

Appendix A: Background

Background

The Oronogo-Duenweg Mining Belt (primarily in Jasper County) and the Newton County Mine Tailings Superfund sites are listed on the EPA's NPL and are part of the TSMD which encompasses approximately 2,500 square miles of land in Kansas, Missouri, and Oklahoma. The Missouri portion of the district lies mostly within the southwest corner of Jasper County and throughout Newton County. Other contaminated areas are scattered throughout the counties [Appendix B]. Lead and zinc ores were actively mined, milled, and smelted for over 100 years in the district.

The TSMD was one of the foremost lead-zinc mining areas of the world from 1850-1970; mining operations were primarily underground and involved the use of sinking shafts to subsurface ore bodies. Mining in the Oronogo-Duenweg portion of the TSMD was conducted from about 1848-1957. In the early mining years lead concentrates were smelted at each mine. Advances in smelter technology led to the centralization of smelting and by 1894 there were three smelters in the Joplin area; Granby Mining and Smelting Company in Granby, Pitcher Lead Company in Joplin, and the Case and Searge Lead Company at Grand Falls on Shoal Creek. Most mining in the TSMD used underground methods; however, ten large open-pit operations and a few smaller surface excavations were also present in the Oronogo-Duenweg Mining Belt. For most of the mining history, mined ore was hoisted to the surface and treated at mills where crude ore was crushed, sized, and then concentrated.

Historic mining, milling, and smelting activities across the TSMD generated millions of tons of waste materials containing elevated levels of lead, cadmium, and zinc. Several types of waste or process materials are present at the surface as a result of the physical removal and refinement of ore and can be characterized according to the process by which they were generated: *mine wastes* – development rock and overburden, *mill wastes* – chat, sand, and fine tailings from gravity and flotation separation processes, and *smelter-related materials* – slag, clinker, flux, and residues of stack or fugitive emissions. The Oronogo-Duenweg Mining Belt and the Newton County Mine Tailings sites were added to the NPL in 1990 and 2003 respectively.

Millions of tons of waste materials were produced and the presence of chat piles, tailings impoundments, and waste mine rock piles are common features of the landscape. These wastes have been dispersed over time by both human and natural activities and have contaminated surface soils, groundwater, surface water, and stream sediments. Over 500 square miles have been impacted by these wastes in Jasper and Newton Counties [EPA 1995a, 1996, 2004, 2010].

ATSDR authored a Preliminary Public Health Assessment for the Oronogo-Duenweg Mining Belt in 1990 and a Public Health Assessment for the Newton County Mine Tailings Site in 2006. Public Health Assessments evaluate hazardous waste sites to determine whether people could be harmed by coming into contact with site-related substances. Both assessments concluded that the sites pose a public health concern due to human exposure to metals via ingestion and inhalation of contaminated groundwater, soil, sediment, and air [ATSDR 1990, 2006]

In 1991, ATSDR in partnership with MDOH, now known as MDHSS, initiated a lead and cadmium exposure study. The study was conducted to determine if residents living in the Jasper

County Superfund site area had blood lead and urine cadmium levels higher than residents living in a comparison area with no known source of environmental contamination.

The final report, published in 1995, found that BLLs were significantly higher in the exposed group compared to the control group (mean BLLs in the exposed group 6.24 ± 4.86 $\mu\text{g/dL}$; mean BLLs in the control group 3.59 ± 1.88 $\mu\text{g/dL}$), but there was no significant difference for cadmium between the two groups. The study also determined that environmental exposure to the area soil was the most important factor influencing the distribution of BLLs between the two groups [ATSDR 1995].

In 2000, ATSDR in partnership with MDOH initiated a follow-up lead exposure study to determine whether intervention efforts initiated in Jasper County since the 1995 study had been effective in reducing the mean BLLs of children residing in the area. By June 2000, EPA had remediated 2,288 residential yards and implemented major intervention efforts including an aggressive community education campaign. The final follow-up study report, published in 2002, found that BLLs declined on average by 2.42 $\mu\text{g/dL}$ between 1991 and 2000 (mean BLLs for the 2000 study were 3.82 ± 2.29 $\mu\text{g/dL}$). The results indicated that educational and environmental interventions were effective in reducing the mean BLLs of children residing in the area close to the levels of the control group in the 1995 study [ATSDR 2002].

Significant response actions and cleanup activities taken to date have led to the excavation and replacement of residential yard soil at thousands of properties, the construction and installation of over 100 miles of new public water supply mains, the installation of over 100 individual deep aquifer private drinking water wells, and the removal and disposal of source material from thousands of acres. Though significant response actions and cleanup activities have been taken over the last 30+ years, due to the magnitude and extent of contamination across the sites, many response actions and cleanup activities remain outstanding [EPA 2017, 2019].

EPA's 1996 Record of Decision for residential yard and mine waste yard soils within the Oronogo-Duenweg Mining Belt selected a remedy that included excavation of residential yards with soil concentrations that exceeded an action level of 800 parts per million (ppm) lead. Under this remedy decision, if a residential yard exceeded 800 ppm in any portion of the yard, then all soils exceeding 500 ppm were removed. Additionally, all garden soils that exceeded 500 ppm, even in yards where the action level wasn't exceeded, were removed [EPA 1996]. While cleanup activities and monitoring are ongoing at the site, work on residential properties and drinking water is complete [EPA 2021b].

EPA's 2010 Record of Decision for non-residential mine waste within the Newton County Mine Tailings Site selected a remedy that included excavation of mine waste and contaminated non-residential soil with soil concentrations that exceeded an action level of 400 ppm lead. EPA is currently conducting response actions and investigating residential yards and private drinking water wells at the site [EPA 2021a].

EPA utilizes the Integrated Exposure Uptake Biokinetic (IEUBK) model and the Adult Lead Methodology (ALM) to estimate the concentration of lead in the blood of children, pregnant women, and developing fetuses. The level to which EPA remediates lead contamination at

Superfund sites is guided by risk assessors' application of the IEUBK model and the ALM for site-specific scenarios to estimate blood lead concentrations.

EPA's current approach for addressing lead in soils is to limit exposure such that a hypothetical child would have an estimated risk of no more than 5% of exceeding a 10 µg/dL BLL. Changes to the IEUBK model have been made over time and inputs may vary based on site-specific conditions thus resulting in differing cleanup criteria between the two sites.

CDC Blood Lead Reference Value

Over time, CDC has updated recommendations on when to initiate follow up based on children's BLLs as science and understanding of the health impacts of lead have evolved. Until 2012, children were identified as having a blood lead "level of concern" if the blood lead test result was ≥ 10 µg/dL. CDC no longer uses the term "level of concern" and instead uses a BLRV to identify children who have more lead in their blood than most children. This level is based on the 97.5th percentile of the blood lead values among U.S. children ages 1-5 years from NHANES. Children with BLLs at or above the BLRV represent those at the top 2.5% with the highest BLLs [CDC 2021b].

NHANES is a population-based survey that assesses the health and nutritional status of adults and children in the U.S. to determine the prevalence of major diseases and their risk factors. Every four years, CDC reanalyzes blood lead data from the most recent two NHANES cycles to determine whether the reference value should be updated [CDC 2017].

In 2012, the BLRV for children corresponding to the 97.5th percentile was established to be 5 µg/dL based on NHANES data from 2007-2008 and 2009-2010 NHANES cycles. In 2021, CDC updated the BLRV to 3.5 µg/dL based on the 2015-2016 and 2017-2018 NHANES cycles. The new lower BLRV means that children can be identified as having a lead exposure earlier encouraging parents, doctors, public health officials, and communities to act earlier to reduce the child's future exposure to lead [CDC 2021b].

CDC's BLRV is a screening tool to identify children who have higher levels of lead in their blood compared with most children. The BLRV is not a clinical reference level defining an acceptable range of BLLs in children nor is it a health-based toxicity threshold; rather it is a policy tool that identifies children who have higher levels of lead in their blood compared to most children in order to prioritize prevention efforts and evaluate their effectiveness [CDC 2021c].

There are significant disparities in exposure and health outcomes across racial, ethnic, and socioeconomic status. By paving the way for early intervention and the prevention of additional exposure and associated harm, updating the BLRV supports ATSDR's commitment to health equity and addressing environmental justice.

Changes to CDC's BLRV led to EPA's request for ATSDR assistance in conducting a blood lead assessment. Five-year reviews (FYRs) for both the Oronogo-Duenweg Mining Belt and Newton County Mine Tailings sites recommend BLLs be reassessed. The purpose of a FYR generally is

to determine whether the remedy at a site is/remains protective of human health and the environment.

ATSDR is a non-regulatory federal public health agency and does not develop or advise environmental cleanup levels. ATSDR will conduct this EI to measure and compare BLLs and environmental contamination levels in participating children under the age of six, women who are pregnant, and women of childbearing age residing within the Oronogo-Duenweg Mining Belt and Newton County Mine Tailings sites.

Environmental Sampling Data

Oronogo-Duenweg Mining Belt

The 1995 Remedial Investigation (RI) for the Oronogo-Duenweg Mining Belt Site characterized seven sub-areas of the Superfund site: Waco, Neck/Alba, Snap, Carl Junction, Thoms, Oronogo/Duenweg, and Joplin. Mean concentrations of lead in select mine wastes and soils ranged from 472-3,963 ppm with vegetated chat and fine tailings having the highest mean concentrations. Soils located within a half mile of two investigated historic smelters (Eagle-Picher and Oronogo smelters) averaged 1,806 ppm. Table 1 provides a summary of lead sampling data collected from various waste materials and soil types across the seven sub-areas, and Table 2 provides a summary of mean lead concentrations in smelter zone soils [EPA 1995b, 1996].

Table 1. 1995 summary of select mine material and soil lead sampling Oronogo-Duenweg

Material	Number of Samples	Mean (ppm)	Maximum (ppm)
Chat	97	608	6,000
Vegetated Chat	210	987	13,300
Transition Zone Soils*	160	472	3,900
Tailings	156	3,963	24,100

*Transition zone soils are soils within 200 feet of mapped mine, mill, or smelter-related wastes [EPA 1995b]

Table 2. 1995 summary of smelter zone soils lead sampling Oronogo-Duenweg

Smelter	Number of Samples	Mean (ppm)	Maximum (ppm)
Eagle Picher (Joplin)	20	1,806	11,000
Oronogo	20	290	758

[EPA 1995b]

Groundwater in Jasper County occurs in two aquifers, the shallow and the deep. The aquifers are separated throughout the region by a confining unit. The confining unit is primarily comprised of four formations within the Northview Shale/Compton Limestone sequence ranging from less than five to over 20 feet thick and the Cotter Dolomite/Jefferson City Dolomite sequence that averages 400 feet. The confining formations, the deeper aquifer, yield little to no water wells.

The shallow aquifer averages approximately 300 feet thick with a maximum thickness of approximately 400 feet. The deep aquifer ranges up to approximately 850 feet.

Per the RI, shallow groundwater provided drinking water to some residents of Jasper and Newton County. Shallow groundwater contained lead at concentrations that exceed EPA’s regulatory criteria [Lead Action Level 15 micrograms per liter (µg/L)]. In Jasper County shallow groundwater was used as a source of drinking water in areas via private wells without access to public water supplies. Historically, EPA took action to address lead contamination in shallow groundwater by providing alternate drinking water, installing public service lines, and drilling deep water aquifer wells. Some shallow groundwater wells are still in use as a source of drinking water and/or for watering livestock and gardens. Table 3 summarizes shallow groundwater sampling data for Oronogo-Duenweg [EPA 1995b]. Lead concentrations in the deep aquifer were within regulatory limits at the time of the RI. The deep aquifer is used as a primary source of drinking water for rural water districts within the site boundaries.

Table 3. Summary of lead concentrations in shallow groundwater Oronogo-Duenweg

	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	Number of Samples
Lead	ND	16	290	569

ND = Non-Detect
 [EPA 1995b]

Newton County Mine Tailings

The 2008 RI for the Newton County Mine Tailings sites characterized five sub-districts of the Superfund site: Spring City/Spurgeon, Diamond, Granby, Stark City, and Wentworth. Approximately 238 acres and more than 1.6 million cubic yards are impacted by lead contamination.

Between 1999 and 2003, EPA removed contaminated soils from approximately 450 residential yards throughout Newton County where lead in soils exceeded 800 ppm. Soil samples collected from various locations within each sub-district are summarized in Table 4.

Table 4. Summary of lead concentrations in soil Newton County

Sub-District	Range (ppm)	Average (ppm)	Number of Samples
Spring City/Spurgeon	10-20,425	920	249
Diamond	11-287	83	30
Granby	15-16,741	1,025	93
Stark City	15-1,762	244	33
Wentworth	5-783	78	85

[EPA 2008]

The 2008 Newton County RI reported that over 3,600 private wells were sampled since 1998. Concentrations of lead exceeded EPA’s Action Level at 379 locations. EPA continues to take action to address contaminated residential yards and drinking water wells within the Newton County site boundaries [EPA 2008, EPA 2021a].

Previous Biological Sampling

ATSDR, in partnership with MDOH, published two exposure studies for the Oronogo-Duenweg Mining Belt Site in 1995 and 2002. The first exposure study was initiated in 1991 to determine if residents living in the area had blood lead and urine cadmium levels higher than residents living in a comparison area with no known source of environmental contamination.

The study measured lead in blood and cadmium in urine and compared them to a control population. Lead and cadmium contamination in soil, interior house paint, interior house dust, and water were measured and compared with the control area, and interviews were conducted to determine the extent to which demographic, environmental, behavioral, occupational, and socio-economic factors were associated with the results.

Blood lead and urine cadmium were measured in 695 participants (412 in the study group and 283 in the control group). Environmental samples for dust, indoor paint, soil, and water were taken from a random sample of 105 homes in the study area and 26 homes in the control area. Environmental testing was also done in 20 of the 25 households where children had BLLs higher than 10 µg/dL.

BLLs were almost twice as high in the study group when compared to the control group. Significantly higher environmental levels of lead were found in the dust, paint, and soil in the study area but there were no significant differences in the amount of lead in water between the two areas. While there were no differences in urine cadmium levels, the levels of cadmium in dust and soil were significantly higher in the study area. Table 5 provides a summary of the study’s blood lead and environmental data by study group [ATSDR 1995].

Table 5. Summary of blood lead and environmental data by study group

	Study Group Mean ± SD (n)	Control Group Mean ± SD (n)
Blood Lead by Age Group		
Children 6-71 Months	6.25 ± 4.86 µg/dL (225)	3.59 ± 1.88 µg/dL (128)
Youth 6-14 Years	3.61 ± 1.97 µg/dL (115)	2.46 ± 2.24 µg/dL (94)
Adults 15-44 Years	3.44 ± 4.59 µg/dL (51)	2.22 ± 1.35 µg/dL (49)
Environmental		
Lead Dust	608 ± 1551 ppm (125)	209 ± 408 ppm (26)
Lead Water	2.62 ± 3.60 µg/L (125)	2.12 ± 0.42 µg/L (26)
Lead Paint	1.38 ± 1.65 mg/cm ² (121)	0.412 ± 0.23 mg/cm ² (26)
Lead Soil	599 ± 735 ppm (125)	91.1 ± 112 ppm (26)

SD = Standard Deviation
[ATSDR 1995]

One of the primary objectives of the 1995 study was to determine if there was a relationship between exposure to soil lead from past mining operations and BLLs. The investigators assumed that soil lead in the control area resulted from non-mining sources, including lead-based paint and leaded gasoline, correlation analysis showed that paint samples taken from inside the home were correlated with soil samples. Paint samples were also related to age of houses and age of houses was related to soil lead. The significant correlation between paint and age of home suggested that the amount of lead-based paint inside the home reflects the lead-based paint outside the home. However, this could not be confirmed since paint measurements outside the homes were not taken.

The relationship between BLLs and soil levels were further evaluated adjusting for the age of home. After adjusting for age of home in the study group, the correlation between soil and blood lead was unchanged. After adjusting for age of home in the control group, the correlation between soil and blood lead was reduced indicating that age of home decreased the relationship in the control group.

The relationship between lead paint and blood lead was also substantially reduced for age of home when controlled through stepwise regression modeling, and the correlation between soil lead and blood lead was unchanged. In this study, both lead paint and soil lead were related to the age of home indicating the relationship between lead paint and blood was indirect. The study concluded that soil lead was the primary determinant of BLLs in the study area and that there was no dominant single factor in the control area [ATSDR 1995].

Major intervention efforts were initiated in Jasper County after the publication of the 1995 lead and cadmium exposure study. EPA, in partnership with other federal, state, and local agencies developed a comprehensive lead strategy to address the identified health risks. Actions taken included the remediation of more than 2,300 residential yards, the installation of public drinking water service lines for homes using contaminated drinking water wells, a comprehensive community health education campaign, and some funding to address lead-based paint in homes of children with elevated BLLs [ATSDR 2002, EPA 2017].

In 2000, ATSDR and MDOH initiated a childhood lead exposure study to determine whether environmental and health education intervention efforts initiated since the previous study had been effective in reducing the mean blood lead levels of children living in the area. The 2000 study replicated the previous study by examining a random sample of eligible children from the same area and an additional sample of children outside that area to gather more information about children living in neighborhoods that may have received soil remediation. The 2000 study only selected children between 6 and 72 months of age to participate given that this age group is at highest risk for lead exposure and associated health effects.

Environmental samples were collected and analyzed for lead in outdoor soil, drinking water from private wells, and household dust and selected indoor and outdoor painted surfaces were analyzed by a portable XRF monitor. Sampling protocols differed between the two studies in that soil lead levels were collected as composites of the whole yard, drip line, and play area. Dust was sampled using a wipe method and outdoor painted surfaces were included.

Blood lead was measured from 215 children in the same geographic area as the previous study and 71 children in the oversample area. The mean BLL for the 2000 study from children within the same geographic area was 3.82 ± 2.29 $\mu\text{g/dL}$. Mean BLLs adjusted for factors that were significantly different between study periods (family income, education of head of household, if the child played in a grassy area, and if the child took snacks outside) were 6.2 $\mu\text{g/dL}$ for the 1991 study and 3.7 $\mu\text{g/dL}$ for the 2000 study. The proportion of children with BLLs ≥ 10 $\mu\text{g/dL}$ in the 1991 study was 14% (n=32) compared to 2% (n=44) in the 2000 study. The average BLLs declined 40% between the two studies. The national average BLL declined by 26% during the same period indicating the decline in the study area was substantially greater than the national decline.

The soil lead levels from non-dripline samples in the 2000 study were less than half those found during the 1991 study, likely the result of extensive soil remediation by EPA. The average indoor paint lead levels were similar between the two time periods. Most of the environmental measures (more lead dust, higher soil lead, and higher lead paint) were associated with increased BLLs. Results indicated that children who live in homes with no interior lead paint and low soil lead levels have substantially lower BLLs than children living in homes with either lead paint or elevated soil lead. In general, BLLs were highest for children living in homes with both lead based paint and elevated soil lead and the highest for homes with lead paint and play soils greater than 250 ppm. The next highest was for homes with lead paint but soil less than 250 ppm, followed by homes with no lead paint but soil levels greater than 250 ppm.

The study results were published in 2002 and found that average BLLs significantly declined between the study periods and at a greater rate than the national decline. However, given that a combination of extensive response actions was taken including soil remediation, health education, and paint stabilization, it was not possible to determine the proportional reduction in childhood BLLs from the respective interventions. Since children with the higher mean blood lead levels were those with multi-media exposure, the study noted the importance of combined paint and soil remedial actions [ASTDR 1995, 2002].

MDHSS Childhood Lead Poisoning Prevention Program (CLPPP) publishes childhood blood lead surveillance data in annual reports. Missouri requires reporting of all blood lead tests regardless of level. BLLs have historically been ≥ 10 $\mu\text{g/dL}$. State guidelines describe state supported follow-up actions and case management for children with BLLs ≥ 10 $\mu\text{g/dL}$. Currently, health education information is provided to families of children with BLLs ≥ 5 $\mu\text{g/dL}$. Table 6 summarizes blood lead surveillance data for both Jasper and Newton Counties between 2013-2018.

Table 6. Summary of Jasper and Newton counties' blood lead surveillance data 2013-2018

	BLL Test Results (µg/dL)				Population of Children <72 months	Percent of Total Population of Children < 72 months Tested
	< 3	≥ 3 < 5	≥ 5 < 10	≥ 10		
Jasper						
2013	1,574	407	218	30	10,727	20.8%
2014	1,768	276	107	17	10,727	20.2%
2015	1,780	226	92	16	10,727	19.7%
2016	1,713	268	96	10	10,727	19.5%
2017	1,944	274	113	14	10,727	21.9%
2018	-	-	62	17	10,022	24.2%
Newton						
2013	661	143	82	1	4,638	19.1%
2014	656	119	29	7	4,638	17.5%
2015	689	79	29	6	4,638	17.3%
2016	675	92	31	2	4,638	17.3%
2017	828	122	46	8	4,638	21.7%
2018	-	-	X*	X*	4,351	19.8%

X = The "X" indicates that the confidentiality rule <5 has been triggered and no data were reported

*Although confidentiality rule was triggered, MDHSS reported that 18 BLLs exceeded 5 ug/dL [MDHSS 2013, 2014, 2015, 2016, 2017, 2018]