Health Consultation

Public Health Implications of Exposures to Lead in Surface Soil at two Trenton District schools

Trenton, Mercer County, New Jersey

Prepared by the

New Jersey Department of Health

June 10, 2024

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Office of Capacity Development and Applied Prevention Science

Background and Statement of Issues

In February 2024, the U. S. Environmental Protection Agency (EPA) requested assistance from the New Jersey Department of Health (NJDOH) to evaluate health impacts and address community concerns related to soil contamination found at two schools in Trenton**.** This health consultation was prepared under NJDOH's cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR) in response to this request. This document evaluates the soil data from the schools to determine if the levels of soil contaminants found at the schools may harm people's health.

The pottery industry was prominent in Trenton from the 1850s until the 1920s, with a major hub in the East Trenton and Top Road neighborhoods (See Figure 1). Lead was commonly used in glazes which were subject to very high temperatures in the firing kilns. Lead may have been released in the exhaust from the kiln and gone into the air where it settled onto soil downwind from the kilns. EPA has commenced sampling to assess residential, park, and school properties within the Top Road and East Trenton neighborhoods for lead and other contaminants in soils.

In December 2023, EPA coordinated with the Trenton Public School District to collect and analyze soil samples from the Ulysses S. Grant Intermediate School and the Darlene C. McKnight Elementary School. EPA found that the soil samples from Darlene C. McKnight Elementary School had levels of lead below EPA's regional screening levels for lead. Additionally, this is mostly paved and therefore, exposures to contaminated soil at this school are not likely. Soil samples from the Ulysses S. Grant Intermediate School showed lead levels in soil that required immediate action. As part of the immediate action to reduce exposures to lead contaminated soil, Ulysses S. Grant Intermediate School officials closed all play areas. These actions include installing fencing around the impacted areas on the school property to restrict access to the soil. EPA is also working with the school district to develop a plan to add a protective barrier to the play areas which would allow children to return to these play areas with contaminated soil.

Community Health Concerns

At the request of EPA, NJDOH and ATSDR regional staff attended a public meeting in February 2024 in addition to attending multiple public availability sessions held in February and April 2024. At these meetings, NJDOH and ATSDR regional staff provided educational materials on how to reduce exposures to lead contaminated soil and addressed health concerns from parents and teachers at the Ulysses S. Grant School where the elevated lead levels were found.

NJDOH staff collaborated with the Trenton Health Department to provide NJDOH's fact sheets on reducing exposures to lead in soil to the school staff and parents. Approximately 30 people attended each of these meetings. NJDOH also shared the fact sheet with the local health department. NJDOH continues to collaborate with EPA, the local health department and NJDOH's childhood lead poisoning prevention program to ensure that people potentially impacted by lead from the historic pottery sites in Trenton have the knowledge to protect themselves from soil lead exposures.

As part of this effort, NJDOH developed a new information sheet for residents describing EPA's investigation, the health impacts of lead, educating about other sources of lead and outlining steps to prevent exposures to lead. This information sheet has been provided to the community in English, Spanish, and Haitian Creole.

Environmental Contamination

An evaluation of environmental contamination consists of a two-tiered approach: 1) a screening analysis; and 2) a more in-depth analysis to determine public health implications of contaminant exposures (ATSDR 2005).

Screening Analysis

Maximum concentrations of detected substances are compared with media-specific comparison values (CVs) for screening contaminants. If concentrations exceed the CV, these substances, referred to as potential contaminants of concern, are selected for further evaluation. Contaminants without CVs are also selected.

Contaminant levels above CVs do not mean that adverse health effects are likely, but that a health guideline comparison is necessary to evaluate site-specific exposures [ATSDR PHAGM 2022].

Comparison Values

A number of CVs are available for screening contaminants to identify potential contaminants of concern. These include ATSDR environmental media evaluation guides (EMEGs) and reference media evaluation guides (RMEGs). EMEGs are based on ATSDR's minimal risk levels and are estimated contaminant concentrations in water or soil that are not expected to result in adverse noncarcinogenic health effects. RMEGs are based on EPA's reference doses and represent the concentration in water or soil at which daily human exposure is unlikely to result in adverse noncarcinogenic effects.

If the substance is a known or a probable carcinogen and has cancer toxicity values, ATSDR's cancer risk evaluation guides (CREGs) were also considered as comparison values. CREGs are estimated contaminant concentrations in soil or water that would be expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed during their lifetime (78 years).

In the absence of an ATSDR CV, other screening levels, such as EPA's regional screening levels, can be used to screen contaminant levels in environmental media. Regional screening levels are contaminant concentrations corresponding to a fixed level of risk (i.e., a hazard quotient[1] of 1, or lifetime excess cancer risk of one in one million, whichever results in a lower contaminant concentration) in water, air, biota, and soil. For soils and sediments, other screening levels include the New Jersey Department of Environmental Protection (NJDEP)

[1]The ratio of estimated site-specific exposure to a single chemical in a particular medium from a site over a specified period to the estimated daily exposure level at which no adverse health effects are likely to occur.

Residential Soil Remediation Standards. These criteria are health-based and may account for natural background concentrations, analytical detection limits, and ecological effects.

For this evaluation, ATSDR's EMEGs, RMEGs, CREG, EPA's Regional Screening Levels (RSL) for lead and NJDEP's Residential Soil Remediation Standards (RSRS) were utilized as environmental comparison values.

School play areas

At the time of sampling, it was observed that most of the school grounds are used as play areas by children who attend the school, and children from different grades use separate parts of the play areas during recess. The schoolyard is open to the public and members of the community use the play areas for various activities. There are areas of exposed soil on the playing field, and there are garden beds present in one area of the playground area.

Surface soil samples collected from the 0-2 inches depth were used to evaluate the potential for health effects and a summary of the results is provided in Table 1 below.

Table 1: Summary of surface soil (0-2 inches depth) for Grant Ulysses Intermediate school

Soil Contaminant	Number of Samples	Range of Concentration (mg/kg)	Comparison Value[a] (mg/kg)	Source for Comparison Value (CV)	Selected for Further Evaluation
Aluminum	15	7,470 - 9,820	52,000	EMEG[b]	No
Arsenic	15	7 - 59	0.26	CREG[c]	**Yes**
Barium	15	90 - 176	10,000	EMEG	No
Beryllium	15	0 - 1	100	EMEG	No
Boron	15	1 - 23	10,000	RMEG	No
Cadmium	15	0 - 1	5.2	EMEG	No
Calcium	15	1,930 - 28,300	NA**	NA	No
Chromium	15	13 - 23	240	RSRS[d]	No
Cobalt	15	5 - 7	23	EPA SL[e]	No
Copper	15	29 - 81	600	RSRS	No
Iron	15	12,800 - 17,500	NA	NA	No
Lead	15	59 - 560	200	EPA R2[f]	**Yes**
Magnesium	15	1,530 - 2,820	NA	NA	No
Manganese	15	319 - 556	1,900	EPA SL	No
Nickel	15	9 - 23	1000	RMEG	No
Potassium	15	616 - 1,200	NA	NA	No
Silicon	15	859 - 1,180	NA	NA	No
Silver	5	0.518 – 0.762	260	EMEG	No
Tin	15	4 - 16	16,000	EMEG	No
Titanium	15	97 - 220	NA	NA	No
Vanadium	15	22 - 45	370	RSRS	No
Zinc	15	132 - 357	16,000	EMEG	No

[a]Comparison Values given in milligrams of contaminant per kilogram of soil (mg/kg); [b]Environmental Media Evaluation Guide; [c]Cancer Risk Evaluation Guide; [d]New Jersey Residential Soil Remediation Standard; [e]EPA Screening Level; [f]EPA Region 2 Screening Level[2]; [**]Not Available

Contaminants of Concern:

For the school, lead and arsenic were found in surface soil above comparison values as shown in Table 1 above.

Lead Lead is a naturally occurring chemical element that is normally found in soil. Currently, the main pathways of lead exposure in children are ingestion of paint chips, contaminated soil and house dust, and drinking water in homes with old plumbing.

Lead can cause a variety of harmful health effects including damage to the nervous system, kidneys and the red blood cells. Children are the most sensitive to the harmful effects of lead since they absorb more lead into their bodies than adults and are more susceptible to its effects on brain development. Although lead can affect almost every organ and system in the body, the main target for lead toxicity is the nervous system. In general, the level of lead in a person's blood gives a good indication of recent exposure to lead and also correlates well with adverse health effects[3].

Children ages 7 years old and under are particularly vulnerable to the effects of lead. Compared to older children and adults, they tend to ingest more dust and soil, absorb significantly more of the lead that they swallow, and more of the lead that they absorb can enter their developing brain. Pregnant women and women of childbearing age should also be aware of lead in their environment because lead ingested by a mother can affect the unborn fetus.

Arsenic Arsenic is a naturally occurring, semi-metallic element widely distributed in the Earth's crust. The most common source of arsenic in people is contaminated drinking water. Because arsenic occurs naturally, waters that come in contact with particular rocks and soils may contain it. Arsenic may be found in foods, including rice and some fish, due to its presence in soil or water. As a naturally occurring element, it is not possible to remove arsenic entirely from the environment or food supply.

Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet. Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso. Skin contact with inorganic arsenic may cause redness and swelling. There is some evidence that long-term exposure to arsenic in children may result in lower IQ scores. There is also some evidence that exposure to arsenic in the womb and early childhood may increase mortality in young adults. Several studies have shown that ingestion of inorganic arsenic

---

[2][USEPA] United States Environmental Protection Agency memorandum January 2024. Updated Residential Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities: https://www.epa.gov/system/files/documents/2024-01/olem-residential-lead-soil-guidance-2024_signed_508.pdf

[3]Agency for Toxic Substances and Disease Registry. 2019. Toxicological Profile for Lead. U.S. Department of Health and Human Services, Public Health Service. Atlanta, GA. May 2019. Available from: https://www.atsdr.cdc.gov/toxprofiles/tp13.pdf

can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. Inhalation of inorganic arsenic can cause increased risk of lung cancer. The U.S. Department of Health and Human Services (DHHS) and EPA have determined that inorganic arsenic is a known human carcinogen.

Scientific Evaluation

NJDOH uses a standard method for assessing whether a community is at risk for a health hazard. The first step is to determine whether there is a completed exposure pathway from a contaminant source to an exposed population, and screening contaminants against comparison values to determine contaminants of concern. The next question is whether the exposures to contamination are high enough to be of health concern [ATSDR 2005]. Site-specific exposure doses can be calculated and compared with health guideline values. Health guideline values are not available for lead since there is no safe level of lead. Therefore, lead exposure doses cannot be calculated using this approach. Instead, lead is evaluated using EPA's integrated exposure uptake biokinetic (IEUBK) model [EPA 2021a].

Exposure Pathway Analysis

An exposure pathway is a series of steps starting with the release of a contaminant in environmental media and ending with contact with the human body. A completed exposure pathway has five elements:

1) Source of contamination (historic pottery sites)
2) Environmental media and transport mechanisms (soil)
3) Point of exposure (school yards)
4) Route of exposure (ingestion)
5) Receptor population (children and staff)

Generally, NJDOH considers three exposure pathway categories:

1) Completed exposure pathways — all five elements of a pathway are present
2) Potential exposure pathways — one or more of the elements might not be present, but information is insufficient to eliminate or exclude the element
3) Eliminated exposure pathways — one or more of the elements is absent

Exposure pathways are used to evaluate specific ways in which people were, are, or will be exposed to environmental contamination in the past, present, and future.

Completed Exposure Pathways

<u>Incidental ingestion of and dermal contact with contaminated soil (past):</u> Surface soil at the Ulysses S. Grant Intermediate School had detectable levels of metals. Children and staff were exposed to the contaminants while engaging in outdoor activities in the school yard and from tracked dust and dirt into the school property. Children were most likely exposed from hand-to-mouth activity involving outdoor soil and indoor dust.

School officials have closed the play areas at the Ulysses S. Grant Intermediate School. EPA and the school have installed fencing around the impacted areas on the school property to restrict access to the soil. As such, the current and future status of this pathway is considered eliminated because children and staff are no longer contacting contaminated soils. In addition, the school was thoroughly cleaned, and EPA determined that the school has been kept clean. Therefore, exposure to dust from the contaminated soil is not likely.

Public Health Implications of Completed Exposure Pathways

After determining that people have or are likely to contact site-related contaminants (i.e., a completed exposure pathway), the next step in the public health assessment process is to calculate site-specific exposure doses. This is called a health guideline comparison. It involves looking more closely at site-specific exposure conditions, the estimation of exposure doses, and the evaluation with health guideline values. Health guideline values are based on data drawn from the epidemiologic and toxicologic literature. These guidelines often include uncertainty or safety factors to ensure that they are amply protective of human health.

Exposure doses are not calculated for lead. The Centers for Disease Control and Prevention (CDC) currently uses a blood lead reference value of 3.5 micrograms of lead per deciliter of blood (µg/dL) to identify children with higher levels of lead in their blood compared to 95% of children ages 1-5 years old living in the U.S.

Residential child lead exposures are evaluated using EPA's IEUBK model[4]. This model is designed to predict the probability that children ages birth to 7 years who regularly play in areas with soil lead contamination could be exposed to lead at levels high enough to raise their blood lead levels above 5 µg/dL. CDC previously used 5 µg/dL as its blood lead reference value; it is the lowest blood lead level verified for the model. This probability estimate should be at or below a protection level of five percent, as recommended by the EPA Office of Solid Waste and Emergency Response (EPA 1994). In other words, EPA's goal is that a typical child or group of similarly exposed children should have an "estimated risk" of no more than 5% of exceeding a blood lead level of 5 µg/dL. EPA guidance states that average soil lead concentrations should be used when running the model [EPA 1994]. Because a safe blood lead level has not been identified, it is important to reduce lead exposure as much as possible.

Determining the Exposure Concentration for Contaminants of Concern

When assessing the public health implications of exposure to a contaminant of concern, ATSDR recommends using the 95% upper confidence limit (UCL) of the arithmetic mean to determine the exposure point concentration (EPC) for site-related contaminants[5] [ATSDR 2019]. The 95% UCL is considered a "conservative estimate" of average contaminant concentrations in

---

[4][USEPA] United States Environmental Protection Agency 2021.Users Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Windows® Version 2. May 2021. Available at: epa.gov/superfund/lead-superfund-sites-software- and-users-manuals#overview

[5][ATSDR] Agency for Toxic Substances and Disease Registry. 2019. Division of Community Health Investigations. Exposure Point Concentration Guidance for Discrete Sampling. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA. July 2019.

an environmental medium. Using ATSDR guidance, the 95% UCL was calculated to be 29 mg/kg for arsenic [ATSDR 2019]. The arithmetic mean was used as the EPC for lead. This is because EPA recommends using the mean as the preferred measure of lead in soil for the IEUBK model.

Evaluating the Possibility for Health Effects

The method for assessing whether a health hazard exists is to determine if:

- there is a completed exposure pathway from a contaminant source to a receptor population;
- exposures to contamination are high enough to be of health concern for cancer or other health effects (referred to below as "non-cancer health effects").

Site-specific exposure doses have been calculated for arsenic and compared with health guideline values (i.e., reference dose). If the calculated site-specific doses are below health guideline values, they are not expected to result in adverse health effects over a lifetime of exposure. Exposure doses were calculated using a "Public Health Assessment Site Tool" (PHAST) developed by the ATSDR. As previously mentioned, lead is evaluated using the IEUBK model as an exposure dose cannot be calculated for lead.

Noncancer Health Effects

To assess noncancer health effects, ATSDR has developed minimal risk levels (MRLs) for contaminants that are commonly found at hazardous waste sites. An MRL is an estimate of the daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk for adverse, noncancer health effects. MRLs are developed for a route of exposure, such as swallowing or breathing, over a specified period. Exposure periods are classified as:

- acute (less than 14 days),
- intermediate (15 – 364 days), or
- chronic (365 days or more).

MRLs are based largely on toxicological studies in animals and on reports of human occupational (workplace) exposures. MRLs are usually extrapolated doses from effect levels reported in animal toxicological studies or human epidemiological studies. They are adjusted using a series of uncertainty (or safety) factors or through statistical models. In toxicological literature, observed effect levels include:

- no-observed-adverse-effect level (NOAEL) and
- lowest-observed-adverse-effect level (LOAEL).

A NOAEL is the highest tested dose of a substance that has been reported to have no harmful health effects on people or animals. A LOAEL is the lowest tested dose of a substance that has been reported to cause harmful health effects in people or animals. Based on current ATSDR guidance, calculated exposure doses are compared to effect levels (LOAELs) rather than no effect levels (NOAELs) when deciding possible health effects. As the exposure dose increases beyond the MRL to the level of the LOAEL, the likelihood of adverse health effects increases.

To ensure that MRLs are sufficiently protective, the extrapolated values can be several hundred times lower than the effect levels reported in experimental studies.

Evaluating arsenic and lead in soil at the Ulysses S. Grant Intermediate School

Arsenic

ATSDR's exposure dose guidance for soil and sediment ingestion and EPA's Exposure Factor Handbook were used to calculate exposure doses [ATSDR 2018, EPA 2011]. Exposure doses were calculated for adults and children ingesting contaminated soil on the school property.

Exposure doses were calculated for three soil ingestion scenarios using the ATSDR Public Health Assessment Site Tool (PHAST). For people with typical, (average) soil ingestion rates, we used a "central tendency exposure" (CTE) scenario. For people with above average ingestion rates, a "reasonable maximum exposure" (RME) scenario was used. The RME refers to people with above average exposures but still within a realistic exposure range.

For CTE and RME scenarios, the age range for children is from infant through less than 21 years. The adult scenario is for people 21 years of age and older. Table 2 shows the exposure parameters and assumptions used to calculate exposure doses for both scenarios.

For the Ulysses S. Grant Intermediate School, the model accounts for exposures to children aged 2 through 16 years old and school staff who are assumed to work at the school for 33 years[6]. These age ranges were selected to provide a conservate estimate of exposure to children attending the school as well any younger siblings utilizing the school yard for recreation. Other model inputs come from the site-specific environmental data and parameter values (ex: for body weight and dermal absorption rates) published by EPA and ATSDR[7].

Table 2. Exposure Assumptions used in Dose Calculations

Age Group	**CTE - Average soil ingestion (mg/day)**	**RME - Above average soil ingestion (mg/day)**	**Body Weight (kg)**	**Exposure Frequency**
Child ages 2 to < 6 yrs	60	200	17.4	180 days/year
Child ages 6 to < 11 yrs	60	200	31.8	
Child ages 11 to < 16 yrs	30	100	56.8	
Adult ages ≥ 21 yrs	30	100	80	

[6]Agency for Toxic Substances and Disease Registry. 2019. Public Health Assessment Site Tool (PHAST). Version 1.5.1.0. U.S. Department of Health and Human Services, Public Health Service. Atlanta, GA. December 2019.
[7][USEPA] United States Environmental Protection Agency. 2011. Exposure Factors Handbook. Update for Chapter 5. Soil and Dust Ingestion. Updated September 2017. Available from: https://www.epa.gov/sites/production/files/2018-01/documents/efh-chapter05_2017.pdf

The third soil ingestion scenario is for children with soil-pica behaviors. Pica is defined as the consumption of nonfood items and is well documented in children [ATSDR 2018]. Soil-pica is the consumption of large amounts of soil. Within any population of children, particularly those of preschool age, some could have soil-pica behavior.

Soil-pica behavior is most likely to occur in preschool children as part of their normal exploratory behavior, with somewhere from 4% to 20% of preschool children having soil-pica behavior. Children between the ages of 1 and 2 years have the greatest tendency for soil-pica behavior, which diminishes as they age [ATSDR 2018]. For this health consultation, soil-pica behavior was assessed for the 2 to < 6 years age group.

Table 3 summarizes the parameters used to evaluate soil-pica behavior in children. These parameters represent a weekly dose for acute exposures or a monthly dose for intermediate durations. The soil ingestion rate for pica behavior in children represents the average (CTE) intake rate. There is no reliable upper percentile intake rate available for soil-pica[8]. NJDOH and ATSDR acknowledge that the pica child scenario uses conservative exposure assumptions. It assumes a child with pica behavior has access to areas with the highest level of soil contamination.

Table 3: Soil Pica Exposure Parameters

Age Group	**Soil ingestion rate pica child (mg/day)**	**Body Weight (kg)**	**Exposure Frequency**
Child ages 2 to < 6 yrs	5,000*	17.4	3 days per week

*Represents average (central tendency exposure) intake rate; mg = milligrams; kg = kilograms

Non-Cancer Health Effects - Soil Ingestion and Dermal Contact

Exposures are based on accidental ingestion of contaminated surface soil for children and adults at the school. Non-cancer exposure doses for PAHs were calculated using the following formula:

$$\text{Exposure Dose (mg/kg/day)} = \frac{C \times IR \times EF \times CF}{BW}$$

where,

mg/kg/day = milligrams of contaminant per kilogram of body weight per day;
C = concentration of contaminant in surface soil (mg/kg);
IR = soil ingestion rate (mg/day);
EF = exposure factor representing the site-specific exposure scenario;
CF = Conversion Factor (10^{-6} kg/mg) and,
BW = body weight (kg).

[8][ATSDR] Agency for Toxic Substances and Disease Registry. 2018. Exposure Dose Guidance for Soil and Sediment Ingestion. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. November 2018.

Dermal exposure doses were also calculated and added to the ingestion doses to create a combined dose. The dermal dose was minimal compared to the ingestion exposure pathway. Dermal exposures doses were calculated using the following formula:

$$\textit{Dermal Exposure Dose (mg/kg/day)} = \frac{C \times AF \times EF \times CF \times ABS_d \times SA}{BW \times ABS_{GI}}$$

where,

mg/kg/day = milligrams of contaminant per kilogram of body weight per day;
C = concentration of contaminant in surface soil (mg/kg);
AF = Adherence Factor to skin (mg/cm^2-event);
EF = Exposure Factor representing the site-specific exposure scenario (unitless);
CF = Conversion Factor (10^{-6} kg/mg)
ABS_d = Dermal Absorption Fraction to skin (unitless)
SA = Skin surface are available for contact (cm^2)
BW = Body Weight (kg).
ABS_{GI} = Gastrointestinal Absorption Factor (unitless)

Non-cancer health effects are assessed by comparing the calculated exposure dose to the reference dose via a ratio known as the "hazard quotient" or "HQ". The hazard quotient is defined as follows:

$$\textit{Hazard Quotient (HQ)} = \frac{\textit{Exposure Dose}}{\textit{MRL}}$$

A hazard quotient is calculated for each age group and exposure duration (acute, intermediate, chronic) for each potential contaminant of concern where health guideline values are available. Tables 4 summarizes the calculated exposure doses and hazard quotients based on the chronic exposure scenario for students and staff. The maximum exposure dose for students using the RME scenario is for students ages 2 to less than 6 years. The RME doses for all students and staff have hazard quotients that are far below one. This means that the doses are far below ATSDR's chronic oral MRL and that harmful, noncancer effects are not likely. For simplicity, only the results of the RME chronic exposure dose are presented as this represents the worst-case scenario. Table 5 shows that the soil-pica hazard quotients for arsenic are not elevated; therefore, noncancer health effects from exposures to arsenic are not likely for children with soil-pica behaviors at the school.

Table 4: Arsenic – Noncancer Health Effects - Chronic Exposures

Area Group	**EPC (mg/kg)[a]**	**RME Dose (mg/kg/day)[b]**	**Chronic MRL (mg/kg/day)**	**Hazard Quotient[c]**	**Potential for Health Effects?**
Child ages 2 to < 6 yrs	29	0.00011	0.0003	0.36	No (HQ <1)
Child ages 6 to < 11 yrs	29	0.000063	0.0003	0.21	No (HQ <1)
Child ages 11 to < 16 yrs	29	0.000022	0.0003	0.074	No (HQ <1)
Adult ages ≥ 21 yrs	29	0.000013	0.0003	0.043	No (HQ <1)

[a]EPC = exposure point concentration derived using 95% UCL of mean; [b]RME dose = reasonable maximum exposure dose representing above average soil ingestion rates; [c]MRL = ATSDR minimal risk level; [d]Hazard quotient = RME dose/MRL; mg/kg/day = milligrams of contaminant per body weight per day.

Table 5: Arsenic Soil-Pica –Noncancer Health Effects – Acute Exposures

Area Group	EPC (mg/kg)[a]	RME Dose (mg/kg/day)[b]	Acute MRL (mg/kg/day)	Hazard Quotient[c]	Potential for Health Effects?
Child ages 2 to < 6 yrs	29	0.0022	0.005	0.44	No (HQ <1)

[a]EPC = exposure point concentration derived using 95% UCL of mean; [b]RME dose = reasonable maximum exposure dose representing above average soil ingestion rates; [c]MRL = ATSDR minimal risk level; [d]Hazard quotient = RME dose/MRL; mg/kg/day = milligrams of contaminant per body weight per day.

Cancer Health Effects

NJDOH evaluates the potential for cancer health effects by assessing the excess cancer risk relating to exposure over the background cancer risk. In New Jersey, approximately 45% of women and 47% of men (about 46% overall), will be diagnosed with cancer in their lifetime [NJDOH 2023]. This is referred to as the "background cancer risk."

The term "excess cancer risk" represents the risk on top of the background cancer risk and is referred to as the Lifetime Excess Cancer Risk, or LECR. An LECR of "one-in-a-million" (1/1,000,000 or 10^{-6} cancer risk) means that if one million people are exposed to a cancer-causing substance at a certain level for a specified period of time, then one cancer above the background number of cancers may develop in those one million people over the course of their lifetime (considered to be 78 years).

To put the LECR of 10^{-6} in context of New Jersey's background cancer risk, the number of cancers expected in one million people over their lifetime is 460,000 (46%) in New Jersey. If these one million people are all exposed to a cancer-causing substance for a specific duration, then 460,001 people might develop cancer instead of the expected 460,000 over the course of their lifetime (78 years) [ATSDR 2014]. This is a theoretical estimate of cancer risk that ATSDR uses as a tool for deciding whether public health actions are needed to protect health. It is not an actual estimate of cancer cases in a community. This theoretical cancer risk is not a prediction that cancer will occur. NJDOH considers estimated cancer risks of less than one additional cancer case among one million persons exposed as an unlikely increased cancer risk (expressed exponentially as 1 x 10-^{6}).

According to the U.S. Department of Health and Human Services (DHHS), arsenic is considered as a known human carcinogen.

Cancer exposure doses were calculated using the following formula:

$$\textit{Cancer exposure dose (mg/kg/day)} = \frac{C \times IR \times EF \times CF}{BW} \times \frac{ED}{AT}$$

Where:

mg/kg/day = milligrams of contaminant per kilogram of body weight per day
C = exposure point concentration of contaminant in soil (mg/kg)

IR = soil ingestion rate (mg/day)
EF = exposure factor representing the site-specific exposure scenario
CF = conversion factor (10^{-6} kg/mg)
ED = exposure duration in years (varies with age and scenario)
AT = averaging time of 78 years
BW = body weight (kg)

The site-specific assumptions and recommended exposure factors used to calculate the LECR are the same as those used to assess noncancer health effects. The LECR was calculated by multiplying the cancer exposure dose by EPA's cancer slope factor (CSF). The CSF is defined as the slope of the dose-response curve obtained from animal and/or human cancer studies. It is expressed as the inverse of the daily exposure dose: $(mg/kg/day)^{-1}$. LECRs for soil exposures were calculated using the following formula:

LECR = Cancer Exposure Dose x CSF

Where:

CSF = Cancer Slope Factor $(mg/kg/day)^{-1}$

Using exposure assumptions (i.e., residential exposures for 30 years), the LECRs were calculated by multiplying the exposure dose by the cancer slope factor. We assumed residents were exposed for 30 years over a 78-year lifetime. The cancer slope factor is defined as the slope of the dose-response curve obtained from animal and/or human cancer studies and is expressed as the inverse of the daily exposure dose, i.e., $(mg/kg/day)^{-1}$.

Arsenic: Arsenic is the only metal carcinogen detected in the residential soil exposure pathway. As shown in Table 6, the calculated LECR[9] range for children is approximately one extra cancer case for every 100,000 similarly exposed individuals (for the RME scenarios), which represents a low cancer risk. The calculated LECR for adults is six extra cancer cases for every 1,000,000 similarly exposed individuals for the RME scenarios, which represents no concern for increased cancer risk.

Table 6: LECRs for Students and Staff - Grant Ulysses Intermediate School

Area Group	**EPC[a] (mg/kg)**	**Exposure Duration (yrs)**	**CSF[b] $(mg/kg/day)^{-1}$**	**RME LECR[c]**
Child ages 2 to < 16 yrs	29	14	1.5	1.4×10^{-5}
Adult ages $\geq$ 21 yrs	29	30	1.5	6.2×10^{-6}

[a]EPC = exposure point concentration derived using 95% UCL of mean; [b]CSF = cancer slope factor;
[c]LECR = lifetime excess cancer risk; mg/kg/day = milligrams of contaminant per kilogram body weight per day.

Lead

The method of evaluating risks from exposure to lead differs from the assessment method mentioned previously where exposure doses are calculated and compared to health-based guidelines. To assess the health risks associated with lead exposure, modeling is used to predict

[9]Note that the LECR is a theoretical estimate of cancer risk that ATSDR uses as a tool for deciding whether public health actions are needed to protect health—it is not an actual estimate of cancer cases in a community.

the blood lead concentration of those exposed because individuals are exposed to lead from a variety of environmental sources. Lead exposures, and the subsequent health effects, have traditionally been described in terms of blood lead concentrations in the scientific literature. Young children (0-7 years) and the developing fetus are the most sensitive to the toxic effects of lead. Thus, children and pregnant women (i.e., the fetus) are the primary receptors of concern for the evaluation of lead exposures.

EPA uses two predictive lead models for risk assessment purposes: the Integrated Exposure Uptake Biokinetic (IEUBK) model for children up to the age of 7 years (EPA, 2002), and the adult lead model; ALM (EPA, 2003b) for adolescents and adults for assessing nonresidential exposures.

The ALM model is designed for nonresidential exposures to lead such as female workers and recreationalists. The model is thought to be protective of the fetus, which EPA considers the most sensitive health endpoint for adults. It is used to estimate the blood lead level in fetuses from the predicted blood lead level of the pregnant mother. These susceptible subpopulations are also considered protective of the general population.

Results from IEUBK lead model for children

The IEUBK model was used to estimate the distribution of BLLs in children 12 to 84 months of age, based on these assumptions:

- Intake of all potential sources of lead including air, water, diet, soil, and indoor air dust at the school added to incremental intakes of lead at home.
- Uptake of lead from those media into the bloodstream.
- Distribution of lead to tissues and organs.
- Excretion of lead.

The concentration of lead detected in surface soil (0-2 inches) ranged from 59-560 mg/kg and the calculated mean soil lead concentration was 248 mg/kg in the playground area.

NJDOH used a school exposure scenario to account for lead intake resulting from exposure to soil and dust (see Tables 7 and 8). The following assumptions were considered as reasonable to run the IEUBK model:

1. Children may be potentially exposed to lead in soil and dust at the school facility as well as at home. For exposure to soil at home, NJDOH assumed default value of 200 mg/kg. A time weighted soil concentration was derived based on the hypothetical time spent at school and home site using EPA's method to assess intermittent exposures[10].

[10][USEPA] United States Environmental Protection Agency 2003. Assessing Intermittent or Variable Exposures at Lead Sites. Office of Solid Waste and Emergency Response.

2. A child plays at school five days per week and stays at home two days per week[11]. The IEUBK model is recommended for exposure durations that exceed a minimum frequency of one day per week and a duration of three consecutive months. Three months is considered as the minimum duration of exposure that is appropriate for modeling exposures that occur no less than once every seven days. Exposure to lead in soil at Ulysses S. Grant Intermediate School is expected to occur more than three months and more than once a day every five days.
3. For soil and dust ingestion, the IEUBK default bioavailability value of 30% was used.

Table 7. Default Input Parameters for the IEUBK Model for Exposure to Children

Exposure Variable	Default Value
Drinking water concentration	0.9 micrograms per liter (µg/L)
Dust Fraction	70 % (0.70)
Geometric standard deviation (GSD)	1.6
Soil concentration (mg/kg)*	Site-specific Time Weighted
Concentration of Lead in Outdoor Air	0.1 micrograms per cubic meter (µg/m^3)
FDA dietary parameters	2.66 – 6.04 micrograms (µg) lead/day
Blood lead level of concern	3.5 micrograms per deciliter (µg/dL)

Table 8. Derivation of Time Weighted Soil Concentration used in IEUBK model

Average Lead in Playground area (mg/kg)	Assumed Average Lead in Residential soil (mg/kg)	Derived Time Weighted Lead concentration (mg/kg)
248	200	220

Weighted Site Soil Lead concentration calculated in accordance with the intermittent exposure guidance; Calculation as follows:
F_{school} = (8 hrs of awake time/14 hrs of awake time) x (5 days a week /7 days a week) = 0.41;
F_{home} = 1-0.41 = 0.59; $Lead_{site}$ = 0.41 x 248 = 102 mg/kg; $Lead_{home}$ = 0.59 x 200 mg/kg = 118 mg/kg
Weighted soil lead concentration = 102+118 = 220 mg/kg

Table 9. The IEUBK Model Estimated Risk to Young Children (1-7 years) from exposure to site-specific surface soil and dust from the school playground

Weighted soil lead concentration using average playground lead concentration of 248 mg/kg (mg/kg)	Geometric Mean Blood Lead Concentration (µg/dL)	Percent > 3.5 µg/dL (%)**
220[a]	2.7	**30[c]**

[a]Residential soil lead assumed to be 200 mg/kg; [c]More than 5% chance of exceeding 3.5 µg/dL, values bolded for effect; µg/dL = micrograms of lead per deciliter of blood; **Blood lead levels were calculated using the EPA IEUBK model (Windows Version 2.0) with default assumptions with the exception of blood lead levels set to 3.5 µg/dL.

[11]Exposure to lead in soil at Ulysses Grant Intermediate is assumed to occur for 5 full days/week for 9 months (for a total of 180 days, which equals 6 months that corresponds to the instructional school calendar). However, the IEUBK Model was not designed to model exposures that may occur only part of the year; therefore, the modeled exposure frequency was set at 5 days/week, year around.

The predicted average blood lead of children aged 1-7 years is less than 3.5 µg/dL; however, children have greater than a 5% probability of having a site-related increase in blood lead greater than 3.5 µg/dL. As such, non-cancer adverse health effects are possible in children from exposure to lead in the surface soil.

The IEUBK model uses the school-age range of 12-84 months; however, the children attending Ulysses S. Grant Intermediate School are older than 84 months. Under similar environmental conditions with similar lead exposures, the IEUBK model tends to predict lower blood lead levels with increasing age. IEUBK estimates around the current blood lead level of concern 3.5 µg/dL are uncertain as the model is only validated down to 5 µg/dL.

Adults

The Adult Lead Model (ALM) was used to estimate blood lead levels in a nonresidential scenario. The model is intended to be used for commercial or industrial workers, but it does provide information on potential harm for nonresidents [EPA 2003]. The model's most sensitive individual is the fetus of a nonresident who develops a lead body burden because of exposure to lead. The model output is the average (geometric mean) adult blood lead and the probability of fetal blood lead ≥ 5 µg/dL, target blood lead value.

The results of the Adult Lead Model (ALM) indicated a less than 5% probability (0.6%) of blood lead levels in the fetus exceeding a level of health concern. Overall, exposure to lead in surface soil at the school is not expected to harm the health of adult staff and/or faculty.

Table 10: The ALM Model Estimated Risk to Staff/from exposure to site-specific surface soil and dust from the playground

Derived Time Weighted Lead concentration (mg/kg)	Blood lead level of adult worker, geometric mean (µg/dL)	95th percentile Blood Lead Level among fetuses of adult workers (µg/dL)	Probability that fetal PbB exceeds target PbB, assuming lognormal distribution (%)
220	0.9	2.0	0.1

mg/kg = milligrams of contaminant per kilogram of soil; µg/dL = micrograms per deciliter of blood

It is important to note that the adult lead model rely on many input parameters to estimate blood lead levels and EPA developed default values for all parameters to allow the model to be used without performing site-specific studies. In the absence of site-specific data, this evaluation used the default values. These default values could result in an over- or under-estimation of the actual blood lead levels.

Children's Health Concerns

The potential for exposure and adverse health effects often increases for younger children compared with older children or adults. NJDOH recognizes that children are susceptible to developmental toxicity that can occur from exposures to contaminants at levels much lower levels. The following factors contribute to this vulnerability:

- Children are more likely to play outdoors in contaminated areas by disregarding signs and wandering onto restricted locations.
- Children often bring food into contaminated areas resulting in hand-to-mouth activities.
- Children are smaller and receive higher doses of lead exposure per body weight.
- Children are shorter than adults; therefore, they have a higher possibility of breathing in dust and soil.
- Fetal and child exposure to contaminants such as lead can cause permanent damage during critical growth stages.

These unique vulnerabilities of infants and children demand special attention in communities that have contamination of their water, food, soil, or air. Children's health was considered in the writing of this health consultation and the exposure scenarios treated children as the most sensitive population being exposed.

Conclusions

The NJDOH has reached the following conclusions for exposures to soil contaminants at the Ulysses S. Grant Intermediate School:

1. *Past exposures to lead in surface soil at the Ulysses S. Grant Intermediate School may harm children's health*. Children may have accidentally ingested lead-contaminated soil at levels that could harm their health. NJDOH considers this a past public health hazard. The average soil lead levels in the playground area were above 200 mg/kg. This is the level that the EPA's lead model predicts children's blood lead levels may exceed 5 µg/dL, which is used to determine if additional risk evaluation and subsequent remediation is necessary. Exposures to any level of lead are of concern and exposures should be minimized to the extent as much as possible. Elevated blood lead levels in children may lead to attention, learning and behavioral problems. It may also cause decreased hearing and slower growth and development. EPA and the school have taken actions to prevent additional exposures to lead contaminated soil by restricting access to areas accessible to children. The results of the Adult Lead Model (ALM) predicted that the blood lead levels of unborn children of pregnant staff at the school would not exceed the CDC reference level of 3.5 µg/dL. Overall, exposure to lead in surface soil at the school is not expected to harm the health of adult staff and/or faculty. Access to the impacted areas is currently restricted, preventing current and future exposures to site contaminants for children and adults.

2. *Past, current and future exposures to arsenic in surface soil at the Ulysses S. Grant Intermediate School are not likely to harm people's health*. Calculated exposure doses for arsenic were below noncancer health guideline values for arsenic. Harmful noncancer health effects are not expected for children and staff at the school. Cancer risks for children and adults from exposure arsenic were also determined to be low. Access to the impacted areas is currently restricted, preventing current and future exposures to site contaminants for children and adults.

Recommendations

NJDOH recommends that:

1. Permanent measures be taken to reduce or eliminate exposures to the contaminated soil at the school.

2. Parents/guardians of young children should consult with their child's health care provider and consider blood lead testing.

3. EPA conduct additional assessments to characterize the extent of contamination in and around the East Trenton neighborhood, to assess exposures that may be occurring outside of the school setting.

4. Interim measures such as fencing should be monitored to ensure that they are in good condition and continue to effectively prevent access to contaminated areas at the school.

Public Health Action Plan

1. NJDOH will collaborate with the Trenton Health Department and EPA to conduct outreach and education activities to ensure that residents potentially impacted by the Trenton historic pottery sites have the knowledge to protect themselves from exposures to soil contaminants. These activities may include developing site-specific fact sheets and attending public meetings.

2. NJDOH will be available to review future soil sampling results at EPA's request.

3. NJDOH will disseminate and discuss findings of this health consultation with local, state, and federal health and environmental officials, and with other interested stakeholders.

4. NJDOH will continue to provide public health-related technical assistance to Trenton Health Department and EPA as they further characterize the extent of contamination from the former Trenton pottery sites.

Non-Certified

This publication was made possible by a cooperative agreement [CDC-RFA-TS-23-0001] from the Agency for Toxic Substances and Disease Registry (ATSDR). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the ATSDR, or the U.S. Department of Health and Human Services.