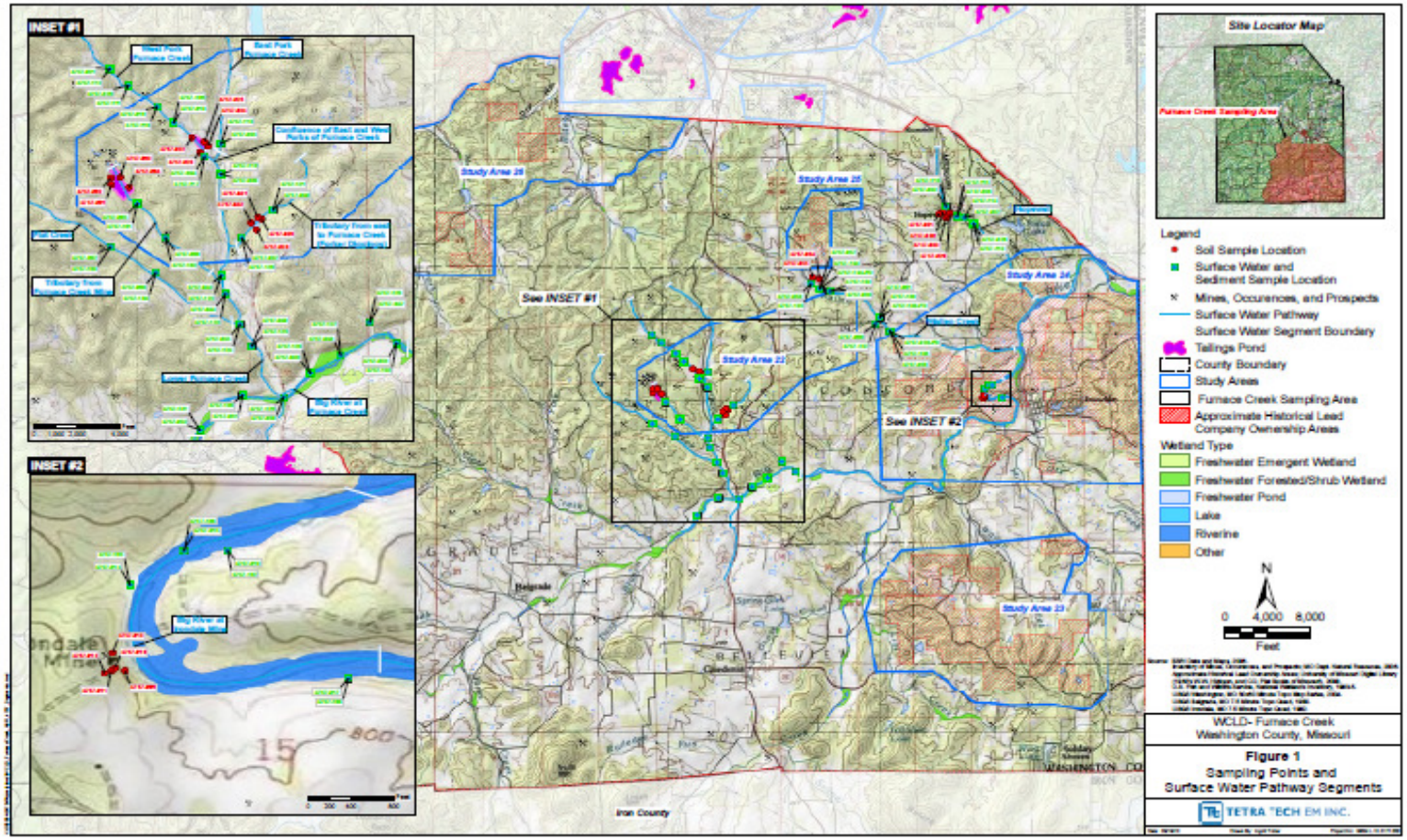


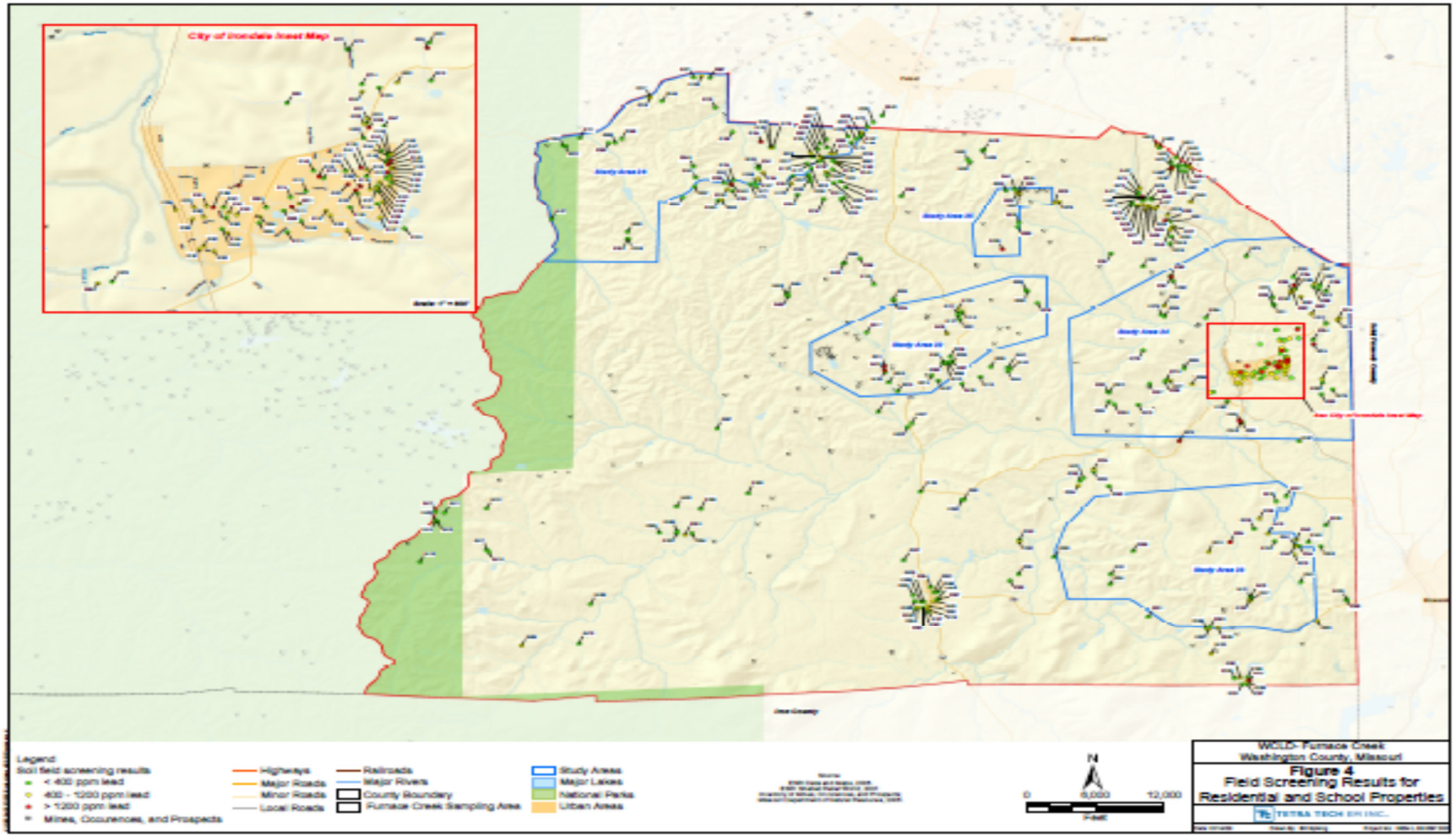
Figure 2
Washington County Lead District – Furnace Creek Area
Sampling Points and Surface Water Pathways Segments



Source: Tetra Tech EM Inc., Site Inspection Report, Washington County Lead District – Furnace Creek, Washington County, Missouri. 2010

Figure 3

Washington County Lead District – Furnace Creek Area
Field Screening Results for Residential and School Properties



Source: Tetra Tech EM Inc. Removal Site Evaluation Report Washington County Lead District – Furnace Creek Area. 200

Table B-1
Washington County Lead District – Furnace Creek Area Exposure Pathways

Pathway Name	Exposure Pathways Elements					Time	Type of Pathway
	Source	Environmental Medium	Point of Exposure	Route of Exposure	Receptor Population		
Soil	Mining and Smelting Waste	Soil	Smelting and Tailings Areas, Private Yards, and Driveways	Ingestion	Residents, Visitors, and Transient Populations	Past, Present, and Future	Completed
Indoor/Outdoor Dust	Mining/Smelting Waste and Lead Contaminated Paint	Dust	Inside Homes and Areas of Generated Dust	Ingestion	Residents, Visitors, and Transient Populations	Past, Present, and Future	Completed
Groundwater	Mining and Smelting Waste	Groundwater	Private Drinking Wells	Ingestion	Residents, Visitors, and Transient Populations	Past, Present, and Future	Completed
Sediment	Mining and Smelting Waste	Sediment	Tailings Areas, Streams, and Ponds or Lakes	Ingestion	Residents, Visitors, and Transient Populations	Past, Present, and Future	Potential
Surface Water	Mining and Smelting Waste	Surface Water	Area Streams and Lakes	Ingestion	Stream and Lake Users	Past, Present, and Future	Potential
Fish	Mining and Smelting Waste	Fish	Locally Caught Fish	Ingestion	Individuals Eating Locally Caught Fish	Past, Present, and Future	Potential
Edible Plants	Mining and Smelting Waste	Edible Plants	Locally Grown or Gathered Plants	Ingestion	Gardeners and Individuals Eating Plants Gathered in the Area	Past, Present, and Future	Potential

Greetings,

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LCDR Donna K. Chaney, MBAHCM
U.S. Public Health Service
4770 Buford Highway N.E. MS-F59
Atlanta, GA 30341-3717
(W) 770.488.0713
(F) 770.488.1542