REPORT TO CONGRESS

Tar Creek Superfund Site

Ottawa County, Oklahoma

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I. Report Summary

Purpose

The Senate Appropriations Committee directed the Agency for Toxic Substances and Disease Registry (ATSDR) "to help assess the level of lead poisoning of families, especially children, at the Tar Creek Superfund Site in Oklahoma. A report to Congress on this assessment is due no later than July 31, 2004" (Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies, Appropriations Bill, 2004, Senate Report 108–143, September 5, 2003, page 86).

Senator James Inhofe, as a senator from Oklahoma and as the Chairman of the Senate Committee on Environment and Public Works, expressed his expectations about the directive: "I cannot emphasize enough the importance of this endeavor to more fully understand the elevated lead levels we're seeing in this community, particularly in children. As the chairman of the committee with jurisdiction over both Superfund and ATSDR, I would like to take this opportunity to elaborate on my expectations of ATSDR in connection with this directive: I am urging ATSDR, in collaboration with the Oklahoma State Health Department, to work to identify significant sources and pathways of exposure to lead that may be contributing to elevated blood lead levels in children at the Tar Creek Superfund site in Oklahoma" (*Congressional Record*, Senate, January 22, 2004, page S140).

Findings

Mine tailings and lead-based paint are two potential sources contributing to lead exposures in children residing in the Tar Creek Site area. Children can be exposed to these sources of lead primarily through contact with household dust and soil.

From 1995 to 2003, a decrease was observed both in the average blood lead levels (BLLs) and the percentage of elevated BLLs (at or above 10 micrograms per deciliter [µg/dL]) among children aged 1 to 5 years who were living at the Tar Creek Superfund site and who were tested for lead. In 2003, the average BLL and the percentage of elevated BLLs among children who were tested for lead and who lived at the site were slightly higher than those of children living in the United States as a whole during 1999 and 2000 (1). This comparison should be viewed with caution, however, because the U.S. data are based on a representative sample of the United States (1), and the data collected for tested children at the site are not representative of all children living at the Tar Creek Superfund site area. Risk behaviors and/or exposure sources in a limited number of households may have been important factors contributing to the number of children with elevated BLLs living at the site from January 2000 to February 2004.

Declining BLLs among tested children living at the site should not be interpreted to mean that existing interventions in the Tar Creek area are no longer needed**.** Indeed, such ongoing efforts as soil remediation and an active lead screening and health education program should be evaluated to determine their contribution to this decline. Meanwhile, these efforts should be continued. Elimination of the sources of lead contamination will achieve long-term protection of children. Screening efforts will confirm and monitor blood lead trends, while ongoing public health education reinforces the need for behaviors that may reduce exposure to lead and its subsequent health effects among adults and children.

Recommendations

On the basis of the review of environmental and blood lead screening data, ATSDR is taking a number of steps to address expressed concerns and has recommended additional actions to protect the health of Tar Creek area residents:

- Continue to provide blood lead screening to children living around the site. Currently, ATSDR provides funds from EPA to the Ottawa County Health Department to conduct screening activities. EPA is continuing to fund these activities through FY 2005.
- Continue to provide lead exposure prevention education to people potentially impacted by the site. Currently, ATSDR provides funds from EPA to the Ottawa County Health Department to engage in prevention education activities. EPA is continuing to fund these activities through FY 2005.
- Recommend that the Oklahoma State Department of Health or the Ottawa County Health Department support periodic reports of Tar Creek and Ottawa County child blood lead statistics to the Ottawa County communities. These reports could include trends and comparisons to state and national levels.
- Complete remediation of residential properties. EPA funds this activity. According to EPA, residential remediation is ongoing.
- Complete the investigation of chat piles, mill and mine residues, and flotation ponds. According to EPA, these activities are planned for completion next year.
- Assess the risk for lead exposure from using mine tailings (chat) for commercial and residential purposes, including processing and transporting the material. ATSDR has included in its FY 2004 and in the FY 2005 President's Budget request funding for an ongoing public health assessment regarding public health hazards associated with the Tar Creek site. The public health assessment will include identification of gaps in existing data and recommendations regarding further monitoring and other activities to evaluate risks of lead exposure. ATSDR recommends that any person proposing to use chat for commercial purposes arrange for an independent assessment of risks from exposure potentially associated with that use.
- To address concerns regarding the sources of lead exposure for children who currently have elevated BLLs, correlate lead isotopes in the environment and in children's blood. This approach would seek to identify specific environmental sources contributing to elevated BLLs in children. The measured ratio of lead isotopes ^{206}Pb and ^{207}Pb in the blood of children and adults would be compared with the ratio of ^{206}Pb and ^{207}Pb in environmental sources and biota (2, 3). ATSDR may conduct a small project to assess the feasibility of this approach.
- Evaluate the health risks of other site-related contaminants and of physical hazards. Funding to support this ongoing activity is included in ATSDR's FY 2004 and the FY 2005 President's Budget.

ATSDR is considering whether to evaluate the effectiveness of activities at the Site, including soil remediation and tribal and non-tribal health education/blood lead screening programs. Such an evaluation might result in identification and then strengthening of those activities that have the most impact on reducing or eliminating lead exposure.

II. Background

The Tar Creek Superfund site (the site) is located in far northeastern Oklahoma (Ottawa County) near the Oklahoma/Kansas border. The site itself comprises a 40-square mile area but is part of the larger Tri-State Mining District that includes areas of Kansas and Missouri and 10 Tribal Nations. The site encompasses portions of several communities, including Quapaw Nation, Picher, Cardin, Quapaw, North Miami, and Commerce. Approximately 6,400 residents live within the site boundaries.

From the early 1900s through the late 1970s, the site was mined extensively for lead and zinc ore. The milling process for the lead and zinc ore resulted in a concentrated form of the original mined material. It also resulted in mine tailings (chat) that were originally considered a waste product. The chat was disposed of in piles or in flotation or tailing ponds. Some piles are as high as 200 feet and contain elevated levels of lead and other heavy metals. The chat in flotation ponds has not been quantified. The U.S. Geological Survey and the U.S. Army Corps of Engineers estimate that the site contains 75 million tons of chat. The chat has been sold as a construction product, similar to limestone gravel, for many years.

The U.S. Environmental Protection Agency (EPA) listed the site on the National Priorities List (NPL) in September 1983. Initially, EPA addressed surface water contamination, which included the mine water discharge in Tar Creek and the threat of contamination from open abandoned wells to the Roubidoux Aquifer. In 1995, EPA began sampling area soils. On the basis of elevated lead levels in soils, EPA began yard remediation activities that continue today. EPA has entered into an Administrative Order of Consent with several entities to investigate the site and provide the information needed to begin cleanup of chat piles, flotation ponds, and mill ponds.

History of ATSDR Activities

In September 1993, ATSDR reviewed the limited environmental data for the site. On the basis of the review, ATSDR made the following recommendations:

- Restrict access to any known open mine shafts and cave-ins at the site.
- Continue sampling of the Roubidoux Aquifer to determine whether acid mine water is significantly impacting it.
- Continue monitoring area drinking water wells, especially public water supply wells, for site-related contaminants.
- Continue periodic sampling of water and sediments in Tar Creek and other area surface waters.
- Consider sampling fish from area surface waters impacted by acid mine drainage.
- Sample area chat piles and soils near piles (including residential yards and other areas that children frequent) to determine whether metals are detected at levels of health concern.
- Review results of any sampling activities conducted in accordance with these recommendations to determine whether further actions by ATSDR are needed.

From 1993 to the present time, ATSDR has participated in numerous activities at the Tar Creek Site. Beginning in spring 1993, ATSDR became aware of blood lead sampling data collected by the Indian Health Service (IHS). ATSDR and IHS evaluated these data and determined that 35% of the children tested at the IHS clinic in Ottawa County had elevated blood lead levels (BLLs) (at or above10 µg/dL). ATSDR initiated a limited investigation to evaluate the lead levels in soil, paint, dust, and water at nine houses identified by IHS as homes to children with BLLs at or above10 µg/dL. The results indicated elevated levels of lead in paint and dust/soil in two homes. In 1995, in a second effort to address exposure, ATSDR provided technical assistance and resources to the Oklahoma State Department of Health (OSDH) to conduct BLL screening in all children who lived in Ottawa County.

On the basis of the finding of elevated BLLs, EPA investigated the contamination of residential yards and play areas. An extensive residential yard cleanup was conducted, and over 2,012 properties were remediated. ATSDR provided health recommendations to EPA on the remediation plans for residential soils.

In 1997, EPA signed a Record of Decision (ROD) for the residential areas. As part of this ROD, EPA recommended ongoing blood lead screening and health professional/community health education. EPA agreed to fund the OSDH/Ottawa County Health Department (OCHD) to implement a lead screening and education program for the Tar Creek area. EPA originally committed to funding $1 million, but it continues to fund the project, even though the $1 million has been expended. Continued funding is determined on an annual basis. EPA has provided $175,000 of FY2004 monies for work in FY2005.

Current ATSDR Activities

ATSDR has identified data that address the multiple pathways of exposure for the Tar Creek Site. On the basis of availability of this data, ATSDR is currently preparing a public health assessment. ATSDR is working collaboratively with OSDH and EPA to evaluate the public health issues associated with the site. Additionally, OSDH requested that ATSDR assist OSDH in evaluating the potential health threat posed by the chat piles. ATSDR, with the assistance of OSDH and EPA, has obtained blood lead and environmental data for completion of this report.

Lead isotopes and isotopic ratios have been used to identify the source of lead poisoning when multiple sources of lead are present (2). ATSDR is developing a protocol to test this technique in the Ottawa County Health Department investigations of children with elevated blood lead levels. This protocol would measure lead isotopes and compare the isotopic ratio of lead in children with elevated blood lead levels to isotopic ratios of lead present in the child's environment.

ATSDR will continue to work with OSDH and EPA to complete the public health assessment. A description of the current evaluation of the sources and pathways of exposure and blood lead exposure status follows.

III. Exposure Pathway Evaluation

Identification of Pathways of Exposure

ATSDR identifies human exposure pathways by examining environmental and human components that might lead to contact with contaminants (4). A pathway analysis considers five principal elements:

- Source of contamination
- Transport through an environmental medium
- A point of exposure
- A route of human exposure
- An exposed population

Completed exposure pathways are those for which the five elements are evident and exposure to a contaminant has occurred, is occurring, or will occur. ATSDR regards people who come in contact with contamination as exposed. That exposure can occur through breathing airborne contaminants, drinking contaminated water, eating contaminated plants or animals, or playing or digging in contaminated soil. Identification of a completed exposure pathway does not necessarily mean that health effects will occur. Exposures may or may not be significant. Thus, even after exposure, human health effects may not necessarily result.

Sources and Exposure Pathways at Tar Creek Superfund Site

ATSDR reviewed site history, site activities, and sampling data for the site. From this review, ATSDR identified sources and pathways of exposure that warranted consideration (Tables 1 and 2). These pathways are subdivided into the major pathways of exposure and pathways for which additional data are needed to assess their contribution to exposure.

Major Completed Exposure Pathways

Residential Area Soil

Residential area soil (i.e., residential yards, daycare centers, playgrounds, and parks) is considered a completed exposure pathway for areas identified (Figure 1) as having soil lead levels at or above 500 milligrams per kilogram (mg/kg). The main source of lead contamination in the residential area of the site is mine tailings (5). The tailings were transported to the residential properties as a result of deposition of airborne dust from tailings piles and ponds and use of chat as fill and for surfacing driveways. People can ingest soils as an incidental consequence of typical outdoor activities, such as working in the yard, gardening, and playing. The soil exposure pathway is especially important for children, who exhibit hand-to-mouth behavior and consequently have higher soil ingestion rates.

The extent of lead contamination of residential soil has decreased since 1995. Over 2,000 residential yards have been cleaned up by EPA, and EPA continues to address residential contamination. As of April 2004, over 500 residential properties still need to be sampled. EPA's system for remediating yards gives top priority to homes with children under 7 years of age. Because all yards have yet to be remediated, young children may continue to be exposed to lead from residential soil.

The tailings also contribute to lead exposures in homes. House dust sampling described in EPA's 1996 Tar Creek Risk Assessment indicate that tailings are present in house dust. Confirming this finding, the 1997 Tribal Efforts Against Lead (TEAL) investigation also identified house dust as a point of exposure to lead (6). Household dust is another point of exposure to site-related lead for children and adults through hand-to-mouth behaviors.

Mine Tailings

Mine tailings are a completed exposure pathway for tailings piles, ponds, and embankments identified (Figure 2). The locations where mine tailings are found in the Tar Creek site area were provided to ATSDR by EPA. Adults and children swallow lead-contaminated mine tailings as an incidental consequence of walking or playing on the tailings piles, ponds, or embankments. The exposure pathway for mine tailings is especially important for children who live near the tailings piles, ponds, or embankments. Hand-to-mouth behaviors of children, especially those 6 years of age or younger, can result in higher soil ingestion rates. At the site, exposure to mine tailings is especially likely in Picher and Cardin, where many homes are within 250 feet of tailings (Figure 2).

Lead-Based Paint

Some lead found in soil and house dust may have come from lead-based paint (LBP) or other sources not related to the site. Exposure to LBP occurs in or around homes painted with LBP that is peeling, chipping, or deteriorating. LBP is an important source of exposure to lead for many children aged at or under 6 years in the site area. Children are exposed to LBP through ingestion of dust, soil contaminated with small particles of LBP, or through direct ingestion of paint chips.

Homes most likely to have LBP were those built before 1950, but lead paint also was used in some homes built during 1950–1978 (7). Use of paint containing lead in homes was banned in 1978, so homes built after 1978 are unlikely to contain LBP. Data from the 2000 Census indicate that 22% of housing units in the United States were built before 1950. In comparison, ATSDR found that 32% of the housing in the general Tar Creek Superfund site area and 39% of housing in the Picher-Cardin area were built before 1950. These statistics for Tar Creek areas are 44% and 75% higher, respectively, than for the United States as a whole (Table 3) [2000 U.S. Census]. As part of the Tar Creek Risk Assessment, EPA sampled a variety of environmental media from randomly selected homes in the site area (5). Paint was tested at all of these homes where chipped or damaged paint was noted outdoors or indoors. Outdoor paint from 28 (65%) of 43 homes contained lead, while indoor paint from four (40%) of 10 homes had lead (8). Therefore, some of the children living in the Tar Creek site area could be exposed to lead from LBP.

Other Exposure Pathways

Ingestion of Homegrown Produce

Plants can absorb lead from the soil (9). Lead-contaminated soil can adhere to plant surfaces, and especially potatoes, carrots, and similar "root" vegetables. Thus, because some Tar Creek residents grow fruits and vegetables in their home gardens, consumption of plants grown in lead-contaminated soil could be another source of exposure. In addition, tribal members regularly use these foods for medicinal and ceremonial purposes, thus increasing their consumption rates.

Recent research indicates that this pathway would be a concern only for children who eat large amounts (about ⅓ pound a day) of homegrown produce (10).

Ingestion of Tap Water

Drinking water contaminated with lead is another exposure pathway for people at the site. The drinking water in most homes comes from municipal water supplies. EPA included tap water in the environmental samples from 100 randomly selected homes at the site as part of its risk assessment (5). EPA found a mean of 1.8 parts per billion (ppb) lead in the tap water tested with a maximum level of 8.3 ppb. EPA's action level for lead in drinking water is 15 ppb. The source of the lead in drinking water is most likely lead pipes or lead solder.

Airborne Dust

Inhalation of dust contaminated with lead is an additional exposure pathway for people at the site (Figures 1 and 2). Mine tailings contaminated with lead are found throughout the site. Residents of Picher and Cardin live near tailings piles, ponds, and embankments. EPA monitored the air for lead and other contaminants at four locations in the Picher/Cardin area and one control location in Afton for 3 months (5). The low levels found did not represent a health risk on the basis of EPA input of the data into the Integrated Exposure Uptake Biokinetic Model for Lead (IEUBK) model. However, this conclusion has some limitations. First, it is based on monitoring during mid-April through mid-July 1995 and may not represent exposures during the rest of the year (8). Second, the IEUBK model evaluated only the health risk for inhalation, not whether airborne transport of the tailings might eventually recontaminate residential areas. To confirm air sampling results from 1995, EPA again collected soil samples in August 2003 from properties in both Picher and Cardin that were remediated during 1997 to early 2000. While this sampling was limited, it may provide useful information in evaluating the recomtamination of residential yards.

The Quapaw Tribe is conducting long-term monitoring of the Picher/Cardin area. Also, the EPA is planning to model air emissions from chat piles and tailing ponds which would include real time wind speed and directions for five consecutive years. A risk assessment will also be completed to evaluate the impact of emitted contaminants from chat piles and tailing ponds on the surrounding communities. These data should provide some valuable information in addressing whether airborne transport of tailings is recontaminating the residential area soils and to what extent residents are being exposed to airborne particulates. ATSDR will evaluate this information to determine whether it addresses these concerns and whether additional sampling is needed.

Use of Biota by Tar Creek Site Area Tribal Populations

The tribal populations may use biota (i.e., plants and animals) for food and for cultural, ceremonial, and religious practices. The tribes would use biota as food probably in amounts much greater than amounts used by other area residents. Native populations can use plant materials for medicine regularly, further increasing consumption rates for lead. Tribal members who practice crafts such as basket weaving may spend most of their day sifting the plant through their teeth, a practice that means they can easily inhale contaminated dust and small soil particulates bound to plant materials. The biota used and the cultural, ceremonial, and religious practices may differ among the 10 tribes in the Tar Creek site area. Therefore, this pathway must be evaluated by or in close cooperation with the 10 tribes. One issue to be discussed with the tribes is the recent Oklahoma Department of Environmental Quality fish tissue sampling data and whether those data address tribal concerns.

Physical Hazards

Although not directly related to BLLs, physical hazards, in particular subsidence issues, play a significant role in the safety of the site. Approximately 2,540 surface acres of land are undermined at Tar Creek, including under the communities of Picher and Cardin (9). The largest form of subsidence occurs when an undermined area collapses. The U.S. Army Corps of Engineers, as part of the comprehensive watershed management plan, will attempt to identify the areas most prone to major subsidence and determine when collapses might occur.

IV. Discussion

Residential area soil, lead-based paint, and mine tailings are the primary exposure pathways for potential lead exposure in the Tar Creek Site area. The points of exposure for the residential soil and lead-based paint pathways are house dust and yard soil (Table 1). In 1997, TEAL conducted blood lead testing of children and environmental sampling and administered a questionnaire (12, 6). Lead-based paint, lead-containing floor dust in residences, and lead in yard soil were identified as sources of elevated BLLs among children living at the site (Table 6).

EPA's Tar Creek Risk Assessment strongly linked house dust and yard soil to elevated BLLs in children (5). EPA tested a variety of environmental media from a random sample of 100 homes in the site area. Fifteen homes were sampled in Afton, Oklahoma, a location well away from the Tar Creek site area and mining activities. House dust, tap water, and soil were obtained from each house. Soil was obtained from the front and back yards, drip line, play areas, and gardens if the home had one. Three floor dust samples were obtained from each home sampled: 1) the entry area, 2) a bedroom (a child's was preferred), and 3) the living room or kitchen. As described earlier, samples of interior or exterior paint were taken at homes in the sample set where the paint was damaged or chipped. Samples of home-grown produce were obtained at the 29 homes in the sample group with gardens. Air was sampled at four locations in the site area and one in Afton for 3 months. These data were entered into EPA's IEUBK Model.

The results of the IEUBK model predicted that 82% of the total uptake of lead came from house dust and soil, 16% from diet, and 2% from water (5). The lead uptake from diet was based mostly on default values from national data, but the lead levels in produce from gardens was factored into the model.

The IEUBK model predicted that about 22% of children exposed to the lead levels in these homes in the site area would have BLLs at or above10 µg/dL. This prediction is based on environmental levels in the Tar Creek site area before remediation of the residential areas. The 22% of children with elevated BLLs predicted by the IEUBK model is similar to the 19% of children with elevated BLLs in the 1997 TEAL survey (12) and elevated BLLs reported to the OSDH during 1995–1997.

Evidence suggests the plausibility that both mine tailings and lead-based paint could be contributing to the BLLs of people living in the Tar Creek Superfund site. However, the relative contributions of exposure to mine tailings and exposure to lead-based paint on the BLLs of people living at the site cannot be determined with existing information.

Blood Lead Evaluation

Datasets Reviewed

ATSDR reviewed and analyzed data on the BLLs of children living at the site from January 1995 through February 2004 (Figure 3). The Ottawa County Sunshine Clinic, the Ottawa County Lead Poisoning Prevention Program (OCLPPP) managed by the OCHD, TEAL and Community Health Action and Monitoring Program (CHAMP) surveys, Tribal Health Clinics, private physicians, and other private and public clinics collect blood from children and test for lead. These programs send data to the OSDH Childhood Lead Poisoning Prevention Program Surveillance System (CLPPSS), which then transmits aggregate data to the Centers for Disease Control and Prevention's Childhood Blood Lead Surveillance Program.

The most useful data sources for assessing BLLs of children living at the site were the 1995–2002 OSDH Childhood Lead Poisoning Prevention Program (CLPPSS), the 1997 and 2000 TEAL survey, and the 1999–2004 OCLPPP screening data (Tables 4 and 5). Children were considered to live at the site if their medical records indicated that they lived at addresses in the northeast Oklahoma towns of Cardin, Commerce, North Miami, Picher, or Quapaw. For this analysis, all children with addresses from North Miami were included as living at the site—even though a portion of North Miami is outside the site boundaries (Figure 1). ATSDR included this portion of North Miami in the estimates for the population or number of children living at the site.

OCLPPP provides blood lead testing free of charge to children living at the site and to all other children, including tribal children, living in Ottawa County. Families with young children who may be at risk for lead poisoning are highly encouraged to participate in the voluntary program. OCLPPP personnel offer testing on site at the OCHD and conduct regular screening efforts at schools, preschools, daycare centers, Head Start programs, and local shopping areas. OCLPPP also conducts identification and screening efforts in coordination with the Women, Infants, and Children (WIC) program and with other public health programs. In addition, OCLPPP provides on-location testing services to potential high-risk areas, as warranted (13).

ATSDR used the OCLPPP data as the source for 2003 BLLs for tested children living at the site because those data incorporate

- The most recent and current data available at the time of this analysis;
- A substantial number of children tested (40% of the estimated population of children, aged 1 to 5 years, living at the site—based on 2000 census block data analysis for population estimate);
- Numerous BLL tests throughout the year (total of 308 for children, aged 1 to 5 years, living at the site in 2003);
- A high level of test result recording accuracy (a check of existing BLL entries with actual patient paper records showed only four errant electronic entries in 390 follow-up patient records that contain up to 14 entries each);
- BLLs reported to the 10th µg/dL (OSDH CLPPSS data were rounded to the nearest whole number) with consistent application of non-detect values (statistical values assigned to test results when lead in a blood sample is too low to be detected);

- Data based on results obtained from consistent testing protocols and analysis criteria; and
- Targeted testing for potentially higher risk children (Head Start programs, siblings of children with elevated BLLs, WIC).

The OCLPPP data system is the largest contributor of data to the OSDH CLPPSS system. Both OSDH CLPPSS and OCLPPP datasets are comprised primarily of capillary blood lead testing data (under OCLPPP, a confirmatory venous test is provided after an elevated capillary test result). Both the OSDH CLPPSS and OCLPPP datasets consist of convenience samples rather than representative samples. All TEAL survey blood lead tests were venous, and TEAL used a door-to-door sampling method. In calculating geometric means for the OSDH CLPPSS and OCLPPP data for each year, ATSDR used the highest test of each child tested in the respective year.

The simple arithmetic mean is not suitable for representing "average" conditions when a large proportion of the observations are clustered at one end of the data range. This is often the situation with blood lead levels. The occurrence of a few high numbers would result in a perceived "average" far higher than a number that would be reflective of actual conditions. In such situations, the geometric mean is a more appropriate measure of central tendency than the arithmetic mean. The result represents a more accurate estimate of common or typical conditions.

Percentage of Elevated BLLs and Geometric Mean of BLLs

Among tested children aged 1-5 years living in the Tar Creek Superfund site, the percentage of BLL elevations and the geometric BLL mean declined from 1995–2003 (Figures 4 and 6). In 1996, OSDH CLPPSS data showed that among tested children aged 1-5 years living at the site, 31.2% (67/215) had BLL at or above 10 µg/dL and the geometric mean was 6.65 µg/dL. In 2003, OCLPPP data showed that among tested children aged 1-5 years living at the site, 2.8% (7/250) had elevated BLLs, and the geometric mean was 3.04 µg/dL. These 2003 statistics are slightly higher than the findings of the National Health and Nutrition Examination Surveys (NHANES) for children living in the United States as a whole. NHANES data indicate that among U.S. children aged 1-5 years during 1999–2000, 2.2% had elevated BLLs, and the geometric mean was 2.2 µg/dL.

Picher/Cardin in Comparison with the Tar Creek Superfund Site as a Whole

Of the children in Picher and Cardin who were tested for blood lead, the percentage with elevated BLLs and the geometric mean declined from 1995–2003 (Figures 5 and 7). In 1996, OKCLPPSS data showed that among tested children aged 1-5 years living in Picher and Cardin, 44.6% (41/92) had elevated BLLs and the geometric mean was 9.17 µg/dL. In 2003, the OCLPPP data showed that among tested children aged 1-5 years living in Picher and Cardin, 3.4% (3/88) had elevated BLLs, and the geometric mean was 3.82 µg/dL.

In 1996, the percentage of children identified with elevated BLLs and the geometric BLL mean for all children tested were higher in the combined areas of Picher and Cardin than at the site as a whole. However, these differences have diminished in recent years.

Characteristics of Children With Elevated BLLs

From January 2000 to March 2004, 37 children under 6 years of age living at the site were identified with elevated BLLs (at or above 10 µg/dL) by the Ottawa County Health Department. Of these children 41% (15/37) were from five households. This could suggest that high-risk behaviors were shared by these family members or that common exposure sources were present.

In 2003, OCLPPP identified seven children aged 1 to 5 years living at the site as having elevated BLLs. The OCLPPP program conducted or received data from environmental assessments of the residences of six of these children at various points in time (some prior to 2003). The potential sources of lead exposure found to be present at the respective residences are described in Table 7 in the appendix and include lead-based paint, lead-containing floor dust (at or above10 µg/ft^2), and soil with elevated lead levels (above 500 mg/kg).

Data Limitations

Any comparisons of the OCLPPP data with NHANES U.S. data should be viewed with caution because the NHANES data are based on a representative sample of the United States (1, 14), and the OCLPPP data comprises a convenience sample rather than representative samples of the site area. As shown in Tables 4 and 5, the OKCLPPSS, TEAL, and OCLPPP data samples include a substantial proportion but not all of the estimated population of children, aged 1 to 5 years, living at the site.

NHANES data are generalized to the U.S. population and were not intended to provide estimates for smaller areas or for specific populations where the risk for elevated BLLs is high (14). Furthermore, all NHANES blood lead tests are collected by venous sampling (14), whereas the OSDH CLPPSS and OCLPPP programs primarily collect blood through capillary sampling. Because sample contamination of a capillary test can over-estimate BLLs (15, 16) and because ATSDR used each tested child's highest BLL to calculate geometric means, geometric means of the OSDH CLPPSS and OCLPPP datasets probably overestimate actual geometric means.

The 1997 and 2000 TEAL surveys measured lead from venous blood. Given the relatively high availability of free screening in the area, it is not known if the use of venous testing and the presence of incentives to participant families could have resulted in higher relative TEAL participation in areas of lower median income and among children with higher risk factors for lead poisoning.

Many other relative factors could be explored, including the prevalence of pre-1950 housing units and poverty at the site area as compared to that of the United States (Table 3). An updated NHANES blood lead survey might show a further decline in national BLLs since 1999–2000. BLLs in U.S. children have been declining (14).

Interventions

Many activities may have been instrumental in reducing elevated BLLs at the site. In 1995, after the confirmation of elevated BLLs, ATSDR funded the OSDH to conduct extensive blood lead testing throughout Ottawa County. OSDH determined that 28.3% of children tested had BLLs at or above 10 µg/dL. Several projects implemented over the past several years have increased community knowledge of exposure and the harmful effects of lead. Some of those include CHAMP and TEAL. Beginning in 1995, EPA began testing and remediating residential soils and areas where children play (e.g., school and city parks and playgrounds, ball fields, daycare centers). Since 1998, the OCHD has conducted extensive blood lead screening, and community and health provider education. OCHD has distributed HEPA vacuums to area households who have children with elevated BLLs. The area also received U.S. Housing and Urban Development funds for lead abatement in homes.

These activities, combined, may have helped to reduce BLLs in Ottawa County. BLLs of children living at or near the site might increase without these interventions.

V. Conclusions

Two potential sources were found for lead in children in the Tar Creek site area: mine tailings and lead-based paint. Both could contribute lead to house dust and soil, which most likely are the points of exposure for children. The relative contributions of exposure to mine tailings and exposure to lead-based paint on the BLLs of people living at the site cannot be determined from existing information.

The evidence available to ATSDR indicates that mine tailings in the residential area soil exposure pathway may have been a primary source of the lead in children's blood before EPA remediated the Tar Creek residential areas. Exposure to mine tailings still could occur because Tar Creek area residents, especially those in Picher and Cardin, remain near tailings piles, ponds, and embankments and can readily access these tailings deposits. In addition, the close proximity of these tailings to residences increases the risk for recontamination of residential soil because of blowing dust or residential or commercial use of the tailings.

A decline in the average BLLs among tested children aged 1 to 5 years living at the site from 1995–2003 has been observed, as was a decrease in the percentage of tested children with elevated BLLs from 1995 to 2003. The average BLLs and the percentage of elevated BLLs among tested children living at the site in 2003 were slightly higher than for children living in the United States as a whole in 1999–2000 (1). However, this comparison should be viewed with caution because the U.S. data are based on a representative sample of the United States (1), the Tar Creek data is from a convenience sample and not a representative sample, and U.S. child BLLs also may have declined since 2000.

Declining BLLs among tested children living at the site should not be interpreted to mean that existing interventions in the Tar Creek area are no longer needed. Potential lead sources, including unremediated yards, chat piles, tailings ponds, and residential lead-based paint, remain at the site.

Existing programs should be evaluated to determine how they may have contributed to this decline. The Ottawa County Health Department should continue existing blood lead screening and public health education efforts. Ongoing screening efforts are needed to confirm and monitor trends. Ongoing public health education reinforces the need for adult, parental, and child behaviors that may reduce exposure to lead and subsequent health effects.

VI. Recommendations

ATSDR recommends the following:

- Continue to provide blood lead screening to children living around the site. Currently, ATSDR provides funds from the EPA to the Ottawa County Health Department to conduct screening activities. EPA is continuing to fund these activities through FY 2005.

- Continue to provide lead exposure prevention education to people potentially impacted by the site. Currently, ATSDR provides funds from EPA to the Ottawa County Health Department to engage in prevention education activities. EPA is continuing to fund these activities through FY 2005.
- Recommend that the Oklahoma State Department of Health or the Ottawa County Health Department support periodic reports of Tar Creek and Ottawa County child blood lead statistics to the Tar Creek Superfund Site and Ottawa County communities. These reports could include trends and comparisons to state and national levels.
- Complete remediation of residential properties. EPA funds this activity. According to EPA, residential remediation is ongoing.
- Complete the investigation of chat piles, mill and mine residues, and flotation ponds. According to EPA, these activities are planned for completion next year.
- Assess the risk for lead exposure from using mine tailings (chat) for commercial and residential purposes, including processing and transporting the material. ATSDR has included in its FY 2004 and in the FY 2005 President's Budget request funding for an ongoing public health assessment regarding public health hazards associated with the Tar Creek site. The public health assessment will include identification of gaps in existing data and recommendations regarding further monitoring and other activities to evaluate risks of lead exposure. ATSDR recommends that any person proposing to use chat for commercial purposes arrange for an independent assessment of risks from exposure potentially associated with that use.
- To address concerns regarding the sources of lead exposure for children who currently have elevated BLLs, correlate lead isotopes in the environment and in children's blood. This approach would seek to identify specific environmental sources contributing to elevated BLLs in children. The measured ratio of lead isotopes ^{206}Pb and ^{207}Pb in the blood of children and adults would be compared with the ratio of ^{206}Pb and ^{207}Pb in environmental sources and biota (2, 3). ATSDR may conduct a small project to assess the feasibility of this approach.
- Evaluate the health risks of other site-related contaminants and of physical hazards. Funding to support this ongoing activity is included in ATSDR's FY 2004 and FY 2005 President's Budget.

ATSDR is considering whether to evaluate the effectiveness of activities at the Site, including soil remediation and tribal and non-tribal health education/blood lead screening programs. Such an evaluation might result in identification and then strengthening of those activities that have the most impact on reducing or eliminating lead exposure.

VII. Appendices

Table 1 — Major Lead Exposure Pathways at the Tar Creek Superfund Site

Pathway Name	Environmental Media and Transport Mechanisms	Point Of Exposure	Route Of Exposure	Exposure Population	Time	Notes	Complete Exposure Pathway?
Residential area soil	Lead present in soil as a result of use of tailings as fill or airborne transport of tailings from piles or ponds	Surface soil outside and house dust inside homes in Tar Creek area with soil leads above 500 mg/kg	Incidental ingestion, inhalation	Residents (particularly children 6 and younger)	Past, Present, Future	Elevated soil lead concentrations and BLLs identified in children in Tar Creek Area prior to the clean up of residential soil by EPA. Exposure continues to occur at any home yet to be remediated.	Yes
Mine tailings	Lead present in mine tailings deposited in tailings piles, ponds, or embankments	Walking or playing on the tailings piles, ponds, or embankments	Incidental ingestion, inhalation	Residents (particularly children 6 and younger)	Past, Present, Future	Many homes in the Picher and Cardin area are within 250 feet of tailings deposits.	Yes
Lead-based paint (LBP) ***Not site-related***	Lead present in house dust, soil, and paint chips due to the use of LBP	House dust, soil, and paint chips in or around homes with deteriorating LBP	Incidental ingestion	Residents (particularly children 6 and younger)	Past, Present, Future	Available data indicate that 30% to 40% of the homes in the Tar Creek area are likely to have LBP.	Yes

Table 2 — Other Lead Exposure Pathways at the Tar Creek Superfund Site

Pathway Name	Environmental Media and Transport Mechanisms	Point Of Exposure	Route Of Exposure	Exposure Population	Time	Notes	Complete Exposure Pathway?
Ingestion of homegrown produce	Uptake of lead from soil by fruits and vegetables grown in residential gardens	Produce consumption	Ingestion	Residents	Past, Present, Future	EPA sampling identified low levels of lead in homegrown produce.	Yes
Drinking water *Not site-related*	Movement of lead from lead pipes or solder into water	Municipal drinking water	Ingestion	Water supply users	Past, Present, Future	EPA sampling identified lead in the tap water of 13 of 100 homes.	Yes
Airborne dust	Airborne transport of mine tailings from piles, ponds, and embankments in the Tar Creek Site Area	Residential areas near tailings piles, ponds, and embankments	Inhalation	Individuals living near tailings piles, ponds, and embankments	Past, Present, Future	EPA sampling identified low levels of lead in the air.	Yes
Biota (wild animals & plants)	Uptake or ingestion of lead which had come from mine tailings in the environment	Consumption of animals and plants contaminated with lead from the site	Ingestion	Anyone who eats animals & plants from site area	Past, Present, Future	Members of the 9 tribes in Ottawa County may be at the greatest risk of exposure to contaminants in this pathway.	Unknown

Table 3 — Demographics in Tar Creek Superfund Site Area*

CHARACTERISTIC	PICHER/CARDIN AREA	TAR CREEK SITE AREA	UNITED STATES
Percent of People in Poverty	26	19	12.4
Percent of Homes Built Prior to 1950	39	32	22.3

*2000 Census Data

Table 4 — Characteristics of Blood Lead Testing Data Among Children Aged 1–5 Years Living within the Tar Creek Superfund Site*

All Tar Creek Superfund Site (also includes portion of North Miami that is outside the boundaries of Superfund site)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	*2004* *(Jan, Feb only)*
Oklahoma Child Lead Poisoning Prevention Program										
Total Elevated (≥10 µg/dL) (%)	20 (19.4)	67 (31.2)	50 (22.5)	14 (19.2)	9 (9.09)	25 (6.9)	16 (6.4)	11 (4.5)		
Geometric BLL Mean	4.80	6.65	6.00	5.36	4.93	3.81	3.32	3.05		
% Child Tested/Pop (actual number tested)	16 (103)	34 (215)	36 (222)	12 (73)	16 (99)	58 (361)	40 (249)	39 (242)		
Sampling Design	Convenience	Convenience	Convenience	Convenience	Convenience	Convenience	Convenience	Convenience		
TEAL Surveys (Personal Conversation, Malcoe 2004)										
Total Elevated (≥10 µg/dL) (%)			26 (18.2)			14 (8.6)				
Geometric BLL Mean			5.77			4.25				
% Child Tested/Pop (actual number tested)			23 (143)			26 (162)				
Sampling Design			Door-to-door			Door-to-door				

Table 4 (Continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004 *(Jan, Feb only)*
Ottawa Lead Poisoning Prevention Program										
Total Elevated (≥10 µg/dL) (%)					N/A	13 (5.4)	14 (8.2)	9 (5.7)	7 (2.8)	*N/A*
Geometric BLL Mean					5.13	3.62	3.15	2.65	3.04	*2.21*
% Child Tested/Pop (actual number tested)					5 (33)	38 (240)	27 (171)	25 (158)	40 (250)	*9 (55)*
Sampling Design					Convenience	Convenience	Convenience	Convenience	Convenience	*Convenience*

* n=625 (estimate based on 2000 Census)

Table 5 — Characteristics of Blood Lead Testing Data Among Children Aged 1–5 Years Living within the Tar Creek Superfund Site*

Picher and Cardin only

	1995	1996	1997	1998	1999	2000	2001	2002	2003	*2004 (Jan, Feb only)*
Oklahoma Child Lead Poisoning Prevention Program										
Total Elevated (≥10 μg/dL) (%)	17 (31.5)	41 (44.6)	34 (33.7)	5 (29.4)	3 (9.1)	17 (13.2)	7 (12.1)	3 (7.0)		
Geometric BLL Mean	6.13	9.17	7.66	6.63	5.24	4.30	4.42	4.24		
% Child Tested/Pop (actual number tested)	36 (54)	61 (92)	67 (101)	11 (17)	22 (33)	86 (129)	39 (58)	29 (43)		
Sampling Design	Convenience	Convenience	Convenience	Convenience	Convenience	Convenience	Convenience	Convenience		
TEAL Surveys (Personal Conversation, Malcoe 2004)										
Total Elevated (≥10 μg/dL) (%)			16 (25.0)			10 (13.3)				
Geometric BLL Mean			6.63			4.76				
% Child Tested/Pop (actual number tested)			43 (64)			50 (75)				
Sampling Design			Door-to-door			Door-to-door				
Ottawa Lead Poisoning Prevention Program										
Total Elevated (≥10 μg/dL) (%)					N/A	6 (8.2)	5 (12.2)	2 (6.67)	3 (3.4)	*N/A*

Table 5 (Continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	*2004* *(Jan, Feb only)*
Geometric BLL Mean					4.99	3.86	4.76	4.64	3.82	*2.43*
% Child Tested/Pop (actual number tested)					9 (13)	49 (73)	27 (41)	20 (30)	59 (88)	*11 (17)*
Sampling Design					Convenience	Convenience	Convenience	Convenience	Convenience	*Convenience*

* n=150 (estimate based on 2000 Census)

Table 6 – Existing Health Study Information

Factors Associated with Elevated BLLs*	**Teal Study** (Lynch et al. 2000) OR (95% CI)	**Teal Study** (Malcoe et al. 2002) OR (95% CI)
Floor lead dust ≥ 10 µg/ft^2	8.1 (1.8, 37.8)	11.4 (3.5, 37.3)
Yard soil lead		
>500 mg/kg	6.4 (1.4, 30.7)	
>165.3 mg/kg (front yard)		4.1 (1.3, 12.4)
Any interior lead paint	3.0 (1.2, 7.8)	
Superfund location	3.4 (1.3, 8.8)	5.6 (1.8, 17.8)
Hand-to-mouth behaviors		
index 2		7.0 (3.0, 16.5)
index 3		48.9 (8.7, 272.7)

* Blood lead levels

Table 7 — Children Aged 1–5 Years Living in the Tar Creek Superfund Site with Known Elevated BLLs in 2003, Residential Assessment Lead Exposure Status

Child	Known Exposure Status*	Environmental Testing (Y/N)	Environmental Testing Date	Age in Years	Race	Sex	Residence	Blood Lead Level
1	Unknown; frequent mover	N		3	W	M	Commerce	13.0
2	Lead-based paint	Y	12/16/2003	2	W	M	Quapaw	11.8
3	Lead-based paint	Y	11/15/2003	3	W	F	Picher	12.1
4	Floor dust, soil, no electricity or running water	Y	2/9/2001	2	W	F	Picher	17.6
5	Floor dust, soil, no electricity or running water	Y	2/9/2001	5	W	M	Picher	15.8
6	Lead-based paint, floor dust, soil	Y	9/12/2002	3	W	M	Quapaw	23.7
7	Lead-based paint, floor dust, soil	Y	9/12/2002	1	W	F	Quapaw	17.0

* Child may have moved and potential exposure source may have been remediated since testing date.

[Source: Ottawa County Lead Poisoning Prevention Program Data, 2003]

VIII. Figures

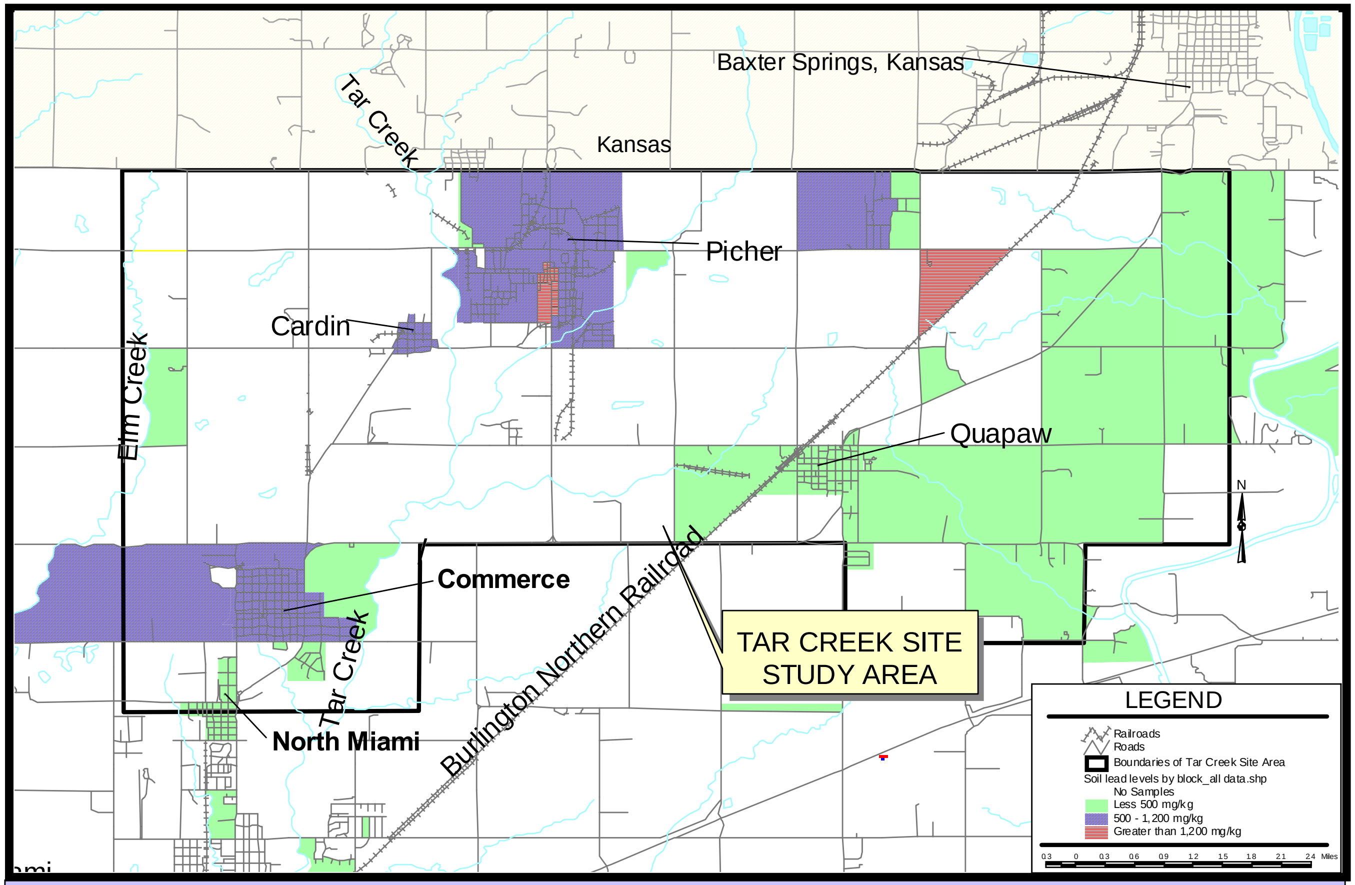


Figure 1 - Soil Lead Levels in Tar Creek Residential Area Soil

Agency for Toxic Substances and Disease Registry

Prepared by John R. Crellin, Ph.D - ATSDR: 042020

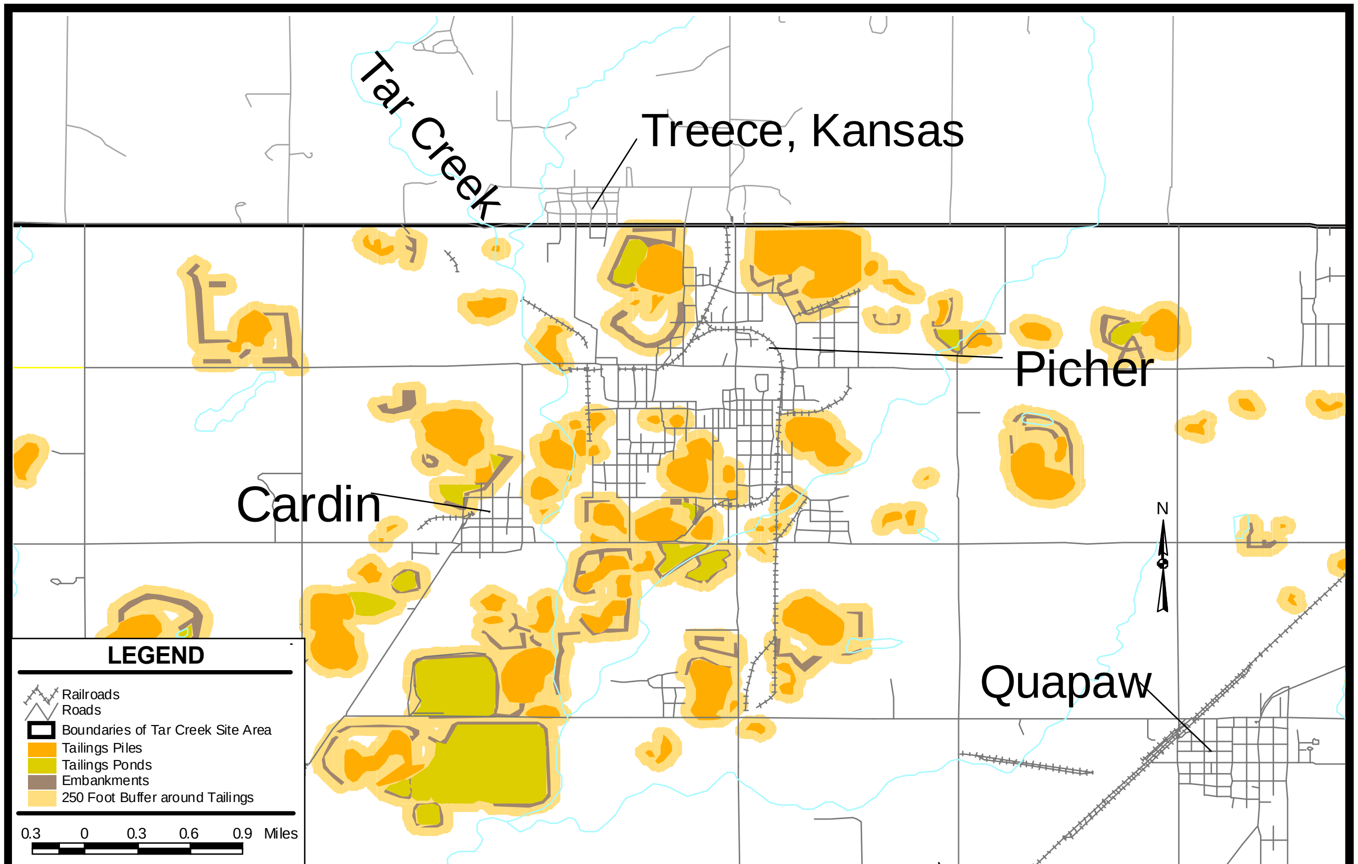
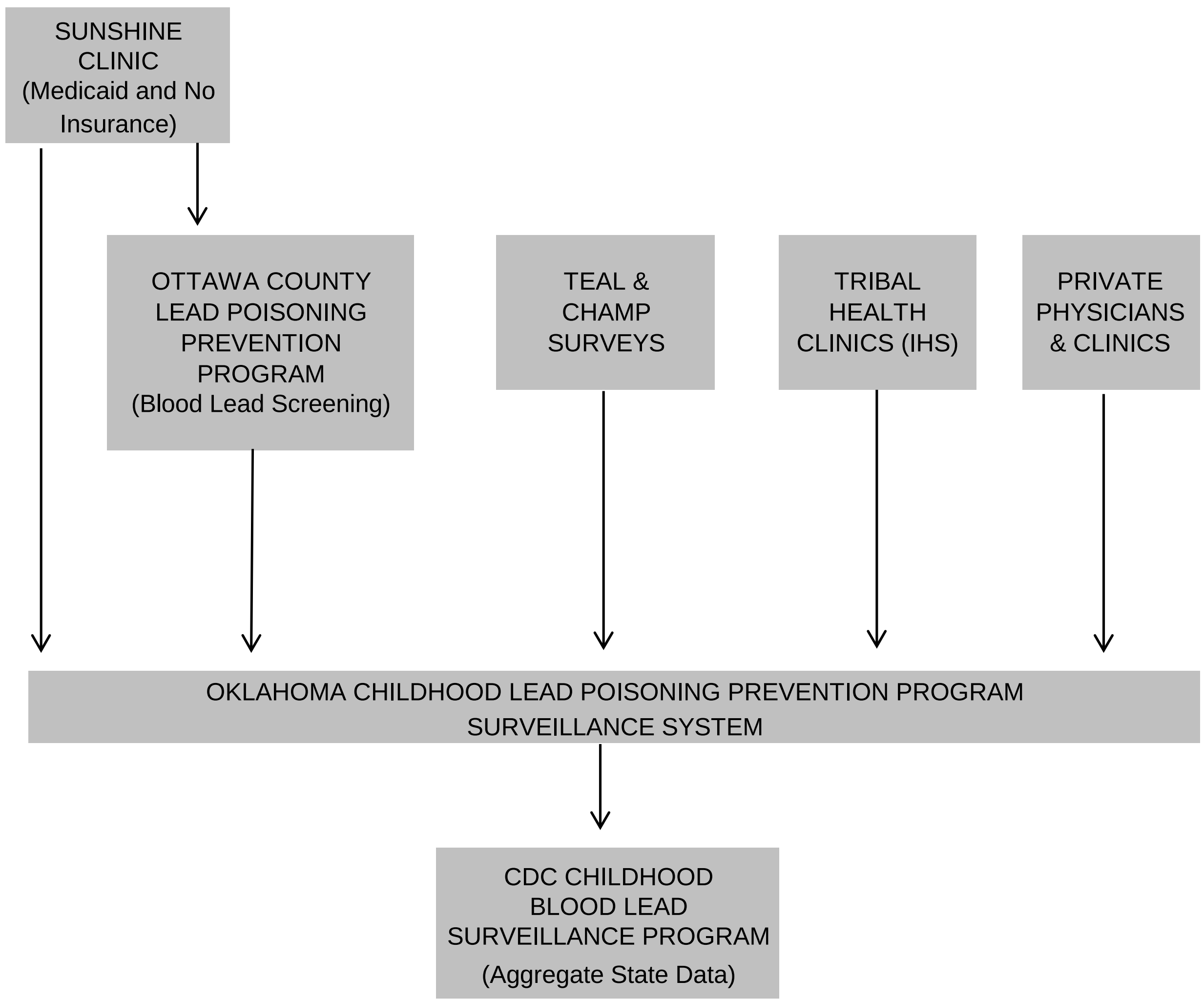


Figure 2 - Tailings in the Picher, Cardin, and Quapaw Area
Agency for Toxic Substances and Disease Registry
Prepared by John R. Crellin, PhD - 04202004

Figure 3

TAR CREEK CREEK SUPERFUND SITE - DATA FLOW FOR CHILD BLOOD LEAD DATA 1995-2004



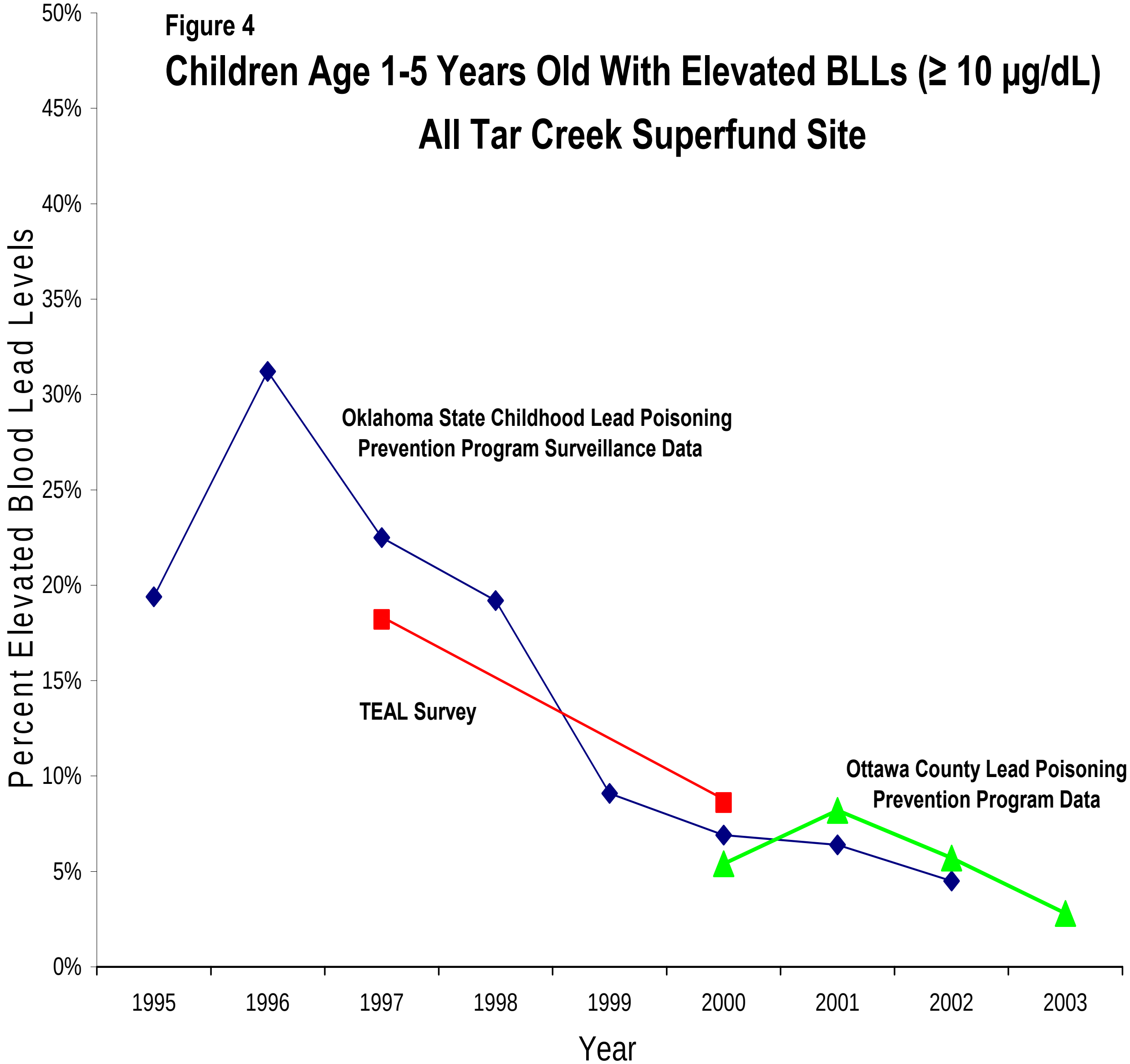


Figure 4
Children Age 1-5 Years Old With Elevated BLLs (≥ 10 µg/dL)
All Tar Creek Superfund Site
Percent Elevated Blood Lead Levels
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Oklahoma State Childhood Lead Poisoning
Prevention Program Surveillance Data
TEAL Survey
Ottawa County Lead Poisoning
Prevention Program Data
1995
1996
1997
1998
1999
2000
2001
2002
2003
Year

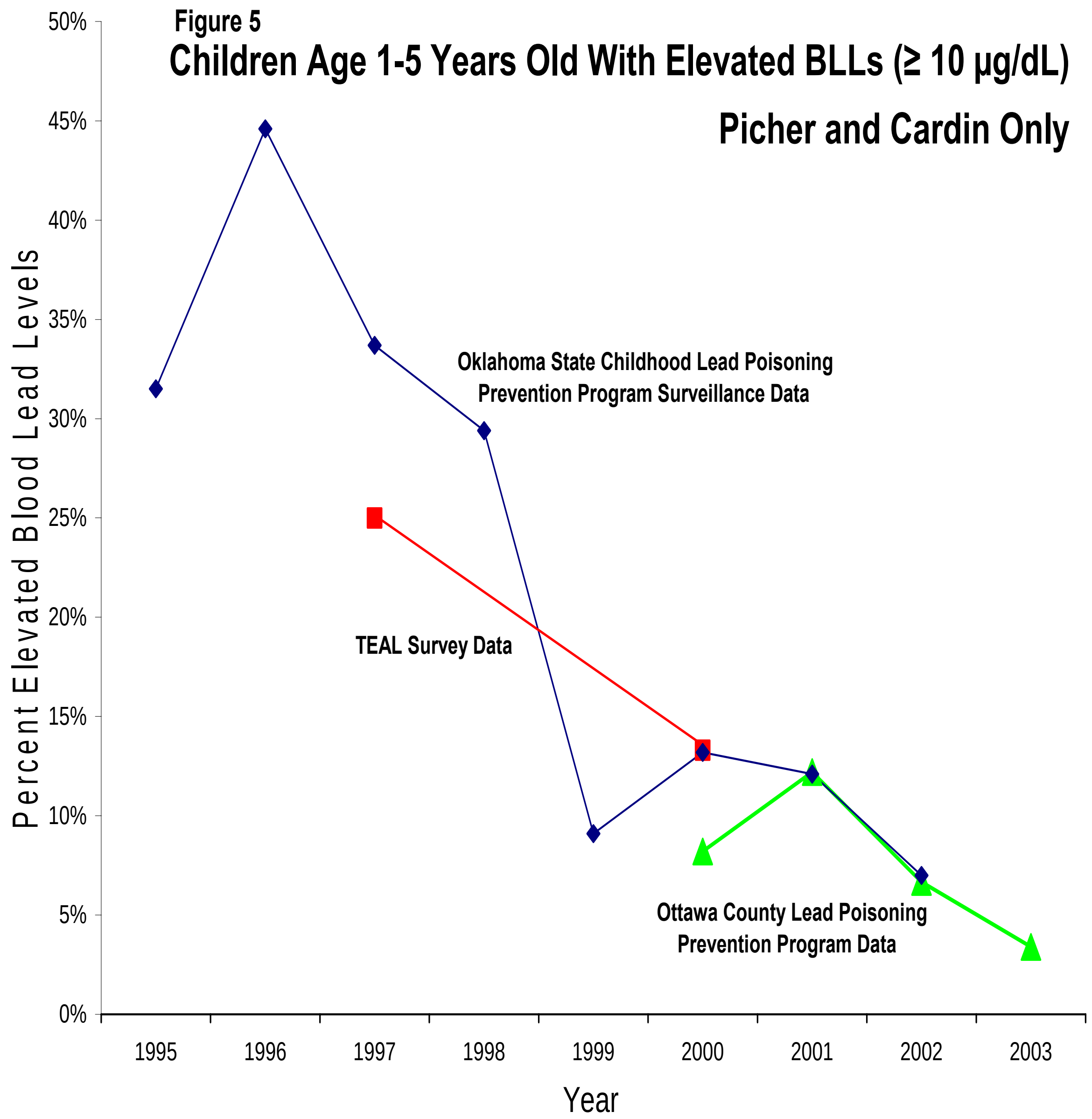


Figure 5
Children Age 1-5 Years Old With Elevated BLLs (≥ 10 µg/dL)
Picher and Cardin Only
Percent Elevated Blood Lead Levels
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Oklahoma State Childhood Lead Poisoning Prevention Program Surveillance Data
TEAL Survey Data
Ottawa County Lead Poisoning Prevention Program Data
1995
1996
1997
1998
1999
2000
2001
2002
2003
Year

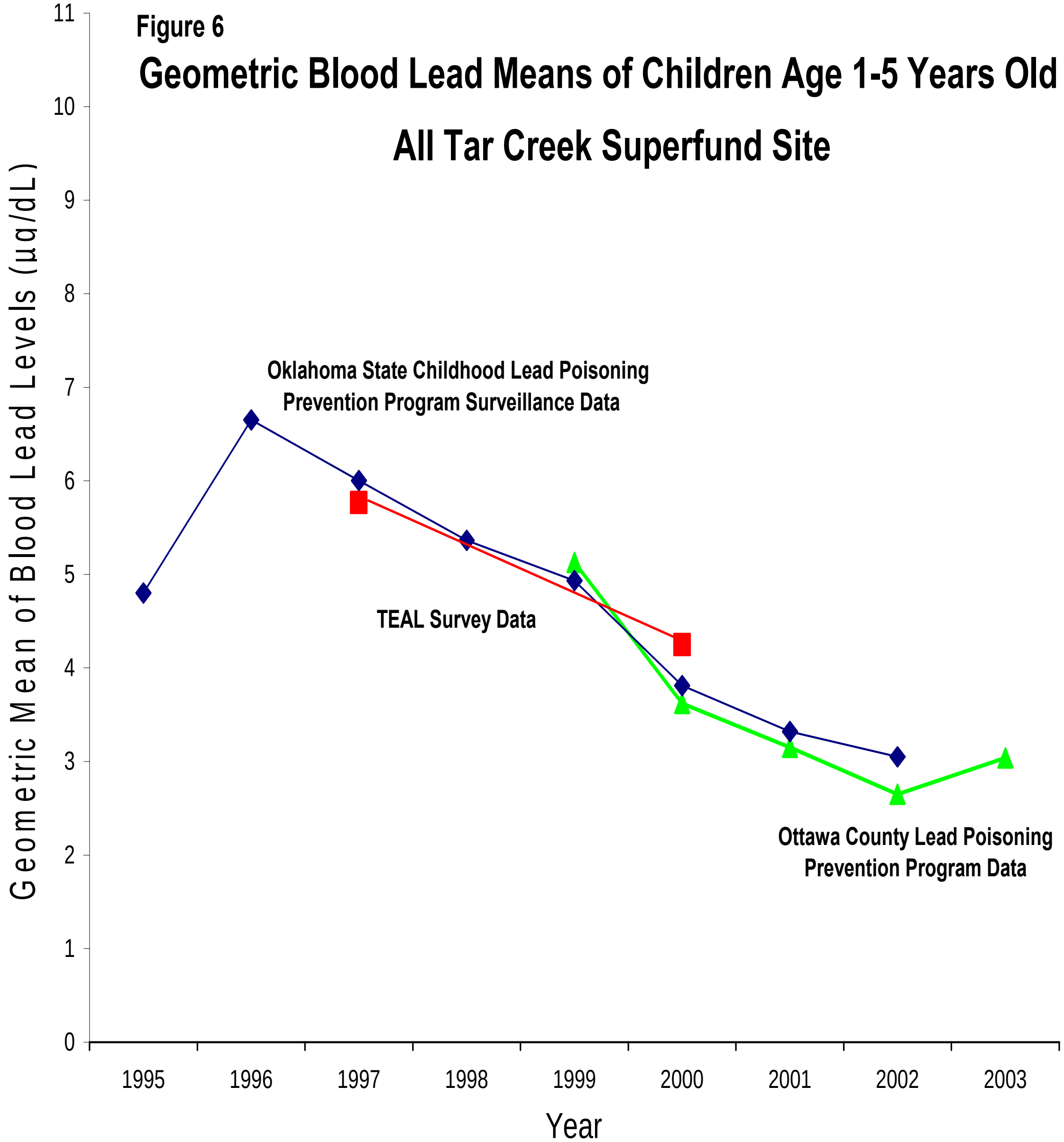


Figure 6
Geometric Blood Lead Means of Children Age 1-5 Years Old
All Tar Creek Superfund Site
Geometric Mean of Blood Lead Levels (µg/dL)
Oklahoma State Childhood Lead Poisoning Prevention Program Surveillance Data
TEAL Survey Data
Ottawa County Lead Poisoning Prevention Program Data
Year
0
1
2
3
4
5
6
7
8
9
10
11
1995
1996
1997
1998
1999
2000
2001
2002
2003

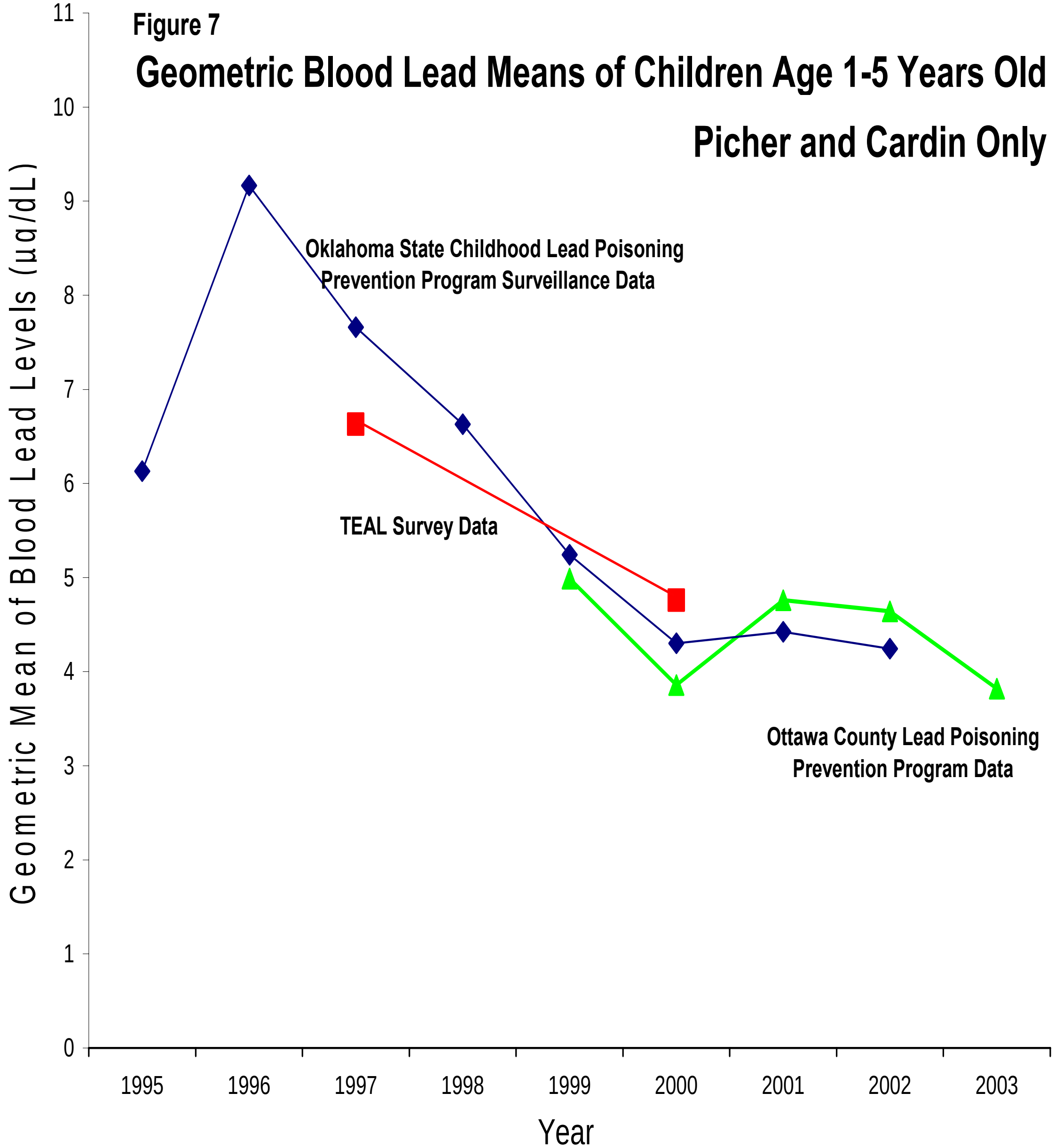


Figure 7
Geometric Blood Lead Means of Children Age 1-5 Years Old
Picher and Cardin Only
Oklahoma State Childhood Lead Poisoning Prevention Program Surveillance Data
TEAL Survey Data
Ottawa County Lead Poisoning Prevention Program Data
Geometric Mean of Blood Lead Levels (µg/dL)
Year
0
1
2
3
4
5
6
7
8
9
10
11
1995
1996
1997
1998
1999
2000
2001
2002
2003

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