Health Consultation

Historical Blood Lead Levels in East Chicago, Indiana Neighborhoods Impacted by Lead Smelters

U.S. SMELTER AND LEAD REFINERY, INC.

EAST CHICAGO, INDIANA

EPA FACILITY ID: IND047030226

AUGUST 16, 2018

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

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

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Prepared By:

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Summary

The U.S. Environmental Protection Agency (EPA) is investigating and remediating residential properties contaminated by emissions from former industrial facilities within the boundaries of the USS Lead Superfund site ("Site") in East Chicago, Indiana. The former industrial facilities included lead smelters, lead refineries, and a processing facility that manufactured white lead used in the formulation of lead-based paint.

CDC's National Center for Environmental Health (NCEH), Agency for Toxic Substances and Disease Registry (ATSDR), and Indiana State Department of Health (ISDH) examined the trends and locations of blood lead levels in the residential areas within the Site. We reviewed 11 years (2005-2015) of blood lead test results for young children living in the residential areas within the Site, designated as: Zone 1 (West Calumet Housing Complex, a federally-funded public housing facility); Zone 2 (Calumet neighborhood); and Zone 3 (East Calumet neighborhood), which are located within the City of East Chicago and compared them to the rest of East Chicago (also referred to as "Other East Chicago" within this report. Based on this assessment, the public health agencies have drawn the following conclusions.

Conclusions

Conclusion 1: The percentage of young children (less than 6 years of age) living in the residential areas of the USS Lead site and across the rest of East Chicago with blood lead levels greater than or equal to (≥) 5 µg/dL[1] continued to decline between 2005 and 2015.

> **Basis for Conclusion:** From 2005 to 2015, the percentage of blood lead tests results that are greater than the current CDC reference level of 5 µg/dL have been gradually declining within each of Calumet neighborhoods, across all of East Chicago, and across all of Indiana.

Conclusion 2: The number of blood lead tests for children younger than 6 years of age tested for blood lead across the City of East Chicago declined from 2008 to 2015. This decline has occurred in an area where children are at risk for higher blood lead levels from high soil lead levels and other possible sources of lead exposure. This decline is similar to the overall decline in blood lead testing among children in Indiana as a whole.

> **Basis for Conclusion**: The average number of blood lead tests for young children (less than 6 years of age) in all of **East Chicago** during the 11-year period (2005 to 2015) declined from 2008 through 2014 (Figure 1). A similar decline in the number of tests was also found within the residential areas of the USS Lead site (i.e. West Calumet Housing Complex, Calumet neighborhood, and East Calumet neighborhood). The number of children <6 years old living in East Chicago dropped 3% between 2000 and 2010, according to the US Census data. However, this slight decrease in population does not account for the decline in children tested. After 2011, the number of blood lead tests conducted also declined across the entire state of Indiana (ISDH, 2015).

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[1] In 2012, the Centers for Disease Control and Prevention (CDC) updated its recommendations on children's blood lead levels. Prior to that, CDC used 10 micrograms per deciliter (µg/dL) as the "level of concern" to identify children who require case management. A reference level of 5 µg/dL is currently used to evaluate children who have been exposed to lead, based on the 97.5th percentile of the distribution of national blood lead levels in children (National Health and Nutrition Examination Survey (NHANES)).

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Conclusion 3: Young children (less than 6 years of age) living in the **West Calumet Housing Complex (WCHC) (Zone 1)** had a higher percentage of blood lead levels greater than or equal to (≥) 5 µg/dL between 2005 and 2015, compared with other areas of East Chicago (not including Zones 1,2 and 3).

> **Basis for Conclusion:** Over the period of 2005-2015, a child living in WCHC (Zone 1) had nearly a three times greater chance of having a blood lead level ≥ 5 µg/dL (Odds Ratio = 2.93), compared to a child living in Other East Chicago (not in Zones 1, 2, or 3). During that time, 27.5% of the blood lead test results were ≥ 5 µg/dL, compared to 11.5% for the remainder of East Chicago. Also during that time 4.4% of the blood lead results were ≥ 10 µg/dL, compared to 1.6% for the remainder of East Chicago.

Conclusion 4: Young children living in the **Calumet neighborhood** (Zone 2) have also experienced a similar higher percentage of blood lead levels ≥ 5 µg/dL as children living in WCHC, compared to the other areas of East Chicago (not including Zones 1,2 and 3).

> **Basis for Conclusion**: Over the period of 2005-2015, a child living in the Calumet neighborhood (Zone 2) also had almost a three times greater chance of having a blood lead level ≥ 5 µg/dL (Odds Ratio = 2.86), compared a child living in Other East Chicago (not including Zones 1,2, and 3). During that time, 28.2% of the blood lead tests were ≥ 5 µg/dL, compared to 11.5% for the remainder of East Chicago. Also during that time, 5.7% of the blood lead tests were ≥ 10 µg/dL, compared to 1.6% for the remainder of East Chicago.

Conclusion 5: Young children living in **the East Calumet neighborhood** (Zone 3) had a similar percentage of blood lead levels ≥ 5 µg/dL, but a higher percentage of blood lead levels ≥ 10 µg/dL, compared to other areas of East Chicago (not including Zones 1, 2, and 3).

> **Basis for Conclusion**: Over the period of 2005-2015, a child living in the East Calumet neighborhood (Zone 3) had a similar chance of having a blood lead level ≥ 5 µg/dL (odds ratio = 0.94), compared to a child living in Other East Chicago. During that time, 11.3% of the blood lead tests were ≥ 5 µg/dL, compared to 11.5% for the remainder of East Chicago. Also during that time, 3.0% of the blood lead tests were ≥ 10 µg/dL, compared to 1.6% for the remainder of East Chicago.

Background and Statement of Issues

The U.S. Smelter and Lead Refinery, Inc. (USS Lead) operated on a 79-acre property at 5300 Kennedy Avenue in East Chicago, Indiana as a primary and secondary lead smelting facility beginning in 1906. From 1920 until 1973, USS Lead operated as a primary lead smelter, which involved processing and smelting of the mined ore, followed by refining the lead through an electrolytic process to generate high purity lead casting (EPA, 2012). In 1973, the facility converted to secondary smelting, which includes recovering lead from scrap metal and automobile batteries. Wastes from the smelting operations and on-site surface soils were heavily contaminated with lead and other metals (EPA, 2012). After USS Lead operations ceased in 1985, the Indiana Department of Environmental Management (IDEM) oversaw clean-up efforts by the responsible party.

The U.S. Environmental Protection Agency (EPA) initially proposed the USS Lead site to the National Priorities List (NPL) in 1992 when USS Lead's parent company, Sharon Steel, filed for bankruptcy. However, EPA did not list USS Lead as a Superfund NPL site until 2008. The USS Lead site, as defined under the NPL listing, includes the former industrial facility and the West Calumet, Calumet, and East Calumet residential neighborhoods just to the north of the former facility. Also included within the USS Lead site was another lead smelting and refining facility operated by the former Anaconda Lead Products and International Lead Refining Company (ILRC). ILRC

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processed lead bullion from its smelter in Tooele, Utah and from the ARASCO smelter in Montana from 1911 until 1968. Anaconda Lead Products operated a process that manufactured white lead for use in paint products.

After operations ceased at the ILRC facility in 1968, the City of East Chicago acquired the property and received federal housing funds from U.S. Department of Housing and Urban Development (HUD) to construct a public housing complex on the footprint of the former industrial property. The West Calumet Housing Complex (WCHC) was opened in 1972, and until recently, the complex housed more than 1,000 residents in the 350 units. Appendix A shows a map of the former ILRC/Anaconda in relation to WCHC and the Carrie Gosch Elementary School. Appendix B shows the timeline of a redevelopment of the residential areas within the USS Lead Superfund site. Appendix C shows the boundaries of the specific areas of investigation (Zones 1, 2, and 3) within the residential portion of the USS Lead site.

ATSDR released a *Preliminary Public Health Assessment* (PHA) for the USS Lead site in 1994. We concluded that "the site was a public health hazard because chronic exposure to contaminated soils, wastes, and airborne dusts could cause adverse health effects". ATSDR recommended soil testing in the residential properties and identified that there was insufficient information available about blood lead levels in children living in areas contaminated by the USS Lead site. In 1997, ISDH and ATSDR collaborated to conduct an exposure investigation of residents within the West Calumet and Calumet neighborhoods. This document includes a summary of the results of that investigation (ATSDR 1998).

1990-1997 Blood Lead Data

The Indiana Childhood Lead Prevention Program provided the CDC Lead Poisoning Prevention Program with blood lead level (BLL) data for children living in the Calumet neighborhoods (West Calumet, Calumet, and East Calumet). The data included blood lead test results for both capillary and venous blood samples of children under 6 years of age. A review of that data showed that between 1990 to 1997, 30.9% of the children had blood lead levels ≥ 10 µg/dL (the CDC blood lead "level of concern" at that time) as compared to the 1993 statewide prevalence rate of 10.9% for children's BLLs ≥ 10 µg/dL. The average BLL for this neighborhood during that time was 8.31 µg/dL (ATSDR, 1998.

1998 ISDH/ATSDR Exposure Investigation

In the 1994 PHA, ATSDR recommended evaluating blood lead levels in children who lived in the West Calumet Housing Complex (ATSDR, 1994). This population was of specific concern because the housing units were constructed on the property of a former lead smelter and processing facility, operated by the former Anaconda Lead Products and ILRC. In 1996, ISDH requested ATSDR assist them in conducting an Exposure Investigation (EI) to address community health concerns and to evaluate potential exposures to lead. The EI focused on two community neighborhoods, West Calumet and Calumet. The results showed that 30.0% of the children <6 years old tested in the West Calumet and Calumet neighborhoods had blood lead levels that were ≥ 10 µg/dL, compared to 10.9% statewide at that time (ATSDR, 1998). Based on these findings, ATSDR recommended: 1) conducting follow-up investigations of participants with an elevated blood lead level, including determining the source of exposure, determining the need for additional soil sampling, and conducting follow-up testing on all of the children; 2) providing healthcare provider education (completed in Oct. 1997); and 3) remediating lead-contaminated soil at the Anaconda site. While it was ATSDR's understanding that IDEM had scheduled the remediation, no remediation actually occurred until years later.

In 2011, ATSDR issued a Public Health Assessment document that included a statement that declining blood lead levels in small children was an indication that breathing the air, drinking tap water, or playing in soil around the USS Lead Site is not expected to harm people's health. However, it should be noted that the statement was based on a review of blood lead data provided to ATSDR for all young children in East Chicago and did not focus specifically on the levels in children living in the residential areas within the USS Lead site.

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More recent EPA soil test results from 2014 and 2015 for the West Chicago Housing Complex and in the Calumet and East Calumet neighborhood led to renewed concerns about lead exposure to children living in these areas. This concern led to an intensive campaign beginning in July 2016 by ISDH and the East Chicago Health Department, with support from ATSDR, to conduct blood lead testing of children living in these areas, at schools, community centers, and in their homes.

Review of Blood Lead Data - Calumet Neighborhood Children

The purpose of this review of blood lead levels from 2005 to 2015 in East Chicago neighborhoods was to:

- Evaluate trends in blood lead testing of children living in neighborhoods impacted by lead smeltering facilities to ensure that exposed individuals are being identified
- Evaluate any differences in blood lead levels (BLLs) within these neighborhoods, compared to the rest of East Chicago or the state of Indiana, which informs an assessment of exposure to lead sources in these areas. A more detailed analysis of the correlation of blood lead data with environmental data will be provided in the upcoming PHA report.
- Provide a basis for responding to community health concerns

2005-2015 Blood Lead Data

CDC's NCEH analyzed ISDH blood lead test results from 2005 to 2015 for children younger than 6 years of age who lived in East Chicago. Descriptive statistics were calculated to compare the populations in each Zone and the remainder of East Chicago. The methodology for the statistical analyses used in this report is summarized in Appendix D.

A total of 5,587 children <6 years of age[2] were tested in East Chicago during 2005-2015 (Table 1). Overall, half were female. An equal percentage of children, nearly 30%, were less than or equal to 24 months of age and 25-48 months of age. Forty percent were black and almost 49% were Medicaid recipients (Table 1). While a child may have been tested more than once per year during the 11-year period, this analysis includes only one test per child per year (Appendix D). However, a child may have been tested in multiple years.

There were a total of 6,920 blood lead test results from these 5,587 individual children for the time period of this analysis: 2005-2015 in East Chicago (overall including Zones 1, 2, 3, and Other East Chicago). The data were stratified by year to evaluate the number of tests per year, and the number and percent of tests that were ≥5 and ≥10 µg/dL in Zones 1, 2, and 3, and the remainder of East Chicago ("Other East Chicago"), as shown in Table 2 and Figure 2. Over the 11-year period, the percentage of blood lead tests that were ≥5 and ≥10 µg/dL decreased, consistent with the statewide trend (Table 3).

Although the number of blood lead tests fluctuates from year to year, there was an overall downward trend in the number of children <6 years of age tested for blood lead levels (Figure 1). The highest number of blood lead

[2] Rule 410 of Indiana Administrative Code Section 29-1-6 uses children less than 7 years of age as the target population. Whereas, CDC uses children less than 6 years of age as the criteria, which is the age cut-off used in the analysis for this report.

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tests was 849 in 2008 and the lowest was 411 in 2014. During this period there was also a similar downward trend in the number of children <7 years of age tested for blood lead levels, beginning in 2012 (Table 3).

The odds of having a blood lead test result ≥5 and ≥10 µg/dL were calculated for each Zone and compared to Other East Chicago (not including Zones 1, 2, or 3) and adjusted for age group and year of blood lead test (Table 4). Compared to the remainder of East Chicago, children had statistically significant higher odds of having BLLs ≥5 µg/dL if they lived in Zone 1 (Odds Ratio (OR) = 2.93; 95% CI: 2.32-3.69) or Zone 2 (OR: 2.86; 95% CI: 2.05-4.00) and of having BLLs ≥10 µg/dL if they lived in Zone 1 (Odds Ratio (OR) = 2.65; 95% CI: 1.59-4.42) or Zone 2 (OR: 3.09; 95% CI: 1.62-5.90). However, the odds of having BLLs ≥5 or ≥10 µg/dL for children living in Zone 3 were not statistically significantly different from those living in the remainder of East Chicago (OR: 0.94; 95% CI: 0.68-1.30) and (OR: 1.79; 95% CI: 0.94-3.38), respectively (Table 4).

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Table 1. Sociodemographic Characteristics of Children (less than 6 years old) with a Blood Lead Test between 2005-2015, by Geographic Area

	WCHC[1] (Zone 1)		Calumet (Zone 2)		East Calumet (Zone 3)		Other East Chicago		Total East Chicago	
	N	%	N	%	N	%	N	%	N	%
Sex										
Female	159	45.7	81	50.3	153	46.7	2,346	49.4	2,739	49.0
Male	183	52.6	77	47.8	168	51.2	2,344	49.4	2,772	50.0
Unknown	6	1.7	*	1.9	7	2.1	60	1.3	76	1.0
Age (months)										
0 to 24	87	25.0	52	32.3	102	31.1	1,403	29.5	1,644	29.4
25 to 48	111	31.9	36	22.4	104	31.7	1,322	27.8	1,573	28.1
49 to <72	150	43.1	73	45.3	122	37.2	2,025	42.6	2,370	42.4
Race										
Black	233	67.0	118	73.3	142	43.3	1,718	36.2	2,211	40.0
White	21	6.0	11	6.8	68	20.7	666	14.0	766	13.7
Other	5	1.4	*	0.6	8	2.4	211	4.4	225	4.0
Unknown	89	25.6	31	19.3	110	33.5	2,155	45.4	2,385	42.7
Medicaid Status										
Yes	180	51.7	90	55.9	162	49.4	2,285	48.1	2,717	48.6
No	69	19.8	48	29.8	99	30.2	1,163	24.5	1,379	24.7
Unknown	99	28.5	23	14.3	67	20.4	1,302	27.4	1,491	26.7
Total tested	**348**		**161**		**328**		**4,750**		**5,587**	

[1] WCHC: West Calumet Housing Complex

* Redactions applied to cell counts less than 5

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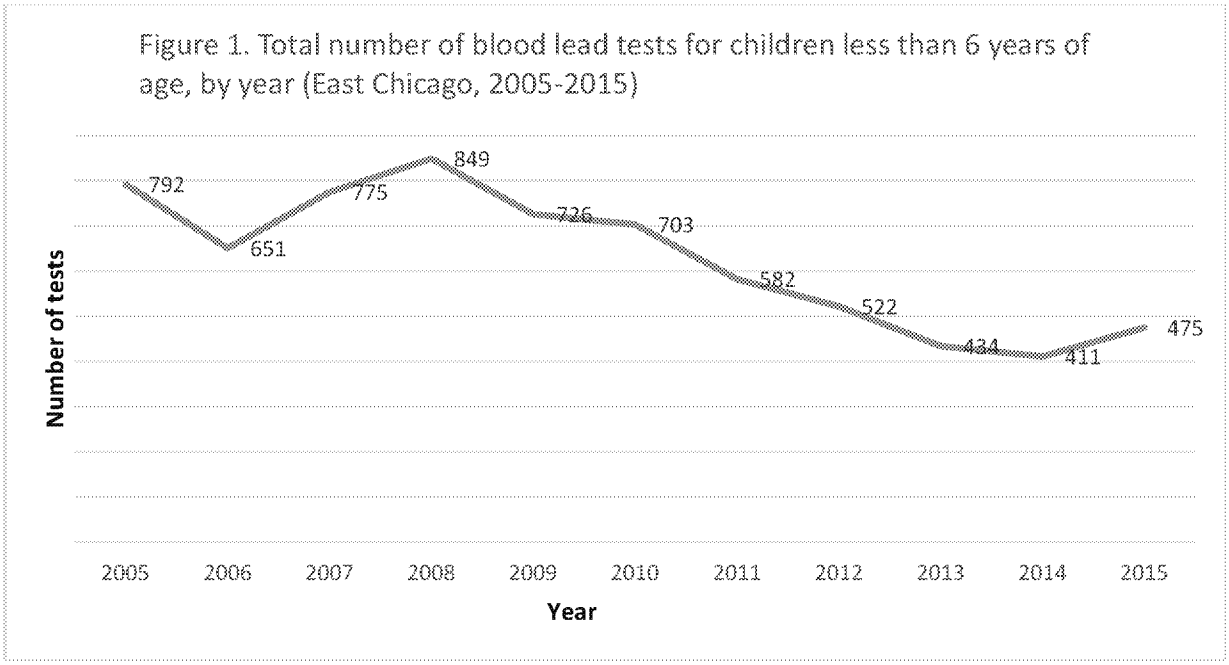
Figure 1. Total number of blood lead tests for children less than 6 years of age, by year (East Chicago, 2005-2015)
Number of tests
792
651
775
849
726
703
582
522
434
411
475
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year

Table 2. Number of Blood Lead Tests for Children (Ages < 6 years old) and Number and Percent of Tests with Blood Lead Levels ≥ 5 µg/dL and ≥ 10 µg/dL, by Zone and Year, East Chicago: 2005-2015[1,2,3]

	Zone 1			Zone 2			Zone 3			Other East Chicago		
		µg/dL			µg/dL			µg/dL			µg/dL	
	Tests	≥ 5	≥ 10	Tests	≥ 5	≥ 10	Tests	≥ 5	≥ 10	Tests	≥ 5	≥ 10
Year	N	N (%)	N (%)	N	N (%)	N (%)	N	N (%)	N (%)	N	N (%)	N (%)
2005	69	28 (40.6)	7 (10.1)	35	12 (34.3)	*	40	8 (20.0)	*	648	110 (17.0)	22 (3.4)
2006	50	19 (38.0)	*	36	13 (36.1)	*	30	*	*	535	90 (16.8)	15 (2.8)
2007	38	15 (39.5)	*	20	12 (60.0)	5 (25.0)	57	*	*	660	124 (18.8)	11 (1.7)
2008	48	14 (29.2)	*	18	6 (33.3)	*	52	9 (17.3)	*	731	103 (14.1)	12 (1.6)
2009	39	9 (23.1)	*	23	7(30.4)	*	48	7 (14.6)	*	616	64 (10.4)	7 (1.1)
2010	37	9 (24.3)	*	20	*	*	38	*	*	608	40 (6.6)	7 (1.2)
2011	35	6 (17.1)	*	14	*	*	31	*	*	502	39 (7.8)	6 (1.2)
2012	26	5 (19.2)	*	*	*	*	17	*	*	476	39 (8.4)	5 (1.1)
2013	20	*	*	5	*	*	18	*	*	391	22 (5.6)	5 (1.3)
2014	29	*	*	8	*	*	24	*	*	350	19 (5.4)	*
2015	46	8 (17.4)	*	13	*	*	27	*	*	389	28 (7.2)	*
Total	**437**	**120 (27.5)**	**19 (4.4)**	**195**	**55 (28.2)**	**11 (5.7)**	**382**	**43 (11.3)**	**11 (3.0)**	**5,906**	**679 (11.5)**	**95 (1.6)**

* Redactions applied to cell counts less than 5

[1] Includes both venous and capillary blood lead test results

[2] There were a total of 6,920 blood lead test results from 5,587 individual children for the time period of this analysis: 2005-2015 in East Chicago (overall including Zones 1, 2, 3, and Other East Chicago). While a child may have been tested more than once during the 11-year period, this analysis includes only one test per child per year.

[3]Note: Indiana Elevated Blood Lead Level (EBLL) Definition: Rule 410 of Indiana Administrative Code 29-1-6 defines "Elevated blood lead level" or "EBLL" as a blood lead level of ten (10) µg/dL or higher. Indiana State Department of Health (ISDH) is currently in the rule promulgation process for changing the action level to the CDC reference level of 5 µg/dL. For purposes of this report, we show both values.

[4]ISDH, 2015. https://www.in.gov/isdh/files/Lead_Report_2015_w_reportable_disease.pdf

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Table 3. Number of Blood Lead Tests for Children (Ages < 7 years old)* and Number and Percent of Tests with Blood Lead Levels ≥ 5 µg/dL and ≥ 10 µg/dL, for the entire State of Indiana during the years 2005-2015

Year	Tests N	≥ 5 µg/dL N (%)	≥ 10 µg/dL N (%)
2005	43,685	5,362 (12.3)	985 (2.3)
2006	48,214	5,338 (11.1)	918 (1.9)
2007	65,361	6,833 (10.5)	1,125 (1.7)
2008	62,652	5,586 (8.9)	973 (1.6)
2009	59,871	5,127 (8.6)	792 (1.3)
2010	61,563	4,136 (6.7)	682 (1.1)
2011	59,900	3,793 (6.3)	585 (1.0)
2012	53,265	3,034 (5.7)	494 (0.9)
2013	48,102	2,323 (4.8)	420 (0.9)
2014	40,811	1,766 (4.3)	289 (0.7)
2015	41,267	1,727 (4.2)	355 (0.9)
Total	**584,691**	**45,025 (7.8)**	**7,618 (1.3)**

* The data is from the 2015 ISDH Report- Childhood Lead Surveillance- Report Environmental Public Health Division Lead & Healthy Homes Program- 10 Years of Childhood Blood Lead Level Data in Indiana. Indiana State Department of Health. Available at https://www.in.gov/isdh/files/Lead_Report_2015_w_reportable_disease.pdf Note that the age range for the ISDH report (<7 years old) is one year older than the age range the CDC/NCEH used in the analysis of East Chicago data (<6 years old). The ISDH Report incorrectly listed the age range as being <6 years old.

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Table 4. Odds Ratio (OR) and 95% Confidence Intervals (CI) for Blood Lead (BL) Test Results ≥ 5 and ≥ 10 µg/dL in Children (<6 years old) by Zone, East Chicago (2005-2015)[1]

	WCHC (Zone 1)	Calumet (Zone 2)	East Calumet (Zone 3)	Other East Chicago (reference group)	Total
BL <5 µg/dL	317	140	339	5227	6023
BL ≥5 µg/dL	120	55	43	679	897
Chi-sq. p-value[2]	<0.0001	<0.0001	0.887		
Crude OR (95% CI)	2.91 (2.33-3.65)	3.02 (2.19-4.17)	0.98 (0.70-1.35)		
Age-adjusted OR[3] (95% CI)	2.93 (2.32-3.69)	2.86 (2.05-4.00)	0.94 (0.68-1.30)		
BL <10 µg/dL	418	184	371	5811	6784
BL ≥10 µg/dL	19	11	11	95	136
Chi-sq. p-value[2]	<0.0001	<0.0001	0.062		
Crude OR (95% CI)	2.78 (1.68-4.56)	3.66 (1.93-6.94)	1.81 (0.96-3.42)		
Age-adjusted OR[3] (95% CI)	2.65 (1.59-4.42)	3.09 (1.62-5.90)	1.79 (0.94-3.38)		
					6920

[1] There were a total of 6,920 blood lead test results from 5,587 children for the time period of this analysis: 2005-2015 in East Chicago (overall)

[2] p-values from chi-square tests of equal proportions comparing each zone to Other East Chicago (not including Zones 1, 2, or 3). Chi square is a calculation used to determine how closely the observed data fit the expected data. The smaller the p-value, the more likely that there is a difference in the comparison.

[3] Cochran-Mantel-Haenszel Estimate adjusted for age and year of test

[4] Note: Indiana Elevated Blood Lead Level (EBLL) Definition: Rule 410 of Indiana Administrative Code 29-1-6 defines "Elevated blood lead level" or "EBLL" as a blood lead level of ten (10) µg/dL or higher. Indiana State Department of Health (ISDH) is currently in the rule promulgation process for changing the action level to the CDC reference level of 5 µg/dL. For purposes of this report, we show both values.

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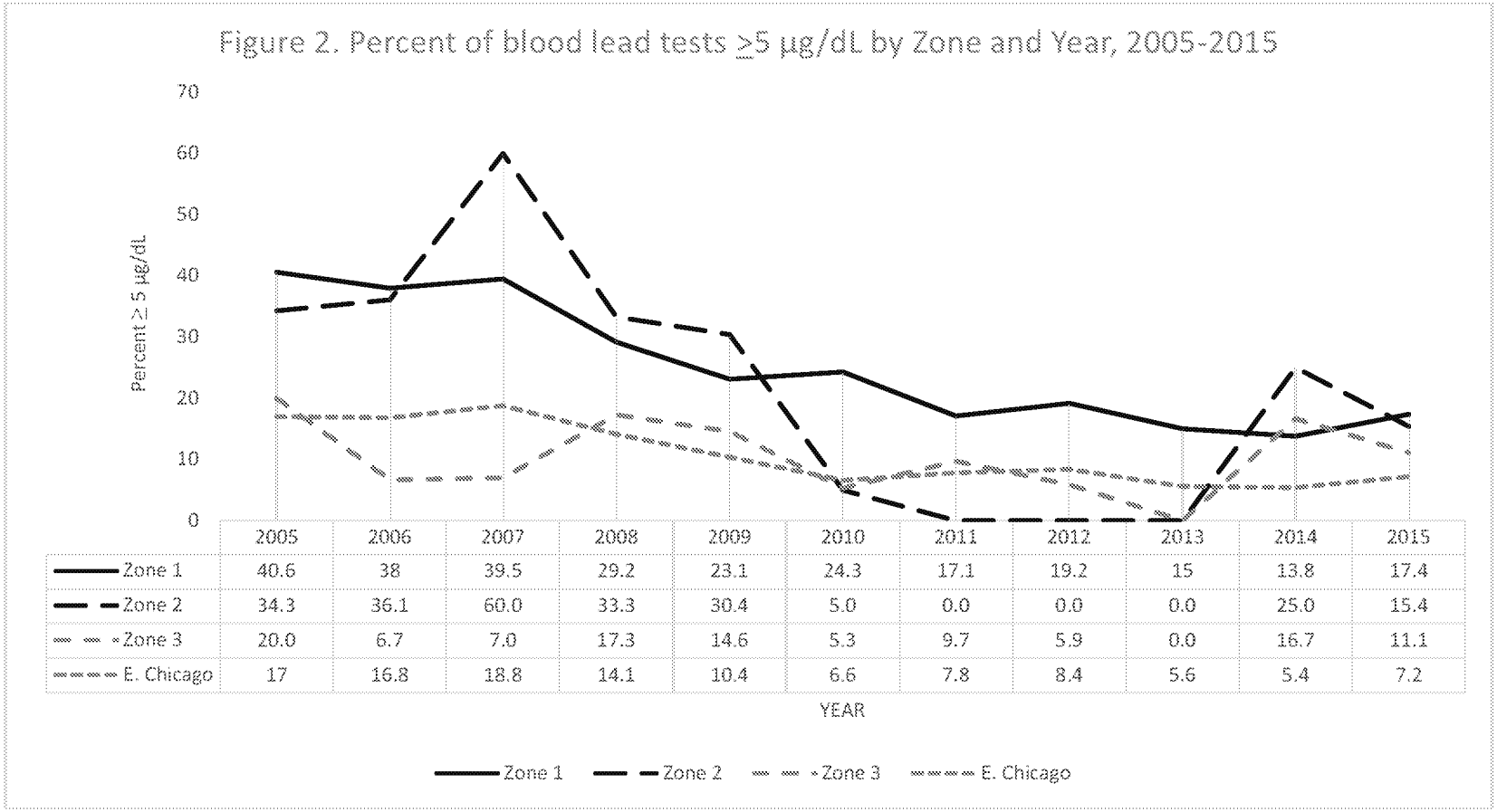

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Zone 1	40.6	38	39.5	29.2	23.1	24.3	17.1	19.2	15	13.8	17.4
Zone 2	34.3	36.1	60.0	33.3	30.4	5.0	0.0	0.0	0.0	25.0	15.4
Zone 3	20.0	6.7	7.0	17.3	14.6	5.3	9.7	5.9	0.0	16.7	11.1
E. Chicago	17	16.8	18.8	14.1	10.4	6.6	7.8	8.4	5.6	5.4	7.2

* E. Chicago in this figure refers to East Chicago outside of Zones 1, 2, and 3

Environmental Data

ATSDR plans to do an extensive review of possible environmental lead sources in this area and report that information in a separate document. We will review the possible sources listed below.

Soil contamination

The USS Lead plant ceased operations in 1985. Since then, IDEM, the Indiana Air Pollution Control Board (IAPCB), and the EPA Superfund Remedial and the Emergency Response Programs have investigated soil lead contamination on-site and also within the West Calumet (Zone 1), Calumet (Zone 2), and East Calumet (Zone 3) neighborhoods over several rounds of investigation.

The investigations found soil lead levels high enough to require immediate remediation for a number of residential properties in 2006 and 2011. A more extensive effort to remove lead-contaminated soil began in September 2016 and is currently on-going[3].

Table 5 shows surface soil lead levels for sampling conducted during 2014-2017 by EPA in each of the Neighborhoods/Zones. The results of limited soil sampling for lead concentrations at several background locations in East Chicago that were not impacted by lead contamination for the USS Lead site are shown as a comparison. The results show that the median (50th percentile) level of lead in surface soil was significantly higher in each of these neighborhoods, compared to the background locations within East Chicago. Comparison of the levels within each of the neighborhoods shows that the WCHC (Zone 1) generally has higher levels of lead contamination in surface soils than either of the other neighborhoods. Calumet (Zone 2) levels are higher than East Calumet (Zone 3).

The fact that the housing complex was built on the footprint of the former Anaconda Smelting facility, a known source of lead contamination, could explain the higher soil lead levels in WCHC/Zone 1. Zones 2 and 3 could have been impacted by airborne lead deposition of historical smelter emissions or the use of contaminated fill material. Soil boring of some properties in Zones 2 and 3 show higher concentrations in subsurface soil and also the presence of "slag-like" material in the soil. These observations provide evidence that lead-containing slag had been used as fill in this area (EPA, 2012; Geochemical Solutions, 2004; Techlaw, 2004).

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[3] The EPA documents on the USS Lead site detailing the soil sampling and remediation activities are available at https://www.epa.gov/uss-lead-superfund-site.

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Table 5. Comparison of Lead Concentration (ppm) in Surface Soils (0-6" depth) by Neighborhood/Zone

Neighborhood/Zone	N	Lead Concentration (ppm)					
				Percentiles			
		Mean	GM (95% CI)[+]	25th	50th	75th	Maximum
WCHC (Zone 1)	94	2,465	1,057 (826-1,353)	416	862	2,420	45,000
Calumet (Zone 2)	1,261	512	379 (363-396)	242	411	630	17,500
East Calumet (Zone 3)	558	424	337 (320-354)	238	340	462	10,000
East Chicago Background*	9	-	-	-	77.6	-	112

*Site-specific background sampling of East Chicago locations unaffected by urban fill or backfill material from USS Lead site (EPA Remedial Investigation report, 2012)

[+] GM = geometric mean; 95% CI = 95% confidence interval (lower, upper) on the statistic

Indoor dust

Lead in indoor dust can come from outdoor sources, such as contaminated soil, or from indoor sources, such as lead-based paint. In Fall 2016, ISDH conducted XRF testing of interior surfaces in the WCHC and found no indication of lead on painted surfaces in the housing complex (ISDH, 2016). EPA also performed indoor dust sampling, the results of which will be included in separate document.

Drinking water

These neighborhoods are supplied by municipal water from the City of East Chicago which is sourced from Lake Michigan. Since groundwater is not used as a source of drinking water, it is unlikely that lead in soil has impacted the drinking water. Testing records indicate that the City of East Chicago has been in compliance with the Federal Lead and Copper Rule testing requirements. However, the City of East Chicago Water Utilities Department has estimated that more than 83% of its residential water service lines across the distribution system may include leaded pipes. In addition, homes built before 1986 are more likely to have lead fixtures and lead-based solder, therefore corrosion of plumbing materials may also be a source of exposure.

Air emissions

Limited information on air emissions is available from the time when USS Lead was in operation. In 1985, when the plant was still operating, IDEM collected air monitoring data on the plant property and in the community. Most of the time, the wind blows from the property towards the northeast. The 1985 quarterly average for air lead, about ¼ mile downwind of the plant, was 1.3 $\mu g/m^3$ [ATSDR 1994]. As a comparison, between 1978 and 2008, the National Ambient Air Quality Standard (NAAQS) based on quarterly averages was 1.5 $\mu g/m^3$. In 2008, EPA lowered the air quality standards for lead to reflect the latest epidemiological findings and to better provide health protection for at-risk groups, including children. The current lead standard is 0.15 $\mu g/m^3$. IDEM has operated two new source-oriented monitors near lead-emitting steel industries of East Chicago since the NAAQS was revised. Monitoring near the former USS Lead site is not required as it is no longer an active air emission source. Air monitoring data show that the East Chicago area has been in attainment of the previous NAAQS and the revised NAAQS since it was implemented.

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Discussion

Evaluation of blood lead testing in the WCHC and Calumet neighborhoods during the 2005-2015 time period shows that beginning 2008, the number of children younger than 6 years of age that were tested showed a steady decline across the rest of East Chicago. After 2011, a similar decline in the number of blood testing was observed across the state of Indiana (ISDH, 2015) and across the U.S. (CDC, 2015). The number of children <6 living in East Chicago dropped 3% between 2000 and 2010, according to the US Census data. However, this slight decrease in population does not account for the decline in children tested. The reasons for that decline are not clear, but these data indicate the need to prioritize targeted testing of children in this community.

Based on the analysis for the period from 2005-2015, children living in the WCHC (Zone 1) and the adjacent Calumet neighborhood (Zone 2), immediately to the east, had a higher percentage of blood lead tests ≥ 5 µg/dL than children in the remainder of East Chicago. Although there are many potential sources of exposure to lead, the high surface soil levels in WCHC (Zone 1) and Calumet (Zone 2) are a source for lead exposure that could contribute to this difference. Therefore, EPA's assessment and remediation of properties within these areas is important to reduce exposure. ATSDR is reviewing environmental sampling results for soil, indoor dust, and air to evaluate exposure to the community, to identify needed public health actions, and to update the 2011 Public Health Assessment.

Children can be exposed to lead from multiple sources, including lead-based paint, soil, dust, air, water, foods, and consumer products. Exposure to these sources and the impact on blood lead levels can vary by individual. Therefore, it is difficult to attribute exposure to a specific source(s).

Given the level of lead contamination in these neighborhoods, particularly in WCHC (Zone 1), the potential for exposure to lead from residential soil was greater than for other areas of East Chicago that were not affected by industrial sources. ATSDR will complete an extensive review of past and present environmental lead sources in another report. Although we may be able to identify potential exposure sources and make recommendations on reducing exposure, we cannot determine the magnitude of the contribution of specific sources to the blood lead levels in these neighborhoods.

The effects of lead exposure are generally irreversible, with negative impacts on attention-related behaviors, IQ, academic achievement, as well as effects on the cardiovascular, immunological, and endocrine systems. The focus of public health agencies is on primary prevention of lead exposure. Identifying children and pregnant women who are at risk for lead exposure is critical to developing effective intervention strategies.

Data Limitations

Data selection: The blood lead test data used in the analysis included only the data that could be linked to a child's address and geocoded. These analyses did not include data for children with missing addresses and for those whose addresses that could not be geocoded. However, the high address match rate for geocoding for East Chicago reduces the likelihood that missing addresses had a serious effect on the results. The results are based on a convenience sample of children who received blood lead tests between 2005-2015 and may not represent the entire population.

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Conclusions

Conclusion 1: The percentage of young children (less than 6 years of age) living in the residential areas of the USS Lead site and across the rest of East Chicago have had a declining percentage of blood lead levels greater than or equal to (≥) 5 µg/dL[4] between 2005 and 2015.

> **Basis for Conclusion:** From 2005 to 2015, the percentage of blood lead tests results that are greater than the current CDC reference level of 5 µg/dL have been gradually declining within each of Calumet neighborhoods, across all of East Chicago, and across all of Indiana.

Conclusion 2: The number of blood lead tests for children younger than 6 years of age tested for blood lead across the City of East Chicago declined from 2008 to 2015. This decline has occurred in an area where children are at risk for higher blood lead levels from high soil lead levels and other possible sources of lead exposure. This decline is similar to the overall decline in blood lead testing among children in Indiana as a whole.

> **Basis for Conclusion**: The average number of blood lead tests for young children (less than 6 years of age) in all of **East Chicago** during the 11-year period (2005 to 2015) declined from 2008 through 2014 (Figure 1). A similar decline in the number of tests was also found within the residential areas of the USS Lead site (i.e. West Calumet Housing Complex, Calumet neighborhood, and East Calumet neighborhood). The number of children <6 years old living in East Chicago dropped 3% between 2000 and 2010, according to the US Census data. However, this slight decrease in population does not account for the decline in children tested. After 2011, the number of blood lead tests conducted also declined across the entire state of Indiana (ISDH, 2015).

Conclusion 3: Young children (less than 6 years of age) living in the **West Calumet Housing Complex (WCHC) (Zone 1)** had a higher percentage of blood lead levels greater than or equal to (≥) 5 µg/dL between 2005 and 2015, compared with other areas of East Chicago (not including Zones 1,2 and 3).

> **Basis for Conclusion:** Over the period of 2005-2015, a child living in WCHC (Zone 1) had nearly a three times greater chance of having a blood lead level ≥ 5 µg/dL (Odds Ratio = 2.93), compared to a child living in Other East Chicago (not in Zones 1, 2, or 3). During that time, 27.5% of the blood lead test results were ≥ 5 µg/dL, compared to 11.5% for the remainder of East Chicago. Also during that time 4.4% of the blood lead results were ≥ 10 µg/dL, compared to 1.6% for the remainder of East Chicago.

Conclusion 4: Young children living in the **Calumet neighborhood** (Zone 2) have also experienced a similar higher percentage of blood lead levels ≥ 5 µg/dL as children living in WCHC, compared to the other areas of East Chicago (not including Zones 1,2 and 3).

> **Basis for Conclusion**: Over the period of 2005-2015, a child living in the Calumet neighborhood (Zone 2) also had almost a three times greater chance of having a blood lead level ≥ 5 µg/dL (Odds Ratio = 2.86), compared a child living in Other East Chicago (not including Zones 1,2, and 3). During that time, 28.2% of the blood lead tests were ≥ 5 µg/dL, compared to 11.5% for the remainder of East Chicago. Also during that time, 5.7% of the blood lead tests were ≥ 10 µg/dL, compared to 1.6% for the remainder of East Chicago.

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[4] In 2012, the Centers for Disease Control and Prevention (CDC) updated its recommendations on children's blood lead levels. Prior to that, CDC used 10 micrograms per deciliter (µg/dL) as the "level of concern" to identify children who require case management. A reference level of 5 µg/dL is currently used to evaluate children who have been exposed to lead, based on the 97.5th percentile of the distribution of national blood lead levels in children (National Health and Nutrition Examination Survey (NHANES)).

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Conclusion 5: Children living in **the East Calumet neighborhood** (Zone 3) had a similar percentage of blood lead levels ≥ 5 µg/dL, but a higher percentage of blood lead levels ≥ 10 µg/dL, compared to other areas of East Chicago (not including Zones 1, 2, and 3).

Basis for Conclusion: Over the period of 2005-2015, a child living in the East Calumet neighborhood (Zone 3) had a similar chance of having a blood lead level ≥ 5 µg/dL (odds ratio = 0.94), compared to a child living in Other East Chicago. During that time, 11.3% of the blood lead tests were ≥ 5 µg/dL, compared to 11.5% for the remainder of East Chicago. Also during that time, 3.0% of the blood lead tests were ≥ 10 µg/dL, compared to 1.6% for the remainder of East Chicago.

Recommendations

1) For ISDH, ECHD, and CDC/ATSDR to continue encouraging blood lead testing of all children <6 years of age in living East Chicago, but particularly in the neighborhoods that have been demonstrated to have been impacted by the lead contamination from the operations within the USS Lead Superfund site.

2) For ISDH, ECHD, CDC/ATSDR, and the Region 5 Pediatric Environmental Health Specialty Unit (PEHSU) continue to support healthcare provider education opportunities for this community.

3) For ISDH to ensure that any child with a BLL ≥ the CDC blood lead reference value (currently 5 µg/dL) from East Chicago is entered into case management, including follow-up blood lead testing at regular intervals according to CDC guidelines. This includes ISDH coordination with HUD and local health agencies to ensure the same follow-up is provided for those children who may have left East Chicago due to the WCHC closure.

4) For the City of East Chicago and ISDH to make residents aware of funding opportunities to address lead hazards in their homes.

5) For ISDH, ECHD, CDC/ATSDR, Indiana Department of Education, and the Region 5 Pediatric Environmental Health Specialty Unit (PEHSU) to provide information to parents of children with a BLL ≥ the CDC Blood lead reference value and school officials and teachers in East Chicago about the risks of lead exposure to cognitive development and make them aware of the accommodations their children may need to be effective learners.

Public Health Action Plan

1) ATSDR will continue to work with ISDH and ECHD to encourage blood lead testing of children through targeted public messaging. The rate of BLLs ≥ 5 µg/dL has been gradually declining nationally. That trend can also be seen for East Chicago, as well as for the WCHC, Calumet, and East Calumet Zones. However, it is still important to continue public outreach to encourage testing of young children throughout the residential areas impacted by contamination from USS Lead and other smelter facilities. There is a specific need to target testing of children in the Calumet neighborhood where the rates of BLLs ≥ 5 µg/dL and environmental contamination remain a concern until remediation has been completed.

2) ISDH, ECHD, ATSDR, and the Region 5 PEHSU will develop on-going healthcare provider education programs to encourage blood lead testing of all young children throughout East Chicago. These agencies

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participated in a Medical Grand Rounds event, sponsored by St. Mary's Hospital on February 4, 2017, which focused on lead education and the USS Lead investigation.

3) ISDH, ECHD, HUD, and the East Chicago Housing Authority will coordinate on the follow-up through case management protocols for children that have a BLL $\geq$ 5 µg/dL who formerly living in the West Calumet Housing Complex. This effort would include children who moved within East Chicago, those moving elsewhere within the state of Indiana, or those who have moved out of state.

4) The City of East Chicago will promote public awareness of resources to abatement residential lead hazards, particularly grants available through the East Chicago Redevelopment Commission to be used for rehabilitation of owner-occupied residences. Such efforts will reduce the risks of future lead exposures to children. ISDH has also received funding through HUD and Medicaid to be used to address residential lead hazards.

5) ISDH, ECHD, and CDC/ATSDR will coordinate to develop an outreach effort targeted to families with young children and educators in East Chicago to provide information about the risks of lead exposure to cognitive development and to encourage development of a program to address the educational needs of lead-exposed children.

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Authors

Mark Johnson, PhD, DABT
Regional Director/Toxicologist
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry
(ATSDR)- Region 5
Chicago, IL

Motria Caudill, PhD
Environmental Health Scientist
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry
(ATSDR)- Region 5
Chicago, IL

James M. Hodge, JD, MPH
ORISE Fellow, Healthy Homes and Lead Poisoning
Prevention Program (through 1/2017)
National Center for Environmental Health
Centers for Disease Control & Prevention
Atlanta, GA

Stella O. Chuke, MBBS, MPH
Epidemiologist, Lead Poisoning Prevention &
Environmental Health Tracking Branch
Division of Environmental Health Science and
Practice
National Center for Environmental Health
Centers for Disease Control & Prevention
Atlanta, GA

Contributors

Sharunda D. Buchanan, PhD, MS
Director of Priority Projects and Innovation
National Center for Environmental Health
Centers for Disease Control & Prevention
Atlanta, GA

Adrienne S. Ettinger, ScD, MPH, MS
Branch Chief (Acting), Lead Poisoning Prevention &
Environmental Health Tracking Branch
Division of Environmental Health Science and
Practice
National Center for Environmental Health
Centers for Disease Control & Prevention
Atlanta, GA

Mary Jean Brown, ScD, RN
Chief (former), Healthy Homes and Lead Poisoning
Prevention Program (through 8/2016)
National Center for Environmental Health
Centers for Disease Control & Prevention
Atlanta, GA

Helen Schurz Rogers, PhD
Senior Scientist
Division of Environmental Health Science and
Practice
National Center for Environmental Health
Centers for Disease Control & Prevention
Atlanta, GA

Magan Meade, MPA, MPH
Environmental Epidemiologist
Environmental Public Health Division
Indiana State Department of Public Health
Indianapolis, IN

Michael Mettler
Director, Environmental Public Health Division
Indiana State Department of Public Health
Indianapolis, IN

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Appendices

Appendix A- Property map of Former Anaconda Lead Smelter and Current West Calumet Housing Complex (WCHC)

Appendix B- Historical Aerial Photographs of Former Anaconda Lead Smelter/Refinery and Surrounding Residential Areas

Appendix C- Map showing areas of lead contamination assessment in soil

Appendix D- Methodology for statistical evaluation of 2005-2015 blood lead data

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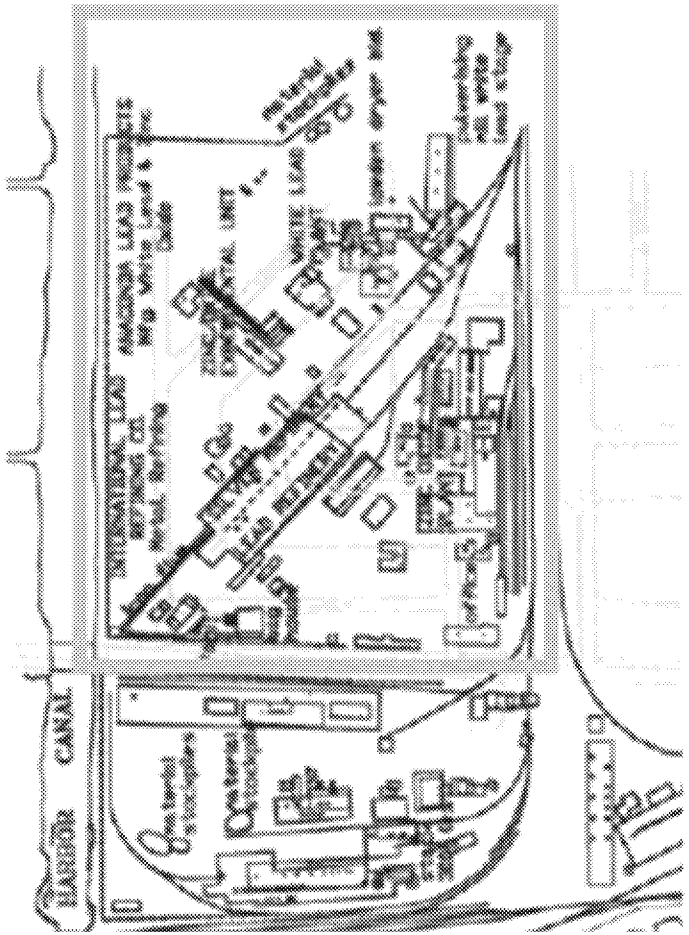
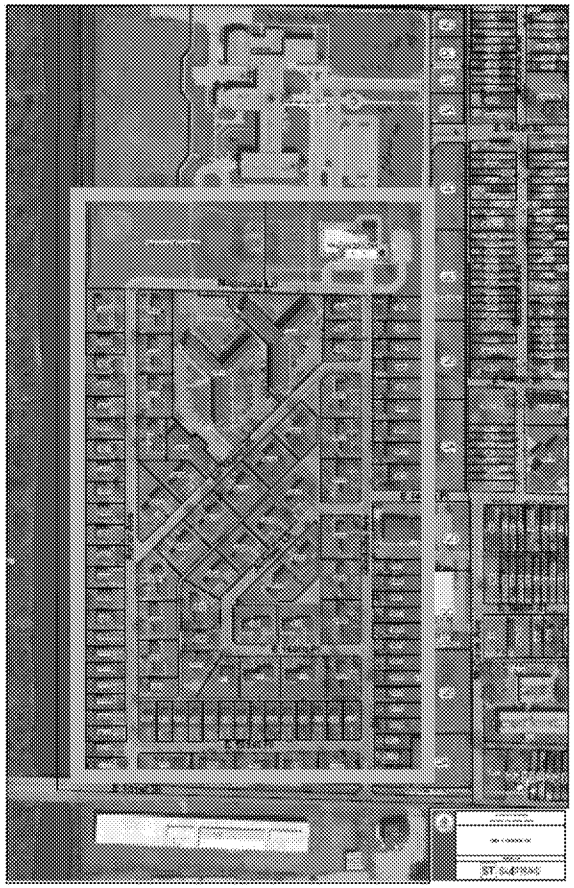
Appendix A: International Lead Refinery/Anaconda Lead Products

Pulverizing Mill & White Lead Storage

White Lead Plant

Lead Refinery

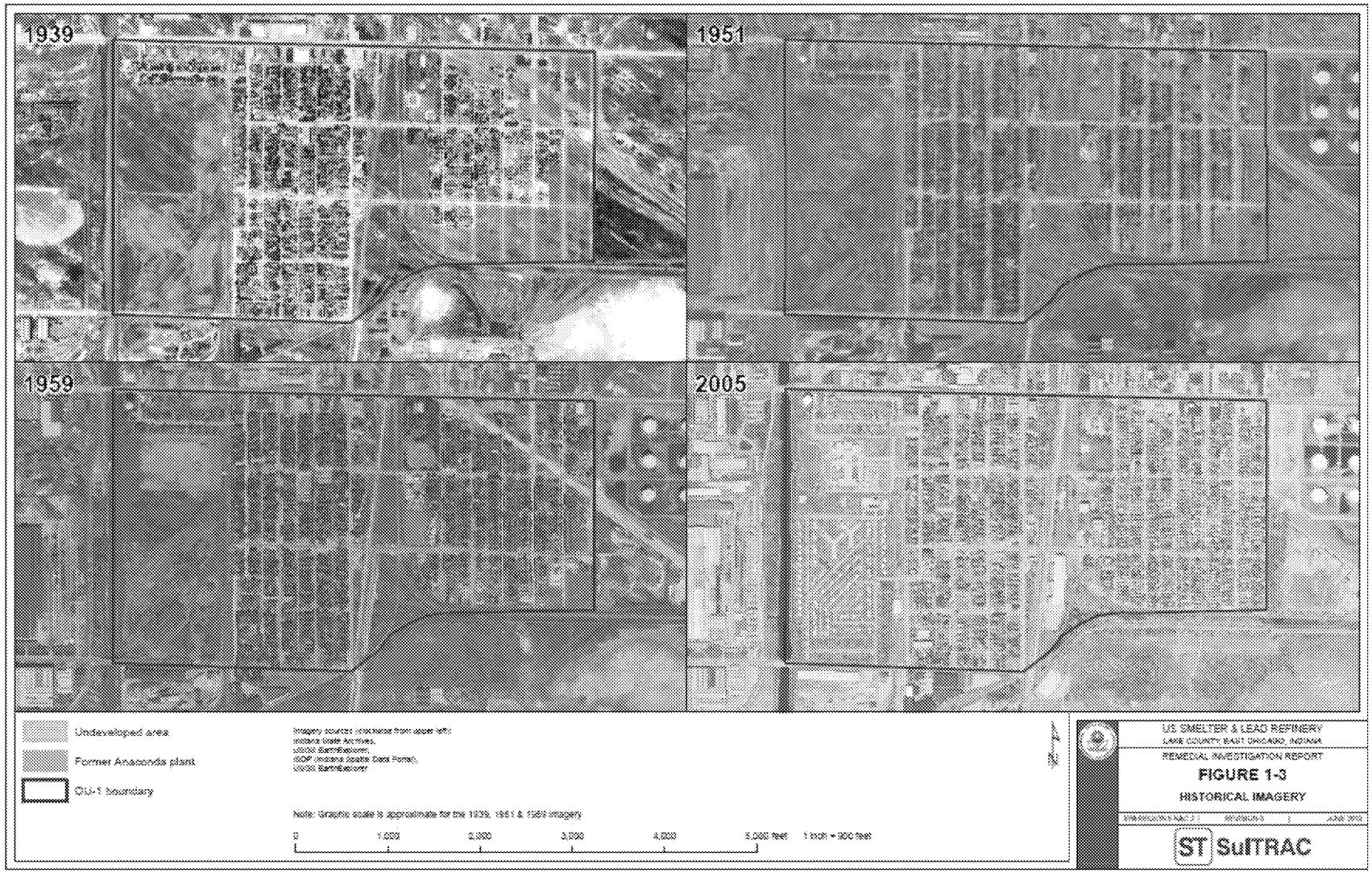




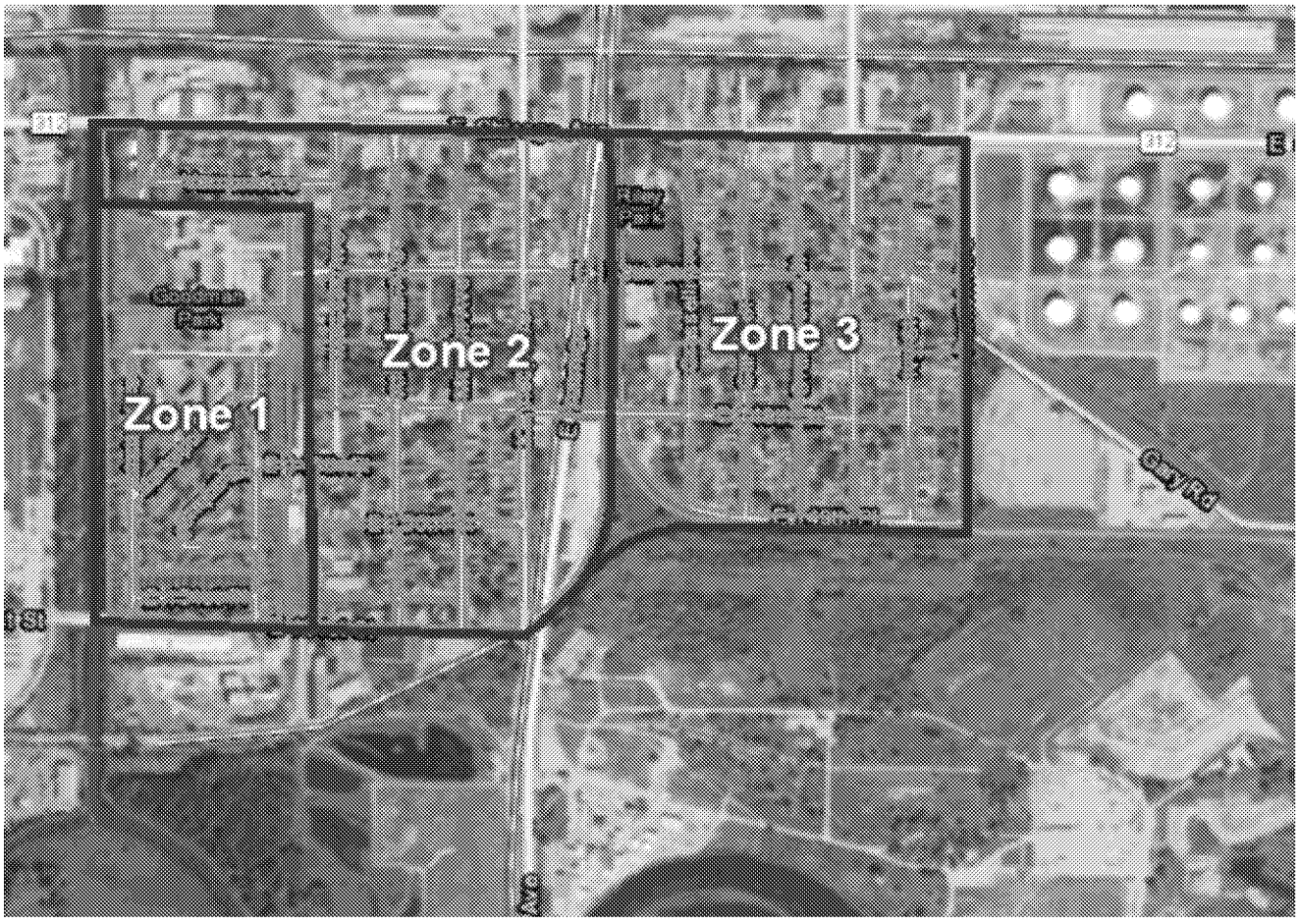
Carrie Gosch Elementary School

West Calumet Housing Complex

Appendix B- Historical Aerial Photographs of Former Anaconda Lead Smelter/Refinery and Surrounding Residential Areas (from EPA Remedial Investigation Report)



Appendix C- EPA map showing areas of lead contamination in soil
(https://www.epa.gov/uss-lead-superfund-site)



Appendix D- Methodology for statistical evaluation of 2005-2015 blood lead data

The Indiana State Department of Health (ISDH) provided all blood lead test results for children less than 6 years of age in their database for 2005 through 2015. These data were limited to include only those tests that were in Lake County or had a missing county variable. There were no identifiers for individual patients, so a matching algorithm was applied to assign each individual an ID number. Matches were determined using a hierarchical matching process. Each observation was checked against the remainder of observations and considered a match if: 1) the billing ID variable was an exact match; 2) the first name, last name, and date of birth were an exact match; 3) a concatenation of the first two letters of the first name, first two letters of the last name, sex, and date of birth were an exact match; or 4) a concatenation of the first two letters of the first name, first two letters of the last name and date of birth were an exact match. Observations that matched based on the concatenated variables were then manually reviewed to ensure that they were in fact the same individual. When address data or sex codes were missing, they were imputed if possible based on the other observations for that individual. Finally, the data were limited to one test per child per year retaining the highest venous test, or, where there were no venous tests, the lowest capillary or unknown test. The dataset used for geocoding and analysis contained 41,650 blood lead test results from 34,347 unique individuals.

Data were geocoded using a GIS mapping tool (TomTom®, 2012). The initial match rate was 89% (36,901 matched). After manual re-matching, an additional 248 addresses were matched and approximately 90% of the observations were mapped to a geographic location. Among addresses identified by either the city ("East Chicago") or zip code ("46312") variable, approximately 97% of the addresses were mapped to a geographic location. Once addresses were geocoded, each observation was assigned an indicator if it was within the West Calumet Housing Complex (Zone 1), the Calumet neighborhood (Zone 2), the East Calumet neighborhood (Zone 3), or the remainder of the city of East Chicago ("Other East Chicago") which served as the comparison).

Descriptive statistics comparing population sociodemographic characteristics (sex, age group, race, Medicaid status), and the number of tests by sample type (venous, capillary or unknown) and year, were calculated within each of the three zones as well as for the rest of East Chicago. Data were stratified by year to determine whether the sample type or the percentage of tests ≥5 and ≥10 μg/dL varied over time within each of the three zones or in the remainder of East Chicago. Odd Ratios (ORs) and 95% confidence intervals (CI) were calculated to determine whether the odds of having tests ≥5 μg/dL or ≥10 μg/dL differed by zone, compared to the remainder of East Chicago (Other East Chicago not including Zones 1,2, or 3). All statistical analyses were conducted using SAS® v. 9.3 (SAS Institute, Cary, NC).

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