Health Consultation

FORMER MOHR ORCHARD SITE

SCHNECKSVILLE, LEHIGH COUNTY, PENNSYLVANIA

EPA FACILITY ID: PAN000306624

Prepared by
Pennsylvania Department of Health

JULY 25, 2013

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

Health Consultation: A Note of Explanation

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.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Summary

Introduction

At the request of a concerned community member, and in collaboration with the Environmental Protection Agency (EPA), the Pennsylvania Department of Health (PADOH) prepared this Health Consultation (HC) document for the Former Mohr Orchard (FMO) site in Schnecksville, Lehigh County, Pennsylvania. The site consists of two EPA sites, which include the FMO Groundwater site and the FMO Pesticide site, collectively referred to in this HC as the FMO site. The site is a former fruit orchard, primarily apple and peach trees, where lead arsenate was historically applied as a pesticide resulting in soil contamination. The site currently consists of residential or public use areas (i.e., parks, open space, schools) and undeveloped land. The purpose of this HC is to determine if exposures to arsenic and lead in the residential soil and well water at the site could harm people's health. This HC was prepared under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Conclusions

PADOH reviewed the environmental sampling data collected in the community and available childhood blood lead surveillance data. Based on this review, PADOH conclude the following for the FMO site:

Conclusion 1

Children with pica behavior and living in homes with residential soil levels of arsenic above 75 ppm could have or are currently receiving a dose of arsenic that may result in acute health effects.

Basis for Conclusion

The estimated arsenic dose for children exhibiting soil-pica behavior in yards with arsenic levels above 75 ppm exceeded ATSDR's short term health guidelines. Soil-pica behavior is a condition where some preschool children eat large amounts of soil (about one teaspoon at a time) while playing. This condition is rare and represents an acute transient exposure scenario, because arsenic is rapidly eliminated from the body within 2 weeks (typically in soil-pica behavior by excessive vomiting and diarrhea). As such, once eliminated from the body, these acute transient exposure events do not represent a chronic health concern. Exposure to arsenic in residential soils is not expected to harm the health of children that do not experience soil-pica behavior.

Next Steps

EPA conducted remedial activities at yards exceeding the site-specific clean-up level for arsenic (73.4 ppm). PADOH will consider evaluating any additional environmental sampling data collected and provide public health conclusions to the community.

Conclusion 2

Depending on activity patterns and the amount of exposed soil in the yard, children living in homes with yards that have lead in the soil might be at increased risk of blood lead levels exceeding Centers for Disease Control and Prevention's (CDC) new childhood blood lead reference value of 5 µg/dL.

Basis for Conclusion

The best available science currently indicates there is no safe level of lead. Exposure to lead in soil could result in blood lead levels in children above the new CDC childhood blood lead reference value of 5 µg/dL. Levels above 5 µg/dL indicate a need for targeted primary prevention or case management.

Next Steps

PADOH consider it prudent to prevent or reduce all exposures to sources of lead-including contaminated soil. EPA performed removal and remedial actions at the site from the most contaminated yards. EPA should consider conducting a bioavailability study for lead in soil at this particular site and community to further define lead exposures at this site, similar to what was done for arsenic. PADOH also recommends the following for any home with lead in soil:

- Educate community members on methods to reduce exposures to lead in their environment, other sources of lead, such as lead-based paint, in the environment and if found, educate those affected on methods to reduce or eliminate exposures.

- Encourage parents who have children less than seven years of age to have their blood tested for lead and follow recommendations from their health care provider.
- Alert area health care providers about the potential for lead exposure.

Conclusion 3

Exposure to arsenic and lead in residential soils is not expected to harm the health of adolescents and adults living on the site. However, pregnant women should take care in avoiding possible exposures that could result in fetal blood lead levels exceeding the CDCs reference value of 5 µg/dL.

Basis for Conclusion

Exposure dose calculations for ingestion of arsenic were below the ATSDR chronic minimal risk level (MRL). In addition, the theoretical cancer risk from exposure to arsenic is very low. Exposure to lead in soil is not expected to harm adults on the site. However, exposure of pregnant women to lead soil could result in elevated fetal blood lead levels greater than or equal to the CDC reference value of 5 µg/dL. Lead is particularly harmful to the developing fetus. Currently, based on available scientific data, there is no safe level of lead.

Next Steps

PADOH will consider evaluating any additional environmental sampling data collected and provide public health conclusions to the community.

Conclusion 4

PADOH reviewed the available child blood lead surveillance data and did not detect elevated blood lead levels in the community as compared to county or state data.

Basis for Conclusion

A review of the data did not show a statistically significant difference between mean blood lead levels for children in the community (i.e., ZIP codes located in the site boundary) and mean blood lead levels for children tested throughout the Commonwealth of Pennsylvania and Lehigh County, during the same time frame. However, since the results represent voluntary blood testing and ZIP code level of analysis, the results of this study do not directly correlate to those potentially exposed at this site. Therefore, the results should not infer that blood lead levels in children living on or near the site are below levels of health concern.

Next Steps

PADOH will consider reviewing additional blood lead data, especially from children living on/near the site.

Conclusion 5

PADOH cannot conclude on whether exposures to soil in undeveloped areas or public use areas because these areas were not sampled during this investigation.

Basis for Conclusion

The site contains large areas of undeveloped land that could potentially contain high levels of arsenic and lead in the soil and be a source of future exposure.

Next Steps

EPA should consider collecting additional soil samples for lead and arsenic in the undeveloped and public use areas that have not yet been sampled. PADOH will review additional environmental sampling data collected at the site. EPA performed removal and remedial actions at the site continue in order to reduce potential exposures to lead and arsenic. PADOH recommends that people living on the site be informed of ways to avoid potential health effects, especially parents of children that might eat contaminated soil.

Conclusion 6

As long as the residential tap water filters are properly maintained and/or bottled water is used as the drinking water source, exposures to lead and arsenic in well water is not expected to harm people's health.

Basis for Conclusion

PADOH evaluated the residential private well water sampling data collected at the site, in both groundwater and tap samples. Only one sample exceeded the EPA's site-specific screening level for lead and they were provided alternate water and/or filtration. The maximum arsenic level detected was below comparison values.

Next Steps

For people at the site that have not had their tap water tested, PADOH recommend sampling of private wells for lead. As a general public health measure, all homeowners with private wells should have their private well water tested periodically. PADOH will review any additional well water sampling data collected at the site, upon request.

For More Information

If you have concerns about your health, you should contact your health care provider. For questions or concerns about the site, please contact the PADOH, Division of Environmental Health Epidemiology at (717) 346-3285.

Background and Statement of Issues

Background

At the request of a concerned community member, and with collaboration of the Environmental Protection Agency (EPA), the Pennsylvania Department of Health (PADOH) prepared this Health Consultation (HC) document for the former Mohr Orchard (FMO) site. Based on EPA's investigations, EPA split the site into two sites: the FMO Groundwater Site and the FMO Pesticide Site (the soil site). The boundaries of the soil site are the former orchard area. The boundaries of the groundwater site have expanded beyond the former orchard and are not currently defined. The groundwater site has been referred to the EPA pre-remedial program for further evaluation and potential listing on the EPA National Priorities List (NPL). In this HC, PADOH will collectively refer to both sites as the FMO site.

Site Description

The FMO site is located in Schnecksville, Lehigh County, Pennsylvania (Appendix A, Figure 1). The site was a fruit orchard, consisting primarily of apple and peach trees and operated through the 1980s. Lead arsenate was historically applied as a pesticide until it was banned in 1988 by the EPA. In the 1980s, the orchard lands were marketed for housing redevelopment. The site is approximately 1.5 square miles in area (or 1,300 acres) and has approximately 1,413 residents. Residential development of the former orchard properties has resulted in a change in land use and exposure potential (i.e., from agricultural to primarily residential) (ATSDR, 2009).

The site is located in a mixed use (commercial, residential, agricultural, and industrial) area on the east and west sides of state route 309. The boundaries are defined as land formerly used as orchard in North Whitehall Township and currently residential or public use (i.e., parks, open space, schools). Large portions of the former orchard area remain undeveloped. The Lehigh County Community College (LCCC) and KidsPeace properties occupy large tracts of land within the site boundaries. KidsPeace is a private non-profit dedicated to serving the behavioral and mental health needs of children, preadolescents and teens, offering, among other services, therapeutic residential treatment programs. Other developed areas of the site are primarily residential, except along route 309, which is mixed residential, commercial, and industrial (ATSDR, 2009). In 2008, EPA became involved with the site as a result of a request from ATSDR, PADEP, and a concerned citizen that indicated their property contained elevated levels of arsenic in the soil. A resident, living on the former orchard land, had their soil sampled for lead and arsenic, and the results showed a maximum concentration of lead of 245 parts per million (ppm or mg/kg) and arsenic of 140 ppm USEPA (2009a).

Since 2008, ATSDR and PADOH have assisted EPA with the assessment of residential properties and public lands at the site. ATSDR and PADOH have provided technical assistance to the EPA, via site visits, community outreach, fact sheets, and technical assistance documents summarizing health conclusions regarding specific concerns (PADOH, 2008a; PADOH 200b). In 2009, ATSDR Region 3 produced a Health Consultation that reviewed the residential soil phase 1 sampling data (ATSDR, 2009). A summary of this health consultation document is discussed below in the Phase 1 soil sampling data section. In November 2010, the PADOH Health Assessment Program and ATSDR Region 3 staff conducted a site visit and met with the EPA to discuss site background information and community concerns. A tour of the surrounding community and site activities was also conducted. The major exposure pathway observed during the site visit was potential residential soil exposure, especially for children, in yards with bare soil.

Previous Evaluations

In 2008, EPA conducted Phase I sampling which consisted of a surface soil evaluation to delineate the site contaminants from historical pesticide applications. The EPA's main objective during Phase 1 soil sampling was to determine if arsenic and lead concentrations were present in current residential and public use areas at levels that could pose a threat to human health. During the investigation, EPA excluded industrial and agricultural grids from the sampling event. Grids eligible for sampling were at least partly residential or public use. This initial investigation defined 15 distinct residential areas where former orchard activities were conducted. Two of these areas were determined not to contain "pesticide contaminated soil" with lead and arsenic at levels that may potentially threaten human health and/or the environment (ATSDR, 2009).

EPA used an adaptive cluster sampling strategy that divided the site into 200 by 200 foot sampling grids; 25% of the grids were sampled. A 10-point composite soil sample (0" to 3") was collected from a grid and analyzed for lead and arsenic using field x-ray fluorescence (XRF) via EPA Method 6200. A total of 327 grids were sampled. Homogenized, dried and sieved samples were analyzed ex-situ by XRF. To confirm the arsenic and lead results by XRF, approximately 9% of the prepared samples were sent to a laboratory for standard EPA metals analysis. The XRF methodology allowed for accurate analyses to a lower limit of detection of approximately 40 ppm. The random grids sampled included multiple properties with varying uses and soil activities, large grid areas have the potential to not represent potential high or low levels within the grid. Routine lawn maintenance activities (e.g., soil tilling, treatments, addition of high-quality topsoil or sod, lawn watering, etc.) on residential parcels could decrease the concentrations of pesticide contaminants in the top three inches of soil relative to the non-residential parcels (ATSDR, 2009).

ATSDR evaluated each composite sample result as though the arsenic and lead concentration applied to the entire 200 square-foot grid. ATSDR produced a Health Consultation which reviewed the Phase 1 sampling data and blood lead data for the site (ATSDR, 2009). Arsenic concentrations at the FMO site ranged from 7 to 149 ppm. The following summarizes the arsenic in soil results:

- 189 composite samples (57% of total) were above 40 ppm arsenic. 43% of these grids were at least partially residential;
- 41 composite samples (13% of total) were above 80 ppm arsenic. 8% of these grids were at least partially residential; and,
- The maximum arsenic level from a grid with at least a portion of residential property was 149 ppm, and maximum arsenic level found at the site was 149 ppm.

Lead concentrations at the site ranged from 35 ppm to 1,950 ppm. Phase 1 sample results for lead were:

- 81 composite samples (25% of total) were above 400 ppm;
- 33 composite samples (10% of total) were above 800 ppm; and,
- The maximum lead level found at the site was 1,950 ppm, located in a public use grid.

Based on the review of the Phase I sampling data, ATSDR concluded and recommended the following in the previous HC:

- The majority of the sampled grids contain either, or both, arsenic or lead at levels that exceeded the screening values;

- Biased, composite sampling of exposed soils, play areas, and high traffic areas on residential parcels will provide appropriate data for evaluating the potential for adverse health effects to residents at these parcels; and,
- EPA should conduct site-specific arsenic and lead bioavailability studies, to determine a site-specific action level.

ATSDR reviewed the blood lead database for children and adults in the ZIP code 18069 for 2008. Based on this review, no children 18 years and younger had a blood lead level above the Centers for Disease Control and Prevention (CDC) childhood blood lead intervention guideline of 10 micrograms per deciliter (µg/dL). For individuals over the age of 18 years of age, 7 individuals were reported to have BLLs at or exceeding the CDC screening level for adults of 25 µg/dL. The adults are believed to have been tested due to possible occupational exposures. (ATSDR, 2009) Since the release of this Health Consultation, CDC has lowered childhood blood lead guideline to 5 micrograms per deciliter (µg/dL) (CDC, 2012a, CDC 2012b). This is discussed further in the Public Health Implications section.

Background Soil Levels

In 2008, EPA collected 12 background discrete (grab) soil samples in residential or public use areas from locations determined to be outside the former orchard areas (Appendix A, Figure 2). Arsenic concentrations ranged from 4 to 30 ppm, with a mean concentration of approximately 10 ppm. Lead concentrations ranged from 21 to 218 ppm, with a mean concentration of approximately 58 ppm (USEPA, 2010a).

ATSDR Comparison Values

To evaluate whether the residents may be exposed to contaminants that could harm their health, PADOH compared the environmental sampling data against ATSDR's comparison values (CVs). CVs are environmental media concentrations below those known or anticipated to result in adverse health effects. They are used to identify contaminants at a site that require further evaluation on a site-by-site and case-by-case basis. Exceeding a CV does not necessarily indicate a level associated with or expected to cause adverse health effects. Rather, concentrations that exceed a CV indicate the need for further assessment to determine potential public health impacts (ATSDR, 2005).

For contaminants that are considered to be known human carcinogens, probable human carcinogens, or possible human carcinogens, ATSDR has developed a cancer risk evaluation guides (CREGs) for some contaminants. CREGs are media-specific comparison values used to identify concentrations of cancer-causing substances that are unlikely to result in an increase of cancer rates in an exposed population. ATSDR develops CREGs using EPA's cancer slope factor (CSF), a target risk level (10-6), and default exposure assumptions. The target risk level of 10-6 represents a theoretical risk of 1 excess cancer cases in a population of 1 million (ATSDR, 2005).

PADOH used the ATSDR CVs, when available, for arsenic and lead to evaluate the soil and well water data collected at the site to determine if exposure could harm people's health. The ATSDR CREG CV for arsenic in soil is 0.5 ppm. However, since this value is well below soil background levels, which in the area of the site averages 10 ppm, as discussed further above, ATSDR recommends that a CV of 20 ppm be used for arsenic exposures in soil. However, based on exposure dose calculations for arsenic in soil at 25 ppm (and less), as described in the Non-Cancer Effects Evaluation and Cancer Effects Evaluation Sections, this is not likely to result in non-cancerous health effects or cause an observable increase in cancers. ATSDR has established a chronic non-cancer Environmental Media Evaluation

Guide (EMEG) CV for children and adults of 20 ppm and 200 ppm, respectively. The Pennsylvania Department of Environmental Protection (PADEP) has a media specific concentration (MSC) for screening arsenic in residential soil of 12 ppm. However this value is typically lower than background levels. PADOH compared the soil sampling data against the EPA action level for soil arsenic of 73 ppm because this value was developed based on site-specific factors including potential exposure frequency, bioavailability (described in the Bioavailability of Arsenic Study Section below), potential risk, and in concurrence with the PADEP. The site-specific action level was based on a cancer risk level of 10^{-4} (or 1 excess cancer in 10,000 exposed). As described previously, a mean background arsenic concentration in the area was 10 ppm, with a range of 4 ppm to 30 ppm. EPA, in concurrence with PADEP, set site-specific arsenic in soil action level of 73 ppm (USEPA, 2010a).

ATSDR has established a CREG CV for arsenic in drinking water of 0.02 parts per billion (ppb or µg/L). ATSDR has a chronic non-cancer EMEG CV for arsenic in drinking water of 3 ppb for children and 10 ppb for adults (ATSDR, 2007a). In addition, the EPA has set a maximum contaminant level (MCL) for arsenic in drinking water of 10 ppb (USEPAa).

Due to limits on analytical accuracy and the small data set available, the EPA On-Scene Coordinator (OSC) selected a site-specific screening level for lead in drinking water of 11 ppb. This level was established as a lower limit for provision of emergency bottled water to ensure that no residents would be exposed to lead in their drinking water over 15 ppb. As a precautionary public health measure, EPA immediately informed residents and supplied bottled water to those residents whose well water tested above the action level (USEPA, 2010b). Details of EPA groundwater sampling and private well water investigation can be found online at EPA's OSC FMO Groundwater Site page at: http://www.epaosc.org/site/site_profile.aspx?site_id=4324

EPA does not currently have an MCL for lead, but has established a maximum contaminant level goal (MCLG) of zero. EPA has set this level based on the best available science which shows there is no safe level of exposure to lead. However, because lead contamination of drinking water often results from corrosion of older plumbing materials belonging to water system customers, EPA established a treatment technique rather than an MCL for lead. A treatment technique is an enforceable procedure or level of technological performance which water systems must follow to ensure control of a contaminant. If more than 10% of tap water samples exceed the lead action level of 15 ppb, then public water systems are required to take additional actions (USEPAb). The action level does not apply to private systems (USEPAa).

Currently, ATSDR does not have CVs for lead in soil and drinking water. In absence of an ATSDR CV for lead in soil, PADOH compared the soil lead data against EPA's screening level under the Toxic Substances Control Act (TSCA) for lead in residential bare soil of 400 ppm for children's play areas (USEPA, 2010c). However, recent science indicates that there may be no safe level of exposure to lead in soil. To ensure no residents are exposed to lead in drinking water, EPA established a site-specific lead in drinking water standard of 11 ppb (USEPA, 2010b). The table below summarizes the ATSDR CVs and screening values used at the site:

ATSDR CVs and EPA Screening Values used for evaluating exposure at the FMO site

Media and Contaminant	Comparison/Screening Value	Concentration
Soil – Arsenic	ATSDR CREG CV (chronic)	0.5 ppm *
	ATSDR EMEG CV (chronic)	20 ppm (child) 200 ppm (adult)
	EPA site-specific action value	73 ppm
Soil – Lead	EPA TSCA screening level	400 ppm**
Drinking Water – Arsenic	ATSDR CREG CV	0.02 ppb
	EMEG CV (chronic)	3 ppb (child) 10 ppb (adult)
	EPA MCL	10 ppb
Drinking Water – Lead	EPA MCLG (MCL goal)	0 ppb
	EPA site-specific screening level	11 ppb

* ATSDR CREG CV for arsenic in soil is 0.5 ppm. However, this value is typically below background levels. ATSDR recommends that a CV of 20 ppm be used for arsenic exposures in soil (ATSDR, 2007a)
**ATSDR does not have a CV; there is no known safe level of lead exposure. All residents should take steps to minimize exposures from all lead sources (lead paint, soil contamination, drinking water, toys, etc).

Environmental Sampling

Residential Soil Sampling

Based on the Phase 1 random soil sampling results and recommendations made by ATSDR, in April through December 2009, EPA conducted Phase 2 sampling which consisted of a biased residential surface soil sampling investigation for arsenic and lead at the site (Appendix A, Figure 3). The purpose of the Phase 2 soil sampling investigation was to determine if historical application of lead arsenate pesticide has resulted in elevated exposure to arsenic and lead that may potentially harm the health of people currently residing in and nearby application areas (USEPA, 2010b). Although not all areas were fully assessed by EPA, Phase 1 sampling identified areas for further assessment and eliminated others. Some areas remain un-assessed due to access limitations and other issues. Additional information on the soil assessment activities for the FMO site can be found on the EPA's On Scene Coordinator (OSC) page at: http://www.epaosc.org/site/site_profile.aspx?site_id=6358

Sampling was not offered to residents of properties where access was previously denied (USEPA, 2010b). During the Phase 2 sampling event, EPA offered to perform soil sampling at:

- All residential dwellings in areas identified for further assessment during previous soil sampling activities;
- Residential dwellings within areas that had not yet been sufficiently sampled;
- Residents whose property owners had granted access for sampling during previous events, but had not been sampled during Phase 1 activities; and
- A randomly selected group of 25 percent of all residential properties bordering the former orchard areas.

PADOH evaluated the Phase 2 ten-point composite surface soil sample (0- to 3-inch depth) laboratory results. A total of 865 soil samples were collected from 156 properties and public use areas during initial Phase 2 soil sampling activities. Twenty one of these properties border the former orchard. Duplicate samples were collected from unique locations within a sampling grid throughout the assessment. Approximately 10% of soil samples were sent for laboratory arsenic and lead analysis to confirm the accuracy of on-site XRF analysis. EPA's Phase 2 sampling event encompassed the following (USEPA, 2010a):

- **Front and back yard** – EPA sampled high traffic areas in both front and back yards. High traffic areas at a residence are those, where there is a greater frequency of use, such as walking to the car, children's play area, and frequently used areas just off a patio or deck. In these areas, the ground cover can be diminished and eventually expose bare soil. For most residences, EPA collected one five-point composite surface (0- to 3- inch) soil sample in both the front and back yard within a 40 foot perimeter of the house.

- **Toddler play area** – If the homeowner did not have a designated toddler or child play area, the EPA allowed the home owner to select a toddler play area in their yard of (approximately 400 square feet for each residence) for sampling. For most residences, EPA collected one surface soil grab sample (0 to 3 inches).

- **Vegetable garden area** – If the homeowner did not already have a designated garden area, the EPA allowed the home owner to select a garden area for sampling of approximately 400 square feet. For most residences, EPA collected one surface (0- to 3-inch) grab soil samples. If any sample result exceeded 73 ppm for arsenic or 400 ppm for lead, EPA provided the home owner with a raised bed containing 12 inches (in depth) of clean top soil and/or the area was excavated and backfilled with clean top soil.

Private Well Water Sampling

In 2008, EPA began a residential private well water investigation at the site to determine if the community was being exposed to lead and arsenic in potable water that could harm their health. The majority of households on the former orchard land are on private well systems. In the preliminary stages of the investigation, EPA collected well water samples at homes located in the Phase 1 randomly selected grids, as described in the Phase 1 sampling section. Samples were collected from the wells, not at the tap. EPA initially was granted access to sample 61 private wells on the site, however only 47 private wells were sampled. Preliminary data showed lead levels above EPA's action level for lead of 15 parts per billion (ppb or µg/L) with lead levels ranging from non-detect to 604 ppb. Lead exceeded the site-specific screening level of 11 ppb in 47 wells (USEPA, 2010d). However, this sampling data is well data and not tap water samples, where people would be exposed. Lead levels at the tap are likely to be lower than lead levels observed in the groundwater samples, because of potential sedimentation in the residential holding tanks as observed by the limited sampling data. This is discussed further in the Results Section below.

Based on the preliminary elevated lead in private well water results described above, EPA initiated sampling of all private wells located within the former orchard areas, not just homes within the 25% randomly selected grids. EPA requested access to 868 homes on the site for sampling. From 2008 to 2010, EPA collected samples from residential well water, holding tanks and sediment filters from home treatment systems, and a very limited number of tap water samples. It was subsequently determined that sediment in the wells and well tanks was accumulating causing the elevated lead levels in the tank samples. EPA investigated the internal processes within the private well systems causing the buildup of lead particles. EPA took samples from the kitchen tap at some residential properties to assist in determining if lead was leaching from private water systems and/or reaching the tap (USEPA, 2010d).

Former Pond Filling Area Sampling

In 2009, EPA collected 99 surface soil samples from an area where a pond formerly existed and was used for mixing lead-arsenate pesticide. Samples were analyzed by XRF EPA Method 6200. Residential properties are present at this location (identified via historical aerial photography). EPA sampled soil at former pesticide mixing preparation areas where water was mixed with a powder-based lead-arsenate pesticide. Two of six former pesticide mixing and preparation areas are currently paved lots and no soil remains accessible. Access was granted to one of the remaining former filling stations. EPA tested surface water and sediment to determine if local surface water bodies were impacted by runoff from former orchard activities (Appendix A, Figure 4). In January 2009, EPA collected sediment and surface water samples from 14 locations throughout the site, adjacent to current residential and undeveloped land (USEPA, 2010a).

Results

Residential soil

Arsenic: PADOH tabulated the mean, maximum and the frequency of CV exceedances for the soil sampling data (Appendix A, Table 1-3). PADOH compared the sampling data against an action level for soil arsenic of 73 ppm. Based on the data reviewed, 3.36% (10 of 298 samples), 7.89% (6 of 137 samples) and 6.57% (9 of 76 samples) exceeded the site-specific action level of 73 ppm for arsenic in the yards, garden areas and toddler play areas, respectively. The maximum arsenic level (212 ppm) was detected in a toddler play area; the minimum level (7 ppm) was found in a gardening area. Average soil arsenic levels ranged from 34 ppm in the yard area to 51 ppm in all toddler play areas combined. Because these were composite soil samples, the maximum concentration of arsenic in soil is not known with certainty Additional samples were collected from 29 of the 135 Phase 2 properties due to elevated concentrations of lead and/or arsenic identified in initial samples. Because EPA was not granted access to all homes, a portion of the site remains unassessed and additional homes could have elevated arsenic (USEPA, 2010a).

Lead: The best available science indicates that there is no safe level of lead in soil, and individuals should take actions to reduce all exposures to lead as much as possible, including lead in soil. Overall, the lead levels ranged from a minimum of 22 ppm to a maximum of 977 ppm. As previously stated, ATSDR does not have a CV for exposure to lead in soil; therefore, PADOH utilized the EPA TSCA level for lead in soil of 400 ppm (USEPA, 2010c). PADOH calculated the frequency of lead results that exceeded the EPA lead clean-up level of 400 ppm, which is the level EPA utilized for soil clean-up at the site (Appendix A, Table 3). Based on this, 3.69% (11 of 298 samples), 5.11% (7of 137 samples) and 3.95% (3 of 76 samples) exceeded the lead screening value in the yards, garden areas and toddler play areas, respectively.

Former Pond Filling Area

Soil arsenic concentrations at the former pond filling area (which since has been filled in but not currently used for residential use) ranged from below the level of detection to 35 ppm, with a mean of 14 ppm. Lead concentrations ranged from 21 to 200 ppm, with a mean of 52 ppm. Arsenic concentrations at the former pesticide mixing areas ranged from 52 to 262 ppm, with a mean concentration of 104 ppm. Lead concentrations ranged from 159 to 880 ppm, with a mean of 375 ppm. While some concentrations were found above EPA's site-specific action levels of lead and arsenic, these areas are either paved over or are areas that have not been developed since orchard operations ceased (USEPA, 2010a). However, there is a potential for future development of these areas and ultimately future exposure by the community. Frequent or prolonged exposure to some of these areas, although unlikely, could potentially pose a health risk.

Surface Water
Lead and arsenic were detected in only one surface water sample at concentrations of 0.05 ppb and 0.011 ppb, respectively, which are below respective screening levels. Concentrations of lead in sediment ranged from 16.5 to 169 ppm. Arsenic concentrations in sediment ranged from 4.7 to 14.3 ppm (USEPA, 2010a). As the maximum values are below site specific action levels, PADOH does not expect exposure to these levels to harm peoples' health.

Private Well Water
PADOH reviewed the private well water sampling data collected by EPA for both arsenic and lead at the site. To summarize, 792 water samples were collected from well, holding tanks and tap, and analysis of 788 samples were sent to the property owners and occupants. EPA established a site specific lead concentration in drinking water of 11 ppb. EPA used this site-specific value, based on elevated levels detected in both tap water and holding tank water samples, as an intervention point to provide drinking water to affected residents and eventually point of use filtration system (USEPA, 2010d). Based on the results of the sampling, 359 property owners were offered bottled water because lead results were above 11 ppb (from any sample location). Most (334) property owners accepted the alternate water. Due to access restrictions, EPA was unable to sample some properties and, overall, very limited tap water samples were collected during the investigation.

Lead in private wells ranged from non-detect to 1,600 ppb. Arsenic concentrations ranged from non-detect to 9.5 ppb. An additional well sample contained arsenic at 134 ppb but was not reproduced when the well was re-sampled. However, these samples were not collected at the tap and, as explained in the following discussion, do not likely represent actual exposure levels. In order to better evaluate potential exposures to lead and arsenic in drinking water, PADOH grouped the residential water data into 3 categories: tap water samples (i.e., samples collected from the tap or sink for potable use in the home), samples collected at non-tap/spigot locations (i.e., spigots, outside hoses, garage utility sinks, etc.), and pre-tap (i.e., groundwater, holding tank, or prior to filtration). (Appendix A, Table 4 - 5). Forty-one tap water samples, 38 non-tap/spigots water samples, and 695 pre-tap/holding tank/groundwater well samples were collected during the investigation. Samples collected in residential holding tanks, prior to home filtration (if present) and use at the tap, can accumulate sediment containing lead, and therefore tank water samples are not reliable for exposure assessments. For example, homes with lead in tap water at a level of 16 ppb and 5.6 ppb had a lead concentration in the holding tank of 264 ppb and 308 ppb, respectively (USEPA, 2010d). Therefore, PADOH cannot utilize tank samples for potential exposure assessment at the site due to potential sedimentation. Also, it is not known if homeowners have filtration systems installed. Tap water sample data are the most relevant for evaluating residential exposures to lead in drinking water.

PADOH calculated the mean and frequency distribution for the residential water sampling data. The mean for the tap water samples, non-tap/spigots, and pre-tap (holding tank/groundwater samples) for lead were 1.81 ppb, 6.94 ppb, and 56.3 ppb, respectively. The levels of lead in the tap water samples range from non-detect to 16 ppb (obtained during a first draw tap samples, in which the water was not flushed, and therefore lead could accumulate). The next highest lead in tap water result was 6.8 ppb, which is below the site-specific action level for lead in drinking water at the site of 11 ppb. Overall, the data indicate that some lead was reaching the tap above the site-specific action level of 11 ppb and the lead levels in the holding tank and groundwater samples are much higher than levels observed in the tap water samples and could potentially act as a collection area for lead contaminants. For arsenic, the mean was 0.1 ppb for tap samples, 0.09 for non-tap/spigot samples, and 0.42 ppb for pre-tap/tank samples. These arsenic levels are below EPA's MCL of 10 ppb.

For homes with private well results below EPA's site specific intervention level or currently using bottler water and/or filtrations systems exposures to lead and arsenic in tap water is not expected to harm their health, as long as the residential tap water filters are properly maintained and/or bottled water use is continued. Residents who use bottle water for potable purposes, but do not have water filters can continue to safely use their well water for other household uses such as bathing, showering, and washing clothes and dishes. Residents who have not had their private well water tested should consider sampling. Due to a very limited data set, PADOH cannot conclude whether past exposure to contaminants in private well water on the site might harm people's health, but past exposure to lead and arsenic in well water could have occurred at the site.

Limitations of Private Well Water Investigation

Several limitations exist in PADOH's ability to evaluate the well water sampling data and draw public health conclusions. These limitations include:

- Very few tap water samples were collected. The majority of the samples were collected either from the well itself or from residential holding tanks prior to home filtration (if present). Tap water sample data are the most relevant for evaluating residential exposures to lead in drinking water, since sediment containing high levels of lead could accumulate in the holding tanks but not reach the tap or exposure point. PADOH recommends that residents periodically flush out their holding tank and/or follow proper maintenance procedures to ensure lead is not present in drinking water.
- Limited sampling data was collected from multiple sampling locations within a single residence (i.e., well water, tank, and tap), which would aid in evaluating the reduction of lead levels from the tank to exposure at the tap.
- Details on the specifics of the water samples were not collected for some homes including presence of a filtration system, last time the holding tank was flushed out, and sampling location (i.e., tap, outside house, tank, etc.).
- Due to the lack of past well sampling data, PADOH cannot assess potential past exposures at the site.

EPA Soil Cleanup Action

Based on the soil sampling results, beginning in 2010, EPA performed soil excavation activities at residences with arsenic levels above 73 ppm and/or lead levels above 400 ppm, where lead contamination is considered to be due to pesticide applications and not some other source (i.e., lead-based paint). The residential soil removal activities include removing the top 6 inches of soil, post excavation sampling to determine arsenic and lead levels at depth, back-filling with clean fill, and restoring ground cover (i.e., sod, mulch, and grass seed). During the clean-up activities erosion controls were in place and dust monitoring was conducted downwind of the work area and within the work zone during excavation and backfill activities. No dust levels exceeding action levels were identified from within the work zone. Soil removal activities occurred at six residential properties. Removal activities at the site concluded in 2011 (USEPA, 2011; USEPA, 2009b). EPA's removal actions targeted residential properties with lead levels of 400 ppm or greater. Therefore, this action would eliminate the highest risk for exposures to lead in soil. However, based on the best available science indicating that there is no safe level of lead and the most recent CDC advisory level for lead in blood being lowered from 10 µg/dL to 5 µg/dL. Please refer to the full report from the Advisory Committee on Childhood Lead Poisoning Prevention for more information (CDC, 2012a; CDC, 2012b).

Public Water Supply

Public water supplies serving homes near the FMO site have not exceeded the Safe Drinking Water Act standards for lead and arsenic and are considered safe to drink. The public water supply for the area includes five wells plus an interconnection with the Northampton Borough Municipal Authority system, which draws water from the Lehigh River and the Spring Mill Dam. A total of 1,128 customers in North Whitehall Township in the Orefield, Schnecksville, and Neffs villages and vicinity in northern Lehigh County utilize this public water supply. Based on the 2011 Water Quality Report for North Whitehall Township, lead and arsenic were not detected above the laboratory detection limit in the public drinking water supply (Lehigh County Authority).

USGS Lead in Groundwater Study

At the request of EPA, the United States Geological Survey (USGS) conducted an investigation in 2010 to determine the types of lead found in groundwater samples at the site. The goal of the study was to determine the type of lead isotope present in the groundwater and conclude on the potential source of the lead. EPA submitted numerous samples for analysis as part of this investigation. Samples included residential well water, sediment filters from home treatment systems, surface water, sediment, surface soil, groundwater and bed-rock cores from wells installed onsite by the EPA, and various other area sources of lead for comparison, including lead arsenate pesticide acquired from the PADEP. The study concluded that the local groundwater has an industrial lead isotope present before it enters the residences. The USGS also concluded that the lead isotope ratios in well water are not similar to lead isotope ratios in lead arsenate pesticide or naturally occurring lead sources such as bedrock. USGS hypothesizes that the lead in groundwater could potentially be a result of many regional lead sources, including the historical use of lead in gasoline, and aircraft industry, metal manufacturing and processing activities including mining, smelting and lead-acid battery production, waste disposal activities, and other potential industrial operations. However, the report concluded that at this time there is not sufficient data on the potential anthropogenic sources in the area to make a direct comparison to the residential soil and well water data (USGS, 2010).

Bioavailability of Arsenic

The bioavailability of arsenic, or the amount of arsenic actually absorbed by the body when ingested, can vary widely depending on the chemical form and type of soil. The bioavailability can ultimately affect potential dose levels. Some arsenic will pass through the digestive system without being absorbed. For example, some arsenic is bound so tightly to soil particles it is less likely to be absorbed by the lining of the intestinal tract (the gut) than is arsenic bound loosely to soil particles. If only half of the arsenic in soil is capable of passing from the gut and into someone's body, the soil arsenic is referred to as being 50 percent bioavailable. The bioavailability of arsenic in soil varies depending upon the source of arsenic (e.g., smelters, mines, pesticide application). Studies have shown soil arsenic bioavailability to range from non-bioavailable to 78% (ATSDR, 2007a).

Site-specific Bioavailability of Arsenic Study

To evaluate the relative bioavailability of arsenic in the soil at the site, EPA conducted a site-specific bioavailability study performed by the University of Missouri. The study used juvenile swine to measure the gastrointestinal absorption of arsenic from the site soil. The oral bioavailability of arsenic was assessed by comparing the absorption of the site soil to that of sodium arsenate. Groups of four swine were given oral doses of either the site soil or sodium arsenate twice a day for 14 days. Three non-treated swine served as a control. The amount of arsenic absorbed by the test animals were evaluated by measuring arsenic in urine over a 48 hour period. The ratio of excreted arsenic to dose was calculated. Next, the relative bioavailability of arsenic was determined by the ratio of excreted arsenic in the test soil by the excreted arsenic in the sodium arsenate dose. Based on the analysis, the relative bioavailability for site-specific arsenic was determined to be 53%. PADOH used the site-specific bioavailability of arsenic in soil when calculating a theoretical exposure dose, as describing in the sections below. The site-specific bioavailability of arsenic was used by EPA to develop the site-specific action level of 73 ppm (USEPA, 2010e).

Exposure Pathway Analysis

An exposure pathway is how a person comes in contact with contaminants originating from a site. A completed pathway requires that all five elements be present: 1) a source of contamination, 2) an environmental medium that transports contaminants, 3) a point of exposure, 4) a route of human exposure, and 5) a receptor population. Potential pathways, however, require that at least one of the five elements is missing, but could exist. Exposure to a contaminant could have occurred in the past, could be occurring now, or could occur in the future. An exposure pathway could be eliminated if at least one of the five elements is missing and will never be present. As an additional note, even though an exposure pathway might be complete or potentially complete, it does not necessarily mean there is a public health concern (ATSDR, 2005).

Residents living on the FMO site may come into contact with arsenic and lead contaminated soils on their property due to the historic use of pesticides. PADOH considers incidental ingestion of lead or arsenic contaminated soils to be the pathway of greatest concern. Soil ingestion could occur by: the inadvertent consumption of soil at the site or brought into the home; incidental consumption of soil particles on fruits and vegetables grown in home gardens; inhalation and subsequent ingestion of soil particles in air; mouthing objects with soil particles such as during play activities by children; or intentional ingestion (children exhibiting soil pica behavior). PADOH evaluated potential exposure to contaminants in soil by calculating estimated exposure doses from contaminants in residential yards, (i.e., potential incidental exposure to soil), as detailed in the Public Health Implications Section below. If grab sample results exceeded 73 ppm for arsenic or 400 ppm for lead, EPA provided the home owner with a raised bed containing 12 inches (in depth) of clean top soil and/or the area was excavated and backfilled with clean top soil.

Another potential exposure pathway of concern is inhalation of airborne soil outside or via indoor dust from soil that is tracked into the home. Inhalation (or breathing), is not considered to be a major pathway of exposure to site-related contaminants because most of the contaminated areas are covered with grass. PADOH believes the pathway of greatest concern at the site is potential ingestion of contaminated soil. It is also important to note that a vegetative cover (e.g., lawn) exists above the surface soil contamination at the site and would act as a buffer, limiting exposure to the contamination. Conversely, residential parcels which have areas of exposed soils with no vegetation will have an increased likelihood and frequency of exposures to contaminated soils. Potential exposure in the past, present or future to elevated lead in arsenic in site soil could include:

- Residential or public use areas of the site with unremediated soil containing elevated lead and arsenic; and,

- Vacant land, not sampled during the investigation, which could be developed into residential properties.

In addition, exposures to arsenic and lead could include ingestion exposures from drinking contaminated water and using contaminated water for cooking. For residents who have not had their well water tested and are not on bottled water, exposure to contaminated groundwater at the site could occur. The following table summarizes the completed pathways at the site:

Source	Medium	Exposure Point	Route of Exposure	Exposed Population
Contaminated groundwater at the site	Groundwater	Private well water	Ingestion	Persons in the past, present and future (wells not tested and not on bottled water) with contaminated well water
Contaminated surface soil on former orchard land	Soil	Residential soil and indoor dust	Ingestion of contaminated soil, outside or tracked into the home	Persons in the past, present and future with (unremediated) elevated levels of arsenic and lead in soil
Contaminated surface soil on former orchard land	Soil	Residential soil and indoor dust	Inhalation of airborne soil, outside or tracked into the home	Persons in the past, present and future with (unremediated) elevated levels of arsenic and lead in soil
Contaminated surface soil on former orchard land	Soil	Residential garden soil	Ingestion of contaminated soil on home grown produce	Persons in the past, present and future with (unremediated) elevated levels of arsenic and lead in garden soil

Public Health Implications

This section evaluates the estimated exposure doses, and the potential non-cancerous and cancerous health effects from exposure to site contaminants that are present above health screening values. In these evaluations, PADOH considered the frequency and duration of the estimated exposures. For cases in which a population exposed through more than one pathway, we considered the combinations of exposure routes. The presence of chemical contaminants in the environment does not always result in contact, and contact does not always result in the chemical being absorbed into the body (ATSDR, 2005).

If sampling data exceeds an existing ATSDR CV, the next step in the evaluation process is to calculate an estimated exposure dose, and compare the doses to ATSDR's MRLs, and available no-adverse-effect-levels (NOAELs) and lowest-adverse-effect-levels (LOAELs) in the literature to determine if exposure to site levels could harm people's health. A summary of MRLs, NOAELs, and LOAELs is presented in Appendix A, Table 6. The NOAEL is the highest dose (from a specific study) at which there are no statistically or biologically significant increases in frequency or severity of adverse effects observed in an animal or human study population. While some effects may be produced at this dose, they are not considered to be adverse, nor precursors to adverse effects. The LOAEL represents the lowest dose from a study that produces statistically or biologically significant increases in frequency or severity of adverse effects in an animal or human study population (ATSDR, 2005).

Arsenic

In the case of arsenic, ATSDR has developed an acute oral Minimal Risk Level (MRL) of 0.005 mg/kg/day. An MRL is a dose below which noncancerous harmful effects are not expected. The acute oral MRL was derived from a human poisoning episode that showed several transient (i.e., temporary) effects at an estimated dose of 0.05 mg/kg/day. The transient effects observed included nausea, vomiting, abdominal pain, and diarrhea. It is important to note the following about the acute oral MRL (ATSDR, 2007a):

- The acute oral MRL is 10 times below the levels thought to cause harmful effects in humans,
- The acute oral MRL is based on people being exposed to arsenic dissolved in water and not arsenic in soil,
- The acute oral MRL applies to exposures less than 2 weeks,
- The acute MRL is provisional because the harmful effect is based on a serious health effect instead of the customary less serious health effect, and
- The acute oral MRL applies to non-cancerous effects only; it is not used to determine whether people could develop cancer.

In addition, EPA has a Reference Dose (RfD) and ATSDR has a chronic MRL for inorganic arsenic of 0.0003 mg/kg/day, which is based on hyperpigmentation, keratosis, and possible vascular complications in humans (ATSDR, 2007a). The EPA RfD is an estimate (with uncertainty spanning approximately an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncancerous effects during a lifetime   The ATSDR chronic oral MRL of 0.0003 mg/kg/day for arsenic is based on a NOAEL of 0.0008 mg As/kg/day for dermal effects in a study of Taiwanese farming population exposed to arsenic in well water (USEPA, 1993; USEPA, 2007).

PADOH evaluated exposures to arsenic in drinking water and in soil for children exhibiting soil pica behavior, children (0 to 7 years), adolescents (8 to 17 years), and adults that may reside at the site. PADOH assumed an exposure frequency of 9 months a year, since the ground would be frozen and/or contact with the soil would very limited, if any, during the winter months. The estimated exposure doses calculated are then compared to established health guidelines such as the ATSDR MRL, as described above.

Child Exposure Dose

Children can be exposed to arsenic in soil by accidentally swallowing small amounts of soil that cling to their hands when they put their hands in their mouths or ingestion via contaminated drinking water. This exposure is greatest for preschool children because of their frequent hand-to-mouth activity. Preschool children, on average, swallow more soil and dust than people in any other age group. This is because some preschoolers often have close contact with soil and dust when they play, and because they tend to engage frequently in hand-to-mouth activity.

To calculate a childhood estimated exposure dose, an ingestion rate of 200 mg/day for children and 5,000 mg/day for children exhibiting soil-pica behavior was applied (USEPA, 2008). For this analysis, PADOH used the site-specific bioavailability for arsenic of 53%, (described in the Site-Specific

Bioavailability of Arsenic Study Section), the range of arsenic in soil levels from the 25 ppm to 212 ppm (the maximum concentration detected in the toddler play area), and the maximum arsenic in tap water concentration of 0.9 ppb. The results of the dose calculations are presented in Appendix A, Tables 7-8. For ingestion of tap water exposure, an ingestion value of 1 liter of water per day was used. A body weight estimate of 17 kg (37 pounds) for children was used in the dose calculations (USEPA, 2000). An estimated exposure dose for soil-pica behavior children was based on an acute scenario (e.g., 2 weeks, with exposure occurring 3 times per week). Since yard results would vary, a range of dose concentrations were calculated. Based on these assumptions the childhood exposure dose for arsenic (to both soil and tap water) is as follows:

- A child exposed to the maximum arsenic soil level (212 ppm) and the maximum arsenic in tap water level would have an exposure dose of 0.001 mg/kg/day. This level is below ATSDR's acute MRL for arsenic (0.005 mg/kg/day), but above the ATSDR chronic oral MRL of 0.0003 mg/kg/day; and,
- A child exposed to soil arsenic concentrations of 75 ppm and to the maximum arsenic in tap water level would have an exposure dose of 0.0004 mg/kg/day, which slightly exceeds ATSDR chronic oral MRL of 0.0003 mg/kg/day but is below the ATSDR acute MRL of 0.005 mg/kg/day and chronic NOAEL of 0.0008 mg/kg/day.

The chronic oral MRL (non-cancerous effects) is based on effects from arsenic ingestion including a pattern of skin changes that include hyperpigmentation and hyperkeratosis. These dermal effects have been noted in some human studies that involved daily, long-term ingestion (more than 45 years) of elevated arsenic in drinking water. Collectively, these studies indicate the dose for hyperpigmentation and hyperkeratosis is 0.014 mg/kg/day. No adverse health effects have been observed below the chronic NOAEL of 0.0008 mg/kg/day (USEPA, 1993). Therefore, PADOH would not expect that chronic exposure to arsenic would result in a dose level or body burden high enough to cause adverse health effects. In order to reduce potential exposures, EPA performed removal and remedial actions at the site continue on properties with soil arsenic levels exceeding the site-specific action levels (73 ppm). In addition, maintaining a vegetative cover in the yard, specifically where children might play, would further reduce potential exposures.

Soil –children with soil pica behavior

A young child exhibiting soil pica behavior and ingesting 5,000 mg of soil/day with the maximum arsenic in soil level (212 ppm) and maximum arsenic in tap water level would have a theoretical exposure dose of 0.0248 mg/kg/day. This level is above ATSDR's acute MRL for arsenic (0.005 mg/kg/day) and below the acute LOAEL of 0.05 mg/kg/day. The estimated dose exceeds the acute MRL for a child exhibiting soil pica behavior at yards with arsenic soil concentrations at or above 75 ppm.

For soil-pica children, acute health effects that might occur from eating arsenic-contaminated soils include nausea, stomach cramps, vomiting, diarrhea, headaches, and facial swelling especially around the eyes. Soil-pica behavior, although rare, represents a transient exposure scenario because arsenic is rapidly eliminated from the body (typically in soil-pica behavior by excessive vomiting and diarrhea). Therefore, exposure to arsenic contaminated soil could pose an acute health hazard to soil-pica children but does not represent a chronic health concern. It is important to remember that estimated dose in children can vary depending on how much soil they eat, how much arsenic crosses the gut, how much they weigh and how frequently they eat dirt. PADOH recommends that people living on the site be informed of ways to avoid potential health effects, especially for children that might eat contaminated soil.

Adult and Adolescent Dose

Adults can be exposed to arsenic in soil by ingesting small amounts of soil that cling to their hands while outdoors working, playing, and gardening as well as drinking contaminated well water. To calculate an exposure dose for adults, a soil ingestion rate of 100 mg/day for adolescents and adults, water ingestion rate of 2 liters of water per day and a body weight of 48 kg (105 pounds) for adolescents and 80 kg (176 pounds) for adults was used in the estimated dose calculations (USEPA, 2000). For this analysis, PADOH used the site-specific bioavailability for arsenic of 53%, as described in the Site-Specific Bioavailability of Arsenic Study Section and a range of arsenic soil levels from 25 ppm to the maximum arsenic soil level (212 ppm). The adult and adolescent exposure dose calculations are presented in Appendix A, Table 7. The estimated theoretical exposure doses for adults and adolescents at the site are as follows:

- Adult estimated arsenic exposure doses, from both soil and tap water ingestion at the site ranges from 0.0000724 mg/kg/day (arsenic soil level of 25 ppm and 0.9 ppb arsenic in tap water) to 0.000187 mg/kg/day (arsenic soil level of 212 ppm and 0.9 ppb arsenic in tap water), which is less than the ATSDR chronic oral MRL of 0.0003 mg/kg/day and the chronic NOAEL of 0.0008 mg/kg/day; and,
- Adolescent estimated arsenic exposure dose ranges from 0.0000582 mg/kg/day (arsenic soil level of 25 ppm and 0.9 ppb arsenic in tap water) to 0.000187 mg/kg/day (arsenic soil level of 212 ppm and 0.9 ppb arsenic in tap water), which is less than the ATSDR chronic oral MRL of 0.0003 mg/kg/day and ATSDR chronic NOAEL of 0.0008 mg/kg/day.

Therefore, PADOH would not expect exposure to arsenic in site soil and well water to cause non-cancer health effects for adults or adolescents. However, the site contains large areas of undeveloped land and residential properties that were not sampled and could potentially contain high levels of arsenic and lead in the soil. This represents a potential exposure pathway and EPA should consider collecting additional soil samples.

Cancer Effects Evaluation

For known or possible carcinogens, the EPA has developed cancer slope factors (CSF) as an estimate of a substance's potential to result in additional cancer cases in a population. The CSF is used to calculate a possible cancer risk, which is an estimate of the number of additional cancer cases that would occur if a population was exposed to a contaminant given site-specific exposure conditions. It is important to note that the estimated risk does not predict a person's actual risk of developing cancer but offers a general estimate for potential risk in an exposed population (ATSDR, 2005).

The Department of Health and Human Services (DHHS), the International Agency for Research on Cancer (IRAC), the National Toxicology Program (NTP), and the EPA has determined that inorganic arsenic is known to be a human carcinogen (a chemical that causes cancer) (ATSDR, 2007a). PADOH evaluated the potential for arsenic exposures to cause cancer by estimating an estimated excess lifetime cancer risk level, based on the estimated dose (1.5 mg/kg/day) calculated in the previous section. The estimated cancer risk is above the already established background risk of cancer, The EPA cancer risk is based on exposure over a lifetime, with an average life expectancy of 78 years. Thirty two years of exposure is assumed as it represents the 95th percentile of length of residency at one address; that is, only 5% of the people will live at the same residence for more than 32 years (USEPA, 2000) PADOH used the following equation to calculate theoretical excess cancer risk for exposure to arsenic at the site for adults (ATSDR, 2005):

Estimated Excess Cancer Risk Equation*
CR = D x CSF x EY/78 years

*Where: CR= Estimated cancer risk; D=Exposure dose (mg/kg/day);
CSF = Cancer slope factor (mg/kg/day)$^{-1}$; and EY= Exposure years

PADOH calculated the excess cancer risk from the lifetime daily exposure to a range of arsenic concentration in surface soils (25 ppm to 212 ppm), as described in the previous section, and the maximum tap water for residents (0.9 ppb) (Appendix B, Table 9). Based on these doses, the cancer risks range from 4.46E-05 or about 5 excess cancers in 100,000 exposed for a lifetime (at arsenic levels of 25 ppm) to 7.88E-05 or about 8 excess cancers in 100,000 exposed (for yards with arsenic levels at 212ppm. The estimated cancer values are low and are below EPA's target risk range (USEPAc). These low cancer risk estimates indicate that arsenic exposures at the site are not likely to cause an observable increase in cancers. In addition, since the residents are being supplied with bottled water and/or point of use filtration systems, and EPA is conducting a soil removal action, the risk is much lower for current exposures. Therefore, PADOH would not expect excess cancers in the community from exposures to arsenic in soil and drinking water.

As reported in ATSDR's Toxicological Profile for arsenic, the lowest arsenic Cancer Effect Level (CEL) for lung cancer is 0.0011 mg/kg/day, for bladder cancer is 0.0033 mg/kg/day, and for skin cancer is 0.0075 mg/kg/day (ATSDR, 2007a). The estimated lifetime arsenic exposure dose for adult residents at this site, from both soil and tap water ingestion exposures ranges from 0.0000349 mg/kg/day (arsenic soil level of 25 ppm and 0.9 ppb arsenic in tap water) to 0.000112 mg/kg/day (arsenic soil level of 180 ppm and 0.9 ppb arsenic in tap water). These exposure doses are orders of magnitude lower than the lowest CELs for arsenic, and therefore PADOH does not expect elevated cancer risk from exposure to the average levels of arsenic in soils and groundwater at the site.

Health Effects from Lead

Until recently, the CDC had established a blood lead level (BLL) of concern for case management of 10 micrograms lead per deciliter of blood (µg/dL) (CDC 2005). Recent scientific research, however, has clearly shown that blood lead levels below this value can cause serious harmful effects in children. BLL below 10 µg/dL have been shown to cause neurological, behavioral, immunological, and developmental effects in young children. Specifically, lead causes or is associated with decreases in intelligent quotient (IQ); attention deficit hyperactivity disorder (ADHD); deficits in reaction time; problems with visual-motor integration and fine motor skills; withdrawn behavior; lack of concentration; issues with sociability; decreased height; and delays in puberty, such as breast and pubic hair development, and delays in menarche (CDC 2011; CDC 2012a; CDC 2012b). On January 4, 2012, CDC's Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended that CDC adopt the 97.5 percentile BLL of children in the United States (ages 1 to 5 years old) as the reference value for designating elevated blood lead levels in children. Based on the latest National Health and Nutrition Examination Survey (NHANES) data, the 97.5% is 5 µg/dL (CDC 2012a). On June 7, 2012, the CDC released a statement indicating concurrence with the recommendations of the ACCLPP (CDC 2012b). CDC now uses the reference value to identify high-risk childhood populations and geographic areas most in need of primary prevention. Yet still, there may be an underestimation of risk for lead because there is no proven safe level of lead in the blood. Appendix B contains additional information on the health risk of childhood exposures to lead.

Childhood Blood Lead Data

PADOH collaborated with the PADOH Childhood Lead Poisoning Prevention Program (CLPPP) to obtain childhood BLL surveillance data for the community, which includes the ZIP codes of 18069 and 18078 (Appendix C). It is important to note that the evaluation of PADOH CLPPP data is based on ZIP code-level data and is not an evaluation of children living on the site. PADOH CLPPP uses an on-line disease surveillance and reporting system called the Pennsylvania National Electronic Disease Surveillance System (PA-NEDSS). A confirmed elevated BLL is defined by the Council for State & Territorial Epidemiologists (CSTE) as a child with one venous blood specimen equal to, or greater than, 10 µg/dL, or any combination of two capillary within 12 weeks of each other. It is common for quantitative test results from children tested initially by capillary method (finger stick) to be high, and subsequent confirmatory test results are lower (PADOH, 2008c). The evaluation of PADOH CLPPP data is based on ZIP code-level data and is not an evaluation of children living on the site.

PADOH reviewed the childhood BLL for a four year period (2007-2010) for ZIP codes 18069 and 18078 (Appendix B, Table 1). The data include such factors as: total lows (<10 µg/dL); total highs (≥ 10µg/dL); total children tested; percent elevated; and average BLL. For comparison purposes, PADOH compared the data against the overall Lehigh County data, and Commonwealth BLL data (all 67 counties). The BLL data for the community shows that of the 139 children tested for BLL in 2007-2010, there were no children in ZIP codes 18069 and 18078 with BLL's at or above 10 µg/dL. In comparison, Lehigh County, during the same time frame, had a % confirmed elevated BLL that ranged from 1.22% in 2010 (22 elevated in 3,592 children tested) to 1.48% in 2009 (59 elevated in 3981 children tested). For the Commonwealth as a whole, confirmed elevated BLLs ranged from 1.72% (2010) to 2.17% (2010). (Appendix B, Table 2) The 2007-2010 average childhood BLL in the two-ZIP code area(3.44µg/dL) was slightly higher than childhood BLL observed Commonwealth wide (2.88 µg/dL) and Lehigh County (2.98 µg/dL) during the same time period. The highest annual mean BLL in the two ZIP code area was 4.33 µg/dL (ZIP code 18078), occurring in 2008 compared to 2.9 µg/dL and 3.1 µg/dL throughout the Commonwealth and Lehigh County, respectively.

To determine if there was a statistical difference between the mean BLLs in the two ZIP codes and the mean values of the Commonwealth and Lehigh County, PADOH performed a t-test on the data. (Appendix B, Table 3) The two-tailed p- values from the t-test were 0.0614 and 0.8026, for the Commonwealth and Lehigh County, respectively. Using a 95% confidence interval, this difference is considered to be not statistically significant since p-values were greater than 0.05. Therefore, it can be concluded that the mean BLL at ZIP codes that include the site area is not statistically different than the mean BLL for the Commonwealth and Lehigh County. There can be a lot of variability at the ZIP code level and this can fluctuate from year to year. In addition, since the entire ZIP code was used, this does not evaluate BLL specifically at the FMO site.

Child Health Considerations

PADOH recognizes that children are especially sensitive and at a greater risk than adults from exposure to hazardous substances. In communities faced with air, water, or soil contamination, the physical differences between children and adults demand special emphasis. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe or ingest dust and soil close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health (ATSDR, 2005) Residents that have young children should take precautions to not track contaminated soil into their home. PADOH's suggestions are summarized in the Recommendations section.

Some uncertainty exists in deciding whether adverse health effects might occur in children at this site. This uncertainty exists in two areas: estimating how much arsenic children are exposed to (i.e., the dose) and determining the possible health effects. The uncertainty that exists in estimating the dose for soil-pica children comes from estimating the amount of dirt that children with soil pica behavior eat, variations in how often children exhibit soil-pica behavior, and whether children eat dirt from areas of the yard with low or high levels of arsenic in soil.

Therefore, a child with soil-pica behavior who lives at a property with arsenic-contaminated soil might not get sick if that child eats soil from an area in the yard with low arsenic levels, or if that child eats only a small amount of soil. Conversely, children with soil-pica behavior might be at greater risk if they eat dirt from a part of the yard that is more heavily contaminated. Children who are exposed to inorganic arsenic may have many of the same effects as adults, including irritation of the stomach and intestines, blood vessel damage, skin changes, and reduced nerve function. Thus, all health effects observed in adults are of potential concern in children. There is also some evidence that suggests that long-term exposure to inorganic arsenic in children may result in lower IQ scores. There is some evidence that exposure to arsenic in early life (including gestation and early childhood) may increase mortality in young adults. In addition, there is some evidence that inhaled or ingested inorganic arsenic can injure pregnant women or their unborn babies, although the studies are not definitive. Arsenic can cross the placenta and has been found in fetal tissues. Arsenic is found at low levels in breast milk. In animals, exposure to organic arsenic compounds can cause low birth weight, fetal malformations, and fetal deaths (ATSDR, 2007a).

A blood lead test is the most useful screening and diagnostic test for evaluating a possible current exposure to lead. Therefore, as a prudent public health practice, blood lead tests are recommended for children seven years of age and younger (CDC, 2012a). For lead, children, especially six years of age and less are considered more vulnerable to lead poisoning than adults. The reasons for children's increased vulnerability to lead poisoning are due to the following factors: children's developing central nervous system; hand-to-mouth behavior exhibited by children increases the ingestion rate for either contaminated soil or the ingestion of lead containing dust or paint chips; children's efficiency of lead absorption from the gastrointestinal tract is greater than adults; and Iron and calcium deficiencies that are prevalent in children may enhance the absorption and increase the toxic effects of lead (ATSDR, 2007c).

Chronic exposure to low lead levels in children has been shown to cause effects on the central nervous system, which can result in deficits in intelligence, behavior, and school performance. Health effects from lead exposure in children and unborn fetuses include both physical and mental impairments, hearing difficulties, impaired neurological development, and reduced birth weights and gestational age. Some health effects from lead exposure, such as impaired academic performance and motor skills, may become irreversible and persist, even when blood lead concentrations are decreased. While there is some discrepancy in the scientific literature between the exact decreases in IQ points associated with a rise in BLL in children, the weight of scientific evidence supports the hypothesis that there is an inverse relationship. It has been hypothesized that the age of exposure, the younger being more susceptible to neurological disorders, is a factor. More research is needed to further delineate the effect of low level lead exposure; particularly on children (CDC). Several studies have observed that low lead level exposure during the developmental stages can possibly produce lifelong changes, such as loss of intelligence in younger children, including:

- Jusko, et. al found children's intellectual functioning at 6 years of age is impaired by blood lead concentrations well below 10 µg/dL. (Jusko TA, et.al, 2008).
- A study by Candfield, R.L., et al concluded that IQ declined by 7.4 points as lifetime average BLL concentrations increased from 1 to 10 µg/dL (Canfield, RL. et al, 2003).
- Lanphear, B.R. et al found environmental lead exposure in children who have blood lead levels < 7.5 µg/dL is associated with intellectual deficits (Lanphear, P. et al, 2005).

Residents that have young children should take precautions to avoid tracking in potentially contaminated soil into their home. Taking shoes of at the entryway, frequent damp mopping, and dusting can reduce exposure to lead indoors. PADOH suggests that parents monitor their children's behavior while they are playing outdoors to ensure that their children (of any age) are not exhibiting pica behavior and eating excessive amounts of soil and discuss their concerns and/or observed behaviors with their health care provider.

Gardening

Residents at the site could potentially be exposed to arsenic and lead through ingestion of contaminated soil on vegetables and fruits grown on the site or from accidentally ingesting soil while gardening. Lead and arsenic can be taken up into edible plants from the soil via the root system. However, this amount is usually small and potential exposure to soil surface deposition on unwashed fruits and vegetable is a pathway of greater concern. The amount of arsenic and lead absorbed by plants can depend on many factors including soil acidity, nutrient content, iron, organic matter, and plant type. The bioavailability of lead and arsenic in soil to plants is limited because of the strong absorption of soil to organic matter. Fruits and vegetables grown in raised beds with clean topsoil is the best way to prevent exposure to chemicals in the soil (Washington State, Department of Agriculture, 2009).

The distribution patterns of lead and arsenic among various plant parts is highly variable. Seeds and fruits typically have lower lead and arsenic concentrations than do leaves, stems or roots. Roots and tubers usually have the highest lead and arsenic concentrations, with the skin having higher lead and arsenic concentrations than does the inner flesh. The lead and arsenic content of roots correlates more closely to soil lead than does lead and arsenic in leaves or stems, possibly because roots tend to retain absorbed lead and arsenic and not transport it higher up into the plant. Tree fruits such as apples and apricots contain very low lead and arsenic concentrations.

Although data are not available for lead and arsenic concentration in garden produce at the site, PADOH believes if produce are cleaned properly, the exposure to lead and arsenic through eating homegrown produce is very minimal. Residents on the site should consider using raised garden beds with clean soil. Concentrations of lead and arsenic in soil may be 10 to 1000 times greater than their concentrations in plants growing on that soil. Because of this, failure to remove soil particles that adhere or become trapped on the outside surfaces of garden crops can substantially increase dietary lead and arsenic obtained by eating garden plants. Home gardeners can control the amount of their exposure to soil lead and arsenic by adopting different land use and personal hygiene practices including (Washington State University, 1999):

- Wash garden crops to remove soil particles. This will reduce the lead and arsenic content of the crops and the transport of soil lead and arsenic into the home.

- Remove and discard the skin from root and tuber crops (such as potatoes, carrots and radishes). Do not compost unused plant skins and peelings for later use in the garden.

- Build containers or raised beds with 12 inches of clean dirt.

- Wash soil particles from gardening tools and supplies outside after each use and store tools outside the home.

- Remove gardening footwear before entering the house, to reduce the potential of tracking contaminants into the home.

Chemical Mixtures

In general, humans are exposed to low levels of chemical mixtures by a variety of routes and for varying lengths of time. The potential health impact of multiple contaminants can be of particular concern in many cases because of the combined action of chemicals (e.g., additive, antagonistic, and synergistic effects). For the chemicals found at this site, however, information is limited in order to quantitatively evaluate toxic interaction by using a weight-of-evidence approach to evaluate influence of interactions in the overall toxicity of the mixture (ATSDR, 2004).

ATSDR has released a report that evaluates the possibility of interactive effects from exposure to several metals, including arsenic and lead. This report is called the Interaction Profile for Arsenic, Cadmium, Chromium and Lead (ATSDR, 2004). The report concludes that if the combined exposure to arsenic and lead are high enough, evidence suggests that there might be a greater potential for causing neurological effects than exposure to arsenic or lead alone. There are potential points of interaction or additivity for arsenic and lead for hematological effects, but the direction is not clear, and might be predicted to be additive or greater than additive. A study by Marlowe and Moon in children suggests that exposure to lead increases scores for maladaptive classroom behavior, such that higher scores were observed for children with lead and arsenic exposure. In addition, the study suggests that exposure to arsenic decreases reading and spelling performance and is further decreased in children with arsenic and lead exposure. Several factors need to be considered when understanding the conclusions from the Marlowe and Moon study. Because of the limited number of studies in humans it should be emphasized that the conclusion about possible interactive effects between arsenic and lead is only suggestive and not definite. In addition, this study used the level of arsenic and lead in children's hair as an indicator exposure. Hair levels may indicate contact with a chemical rather than ingestion of a chemical. For instance, children might come into contact with lead and arsenic in dirt. The lead and arsenic can be transferred directly to the hair from dirt without actually exposing the child. Therefore, hair levels may not indicate actual intake of lead or arsenic (ATSDR, 2004)

When conducting human studies, scientists know to take into account certain variables that might affect a child's performance. For instance, Marlowe and Moon controlled for variables such as the parents' age at their child's birth, parents' occupation and education, father's social class, father's presence in the home, child's birth weight, and child's length of hospitalization. The authors, however, did not control for the child's care-giving environment and the child's nutritional status. Not controlling for these two important variables casts some doubt on the conclusions. For these reasons, the conclusion about possible interactive effects between arsenic and lead are suggestive. Another drawback also exists when trying to use the conclusions about possible adverse effects based on hair levels. Although toxicological effects associated with site-related contamination were evaluated individually, the cumulative or synergistic effects of mixtures of contaminants may increase their public health impact. This depends upon the specific contaminant, its pharmacokinetics, and toxicity in the receptor population (ATSDR, 2004). There is not conclusive information in the scientific literature on the interactions of arsenic and lead in the body. Given this information, it is challenging for PADOH to conclude about any potential interactions on the site.

Conclusions

PADOH reviewed the environmental sampling data collected in the community and available blood lead surveillance data. Based on this review, PADOH concludes the following for the FMO site:

Ingestion of arsenic in soil:

- Children with pica behavior and living in homes with residential soil levels of arsenic above 75 ppm could receive a dose of arsenic that may result in acute health effects such as excessive vomiting and diarrhea. The estimated arsenic dose for children exhibiting soil-pica behavior at yards with arsenic levels above 75 ppm exceeded the ATSDR acute MRL. Soil-pica behavior is rare and represents an acute transient exposure scenario, because arsenic is rapidly eliminated from the body within 2 weeks.

- Exposure to arsenic in residential soils is not expected to harm the health of adolescents and adults at the site as well as children that do not have pica behavior. Estimated doses were below levels that have been shown to cause harmful health effects.

- Based on the estimated dose calculations, exposure to arsenic at the site is not expected to cause an observable increase in cancer.

Ingestion of lead in soil:

- Exposure to lead in soil and drinking water may harm the health of children, as current science indicates there is no safe level of lead. This could result in childhood blood lead levels exceeding new CDC reference value of 5 µg/dL for children. There may be homes on the site that still have low levles of lead in soil. Although exposure to lead in soil are not expected to harm adults on the site, pregnant women exposed to lead soil at properties not remediated could result in elevated fetal blood lead levels, greater than or equal to the CDC reference value of 5 µg/dL. Lead is particularly harmful to the developing fetus. Currently there is no safe level of lead.

Blood lead data:

- PADOH reviewed the limited available child blood lead surveillance data and did not detect a statistically significant difference between mean blood lead levels for children in the community (i.e., of ZIP codes located in the site boundary) and mean blood lead levels for children tested throughout the Commonwealth of Pennsylvania and Lehigh County, during the same time frame. The ZIP code data include more people than those living on the site.

Future exposure to undeveloped areas:

- PADOH cannot conclude whether exposure to contaminated soil in undeveloped or public use areas could harm people's health because these areas were not sampled during this investigation. EPA should consider collecting additional soil samples for lead and arsenic in the undeveloped areas that have not yet been sampled.

Private well water:

- PADOH evaluated the limited number of tap water samples collected at the site. For homes currently receiving bottle water and/or water filter, as long as the residential tap water filters are properly maintained and/or bottled water is used as the drinking water source, exposures to lead and arsenic in well water is not expected to harm people's health.
- PADOH are unable to assess past exposures or current exposures from wells that have yet to be tested.

Recommendations

PADOH recommends the following actions be taken for the FMO site:

1. **Test for lead in the body.** Parents who have children less than seven years of age should have their blood tested for lead, especially if they live near the site , have known lead in their soil detected during EPA sampling, and/or live in older homes that may have lead paint and follow recommendations from their health care provider. Parents should re-test children if they've previously had them tested to see if they fall within the new guidelines of an elevated blood lead level. If levels are elevated, follow instructions from your health care provider and reduce levels of lead in your environment. Parents should periodically re-test children to make sure lead levels don't go up. PADOH will work with the health care providers serving the community and pursue more blood lead screening opportunities for children living at the site.

2. **Reduce exposure to any lead in residential soil.** Eliminate exposures to lead-contaminated soil or reduce exposure as low as feasible. Parents can reduce exposure to lead in soil by covering bare soil with vegetation (grass, mulch, etc.) to avoid contact or even adding a layer of clean soil over existing soil. Creating a raised bed and filling with clean soil for gardening would reduce exposures from gardening and digging. Create safe play areas for children with appropriate and clean ground covers. Consider sand boxes for children that like to dig. Watch children to identify any excessive hand-to-mouth behavior or intentionally eating dirt – these behaviors should be modified or eliminated. Keep children's hands clean by washing periodically, before coming inside, and before eating. Change and launder any dirty clothes after playing outside. Remove shoes before going in the house. Rinse produce well to remove garden soil.

3. **Reduce exposure to lead in private well water.** If lead has been found in your private well water, use and maintain appropriate filters for reducing lead, or obtain alternate water for drinking (it is safe to use the water for bathing and washing). Have your well tested at least annually, including a post-filter sample to ensure filters are working. If your well has not been tested, have it tested at least annually – this is good public health practice for all private well owners. Wells can be flushed out periodically to remove any accumulation of lead sediment deposits.

4. Residents should periodically flush out, or install a sediment filter, on their well water holding tank and/or follow proper maintenance procedures to ensure lead is not present in their tap water. Periodically draining or flushing the storage tank removes minerals and sediments. Residents should consult the owner's manual or contact the manufacturer for the appropriate steps.

5. Undeveloped lots should be sampled for arsenic and lead and remediated if necessary before property transfers or development occurs.

Best Public Health Practices

1. **Reduce exposures during gardening activities.** Although there is some evidence that vegetables and fruits may take up small amounts of arsenic into their roots or leaves, this amount is likely very minimal and soil particles deposited on the surface of produce is a pathway of greater concern. Therefore, residents who garden should:
    a. Use a raised soil beds for gardening, with 12 inches deep of clean soil.
    b. Wash garden vegetables and fruits carefully to remove all soil particles before eating.
    c. Remove gardening footwear before entering the home to reduce the potential of tracking contaminated soil indoors.

2. **Reduce exposures from children playing in soil or tracking in soil to the home.** Parents can reduce potential exposure to lead in soil by:
    a. Covering bare soil with vegetation (grass, mulch, etc.) to avoid contact or even adding a layer of clean soil over existing soil. Consider sand boxes for children that like to dig.
    b. Watch children to identify any excessive hand-to-mouth behavior or intentionally eating dirt – these behaviors should be modified or eliminated.
    c. Avoid tracking soil into the house on shoes, clothing and by household pets. Ask family members to remove their shoes by the door, and frequently bathe your pets as they could also track contaminated soil into your home.
    d. Regularly conduct damp mopping and damp dusting of surfaces. Dry sweeping and dusting could increase the amount of lead-contaminated dust in the air.
    e. Keep children's hands clean by washing periodically, before coming inside, and before eating. Change and launder any dirty clothes after playing outside.

3. **Reduce exposure to lead from other possible sources.** Lead exposure can occur via multiple pathways, including soil, water lead paint, and toys. Homes built before 1978 may have lead-based paint, which can pose a problem if it starts to chip or peel, or if renovation work is done in the house. Lead has been found in some toys and other consumer products. PADOH will continue to educate the community about avoiding sources of lead exposure. For additional information on lead hazards and screening in Pennsylvania, visit childhood lead poisoning prevention program website:
http://www.portal.state.pa.us/portal/server.pt?open=514&objID=558056&mode=2 .

4. **Homeowners with private drinking water wells**. While there is no state requirement to have your private well tested, PADOH as a prudent public health measure, recommend all homeowners with private wells, regardless if they are located on the site or not, have their well water tested periodically for contaminants, including lead. Regular testing can be helpful for

monitoring the effectiveness of a home water treatment unit as well as detecting potential contamination.

a. For additional information on private water wells and testing:
   - For general information on private wells, visit the PADEP website- http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/SrceProt/well/default.htm
   - The Penn State Extension Program offers well water testing for lead, which costs $25. You may contact the Lehigh County Extension Office for further information at 610-391-9840 or visit the Penn State Extension lab testing website - http://www.aasl.psu.edu/Water_drinking_main.html

b. For residents living on the FMO site with a private drinking well that has not been sampled:
   - PADOH recommends that EPA or the homeowners consider collecting tap water samples at these homes, especially for lead.
   - Use bottled water for cooking, drinking, and baby-formula preparation until well water test results are available.

c. For residents with tap water results for lead above 11 ppb:
   - EPA or the home owner should consider sampling, or resampling, well water at the tap for contaminates, especially for lead. A tap water sample will help determine the amount of lead, if any, that is being ingested and/or the effectiveness of the water treatment system, if any.
   - If indicated, maintain and service point-of-use filters, in accordance with recommendations from EPA.
   - Residents can continue to safely use their well water for other household uses such as bathing, showering, and washing clothes and dishes.
   - Boiling water will not reduce concentrations of lead or arsenic and should not be done. Filtration of water is the best means for reducing levels of contaminants.

Public Health Action Plan

The public health action plan for the site contains a description of actions that have been or will be taken by PADOH. The purpose of the public health action plan is to ensure that this health consultation both identifies public health hazards and provides a plan of action designed to mitigate and prevent harmful human health effects resulting from exposure to hazardous substances.

Public health actions that have been taken include:

In 2008, PADOH completed factsheets, for both residents and health care providers that specifically addressing lead exposure in drinking water and necessary precautions to reduce potential exposures.

In 2008-2010, after residential well water sampling, EPA provided residents on the site with lead in well water greater than 11 ppb bottled water and/or point-of-use filtration systems.

In 2008-2011, PADOH, along with PADEP and EPA, discussed concerns related to the site with the local community.

In 2009, ATSDR produced a health consultation for the site, based on the limited Phase 1 soil sampling results.

In 2010, PADOH, along with staff from EPA Region 3, conducted a visit of the site and the surrounding community.

Beginning in 2010, EPA undertook removal activities at the site which include removing contaminated soil and providing homeowners with a raised bed containing 12 inches (in depth) of clean top soil and/or the area was excavated and clean top soil applied.

In 2011, PADOH, as part of this HC, reviewed the residential soil and water data collected at the site and available childhood blood lead surveillance data for the ZIP codes that include the site.

Public health action that currently or will be implemented:

PADOH will:

- Provide education and outreach to the community, especially for residential properties with elevated lead and arsenic where children reside;

- Work with the health care providers serving the community to increase blood lead screening for children living at the site;

- Remain available to discuss any public health questions or concerns related to the site with community members and local authorities; provide and discuss this HC with community members;

- Attend meetings with the community, as well as state and local government agencies; and

- Review additional environmental sampling data and community blood lead data, upon request.

References

ATSDR (2004). Interaction Profile for Arsenic, Cadmium, Chromium and Lead. May 2004. http://www.atsdr.cdc.gov/interactionprofiles/ip04.html

ATSDR (2005). Public Health Assessment Guidance Manual. 2005 http://www.atsdr.cdc.gov/HAC/PHAmanual/toc.html

ATSDR (2007a). Toxicological Profile for Arsenic. August 2007 http://www.atsdr.cdc.gov/ToxProfiles/TP.asp?id=22&tid=3

ATSDR (2007b). Toxicological Profile for Lead. August 2007. http://www.atsdr.cdc.gov/ToxProfiles/TP.asp?id=96&tid=22

ATSDR (2009). Record of Activity Health Consultation, Former Mohr Orchard. Schnecksville, Lehigh County, Pennsylvania. June 2009. http://www.epaosc.org/sites/4324/files/random%20study%20health%20consult.pdf

Canfield, RL. Et al (2003). Intellectual Impairment in Children with Blood Lead Concentrations below 10 µg per Deciliter. New England Journal of Medicine. 348:1517-1526. April 17, 2003 http://www.nejm.org/doi/full/10.1056/NEJMoa022848

CDC. Childhood Lead Poisoning Prevention Program http://www.cdc.gov/nceh/lead/about/program.htm

CDC (1991). Preventing lead poisoning in young children. Atlanta, GA: US Department of Health and Human Services, PHS, Centers for Disease Control and Prevention. (http://www.cdc.gov/nceh/lead/publications/books/plpyc/contents.htm

CDC (2005). Preventing Lead Poisoning in Young Children (5th Revision). Atlanta: U.S. Department of Health and Human Services.

CDC (2011). Lead (web page). Accessed online November 22, 2011: http://www.cdc.gov/nceh/lead.

CDC (2012a). Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention: Report of the Advisory Committee on Childhood Lead Poisoning Prevention, Centers for Disease Control and Prevention. U.S. Department of Health and Human Services, January. Available at: http://www.cdc.gov/nceh/lead/acclpp/final_document_010412.pdf

CDC (2012b). CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in "Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention". Centers for Disease Control and Prevention, June 7, 2012. Available at: http://www.cdc.gov/nceh/lead/ACCLPP/CDC_Response_Lead_Exposure_Recs.pdf

Jusko TA, et.al (2008). Blood lead concentrations < 10 µg/dL and child intelligence at 6 years of age. Environ Health Perspect. Feb 2008; 116(2):243-8. http://ehp03.niehs.nih.gov/article/fetchAticle.action?articleURI=info:doi/10.1289/ehp.10424

Lanphear, P. et al. (2005). Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis. Environ Health Perspective 113(7): 2005 http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.7688

Lehigh County Authority. North Whitehall Division. http://www.lehighcountyauthority.org/index.cfm?pag=49

PADOH (2008a). Lead in Drinking Water at Homes Located on the Former Mohr Orchard, Lehigh County factsheet: Health Professional Update. December 2008 http://www.epaosc.org/sites/4324/files/mohrhpfactsheet120308b.pdf

PADOH (2008b). Community Factsheet on Residential Well Water Recommendations at the Former Mohr Orchard Site. North Whitehall Township, Lehigh County, Pennsylvania. December 2008. http://www.epaosc.org/sites/4324/files/mohr%20orchard%20community%20fact%20sheet%20final.pdf

PADOH (2008c). Childhood Lead Surveillance Program, Annual Report. 2008. http://www.dsf.health.state.pa.us/health/lib/health/familyhealth/2008_lead_surveillance_annual_report.pdf

USEPAa. Drinking Water Standards. http://water.epa.gov/drink/contaminants/index.cfm

USEPAb. Basic Information about Lead in Drinking Water. http://water.epa.gov/drink/contaminants/basicinformation/lead.cfm#What%20are%20EPA%E2%80%99s%20drinking%20water%20regulations%20for%20lead?

USEPAc. Risk Characterization Guidance, Region 8 www.epa.gov/region8/r8risk/hh_risk.html

USEPA (1993). Integrated Risk Information System, Arsenic. February 1993. http://www.epa.gov/IRIS/subst/0278.htm

EPA (1994). Guidance Manual for Integrated Exposure Uptake Biokinetic Model for Lead in Children. 1994. http://www.epa.gov/superfund/lead/products/toc.pdf

USEPA (2000). Exposure Factors Handbook. 2000. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=20563

USEPA (2003a). America's Children and the Environment. Measures of Contaminants, Body Burdens, and Illnesses http://www.epa.gov/ace/publications/ace_2003.pdf

USEPA (2003b). Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. http://www.epa.gov/superfund/lead/products/adultpb.pdf

USEPA (2004). Integrated Risk Information System, Lead. July 2004. http://www.epa.gov/iris/subst/0277.htm#reforal

USEPA (2007). Technology Transfer Network, Arsenic Compounds. November 2007. http://www.epa.gov/ttn/atw/hlthef/arsenic.html#ref1

USEPA (2008). Child-specific Exposures Handbook. 2008
http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=199243

USEPA (2009a). Action Memo, Removal Actions at the Former Mohr Orchard Site. September 2009
http://www.epaosc.org/sites/6358/files/FMOSoil%20Action%20Memo%20Sept%201_2010.PDF

USEPA (2009b). Action Memo Regarding Removal Response Action at the Former Mohr Orchard Site. October 2009
http://www.epaosc.org/sites/4324/files/12%20Month%20Exemption_Oct_23Final.Pdf

USEPA (2010a). Phase II Soil Assessment at the Former Mohr Orchard Site. North Whitehall Township, Pennsylvania. June 2010
http://www.epaosc.org/sites/6358/files/DTN1022%20Former%20Mohr%20Orchard%20Phase%20II%20Soil%20Assessment.pdf

USEPA (2010b). EPA Region 3 Fact sheet for Former Mohr Orchard, Lehigh County, Pennsylvania. July 2010. http://www.epaosc.org/sites/4324/files/7-7-10%20mohrFS2010.pdf

USEPA (2010c). Residential Lead Hazard Standards – Toxic Substances Control Act. November 2010. http://epa.gov/lead/pubs/leadhaz.htm \

USEPA (2010d). Trip Report for the Former Mohr Orchard: Groundwater Site Removal Site Evaluation. June 2010. http://loggerhead.epa.gov/arweb/public/pdf/2108574.pdf

USEPA (2010e). Letter to PADEP regarding Former Mohr Orchard Removal Assessment. January 2010 http://www.epaosc.org/sites/6358/files/PADEP%20Letter.pdf

USEPA (2010e). Integrated Exposure Uptake Biokinetic Model for Lead in Children. 2010.
http://www.epa.gov/superfund/lead/products.htm#ieubk

USEPA (2011). Pollution Report, Former Mohr Orchard site. Orefield, PA. May 9, 2011
http://www.epaosc.org/site/sitrep_profile.aspx?site_id=6358&counter=15277

USGS (2010). Sources of Lead Contamination in Well Water and Soils, Former Mohr Orchard, North Whitehall Township, Lehigh County, Pennsylvania. 2010

Washington State Department of Agriculture (2009). News Release: Group Working to Prevent Crop Planting in High Lead Soil. January 29, 1999

Washington State University (1999), Cooperative Extension. Gardening on Lead and Arsenic Contaminated Soil. October 1999. http://cru.cahe.wsu.edu/cepublications/eb1884/eb1884.pdf

Report Preparation

This Health Consultation for the Former Mohr Orchard Site was prepared by the Pennsylvania Department of Health (PADOH) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented. ATSDR's approval of this document has been captured in an electronic database, and the approving agency reviewers are listed below.

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Appendix A: Figures and Tables

Figure 1 – Site map and overview for the Former Mohr Orchard site.

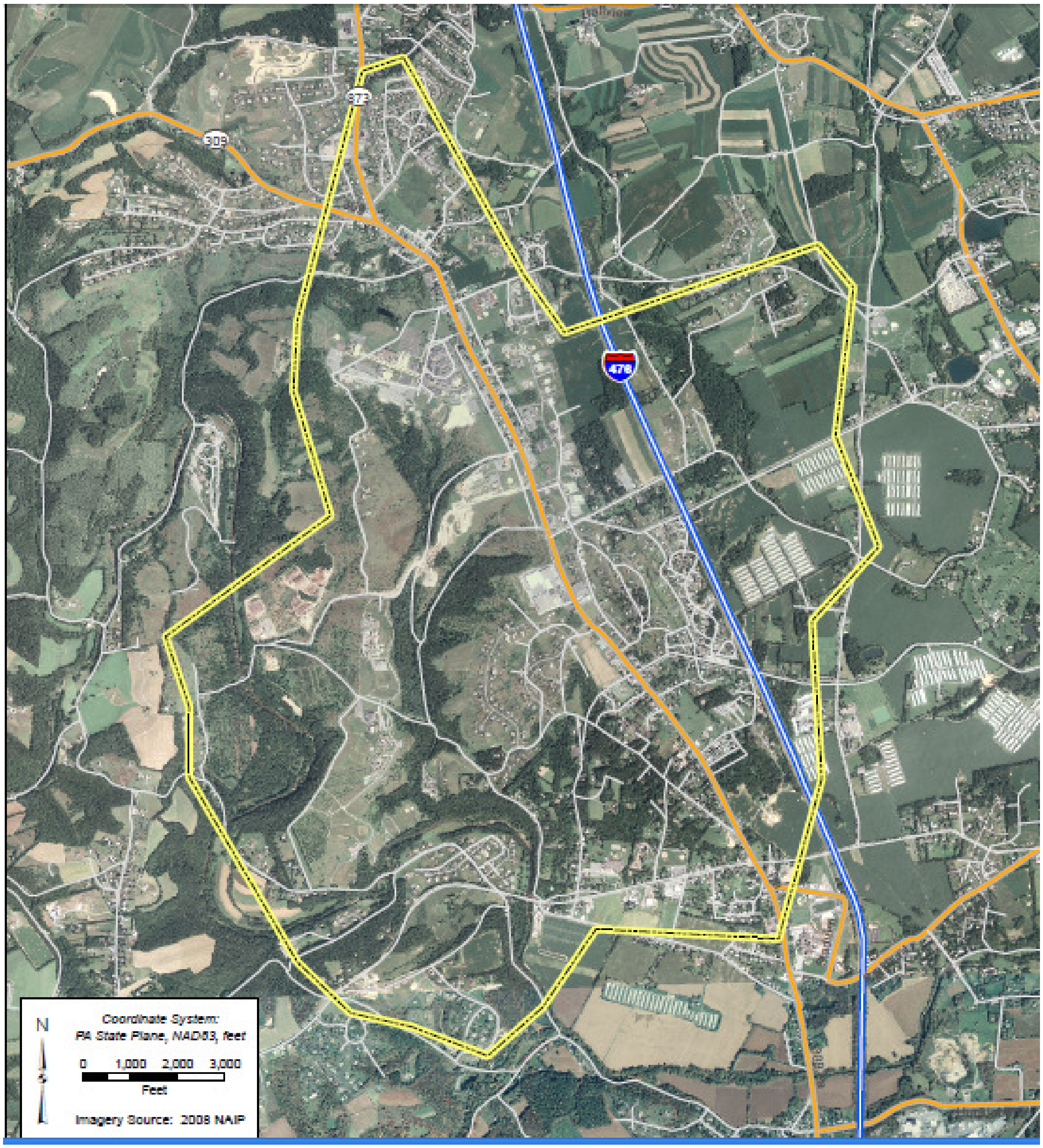


Figure 2 – Soil background sampling locations for lead and arsenic, performed by EPA, at the former Mohr Orchards site.

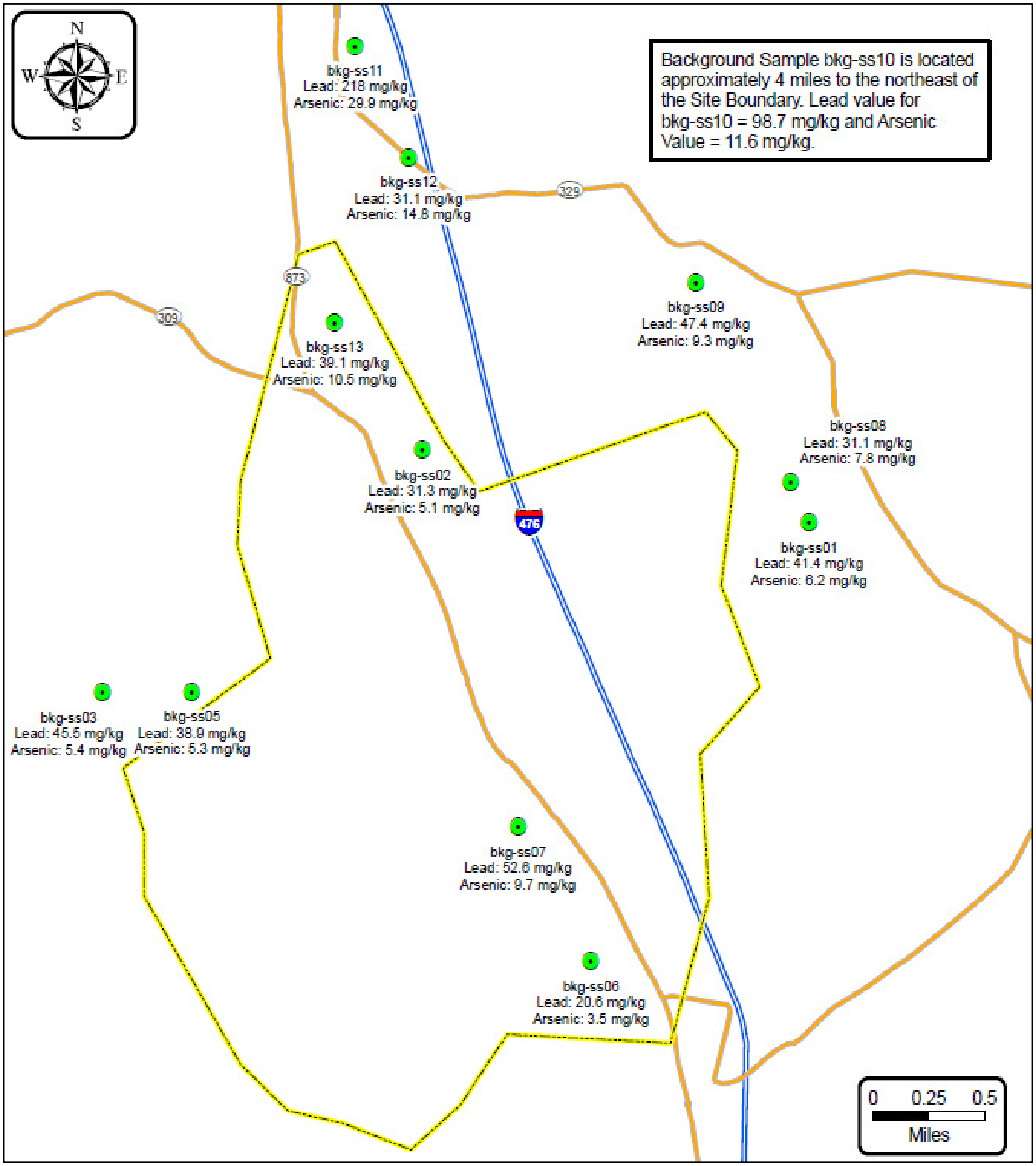


Figure 3- 2009 Phase 2 biased residential soil sampling locations at the Former Mohr Orchard site.

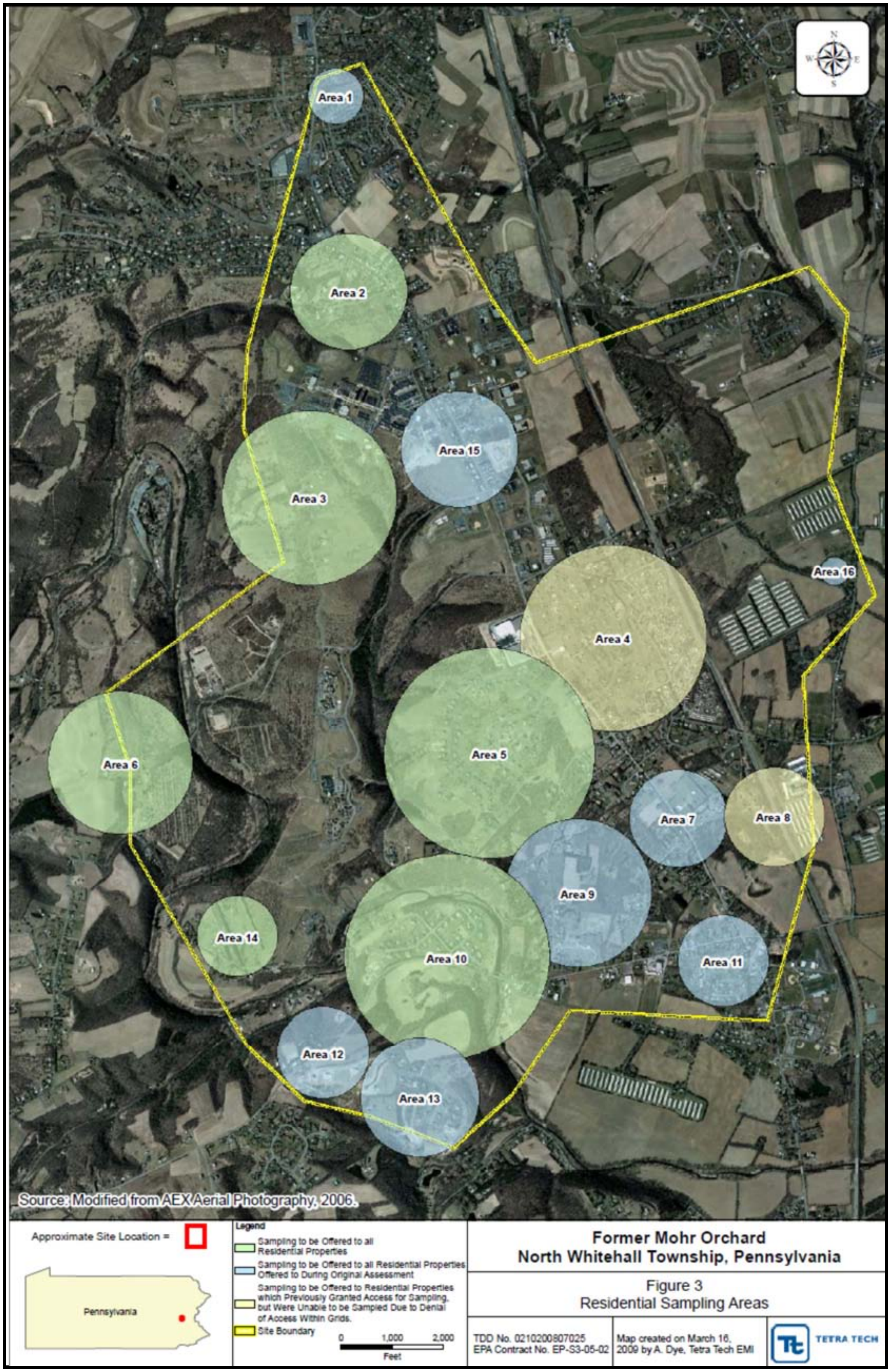


Figure 4 – 2009 surface water and sediment sampling locations at the Former Mohr Orchard site.

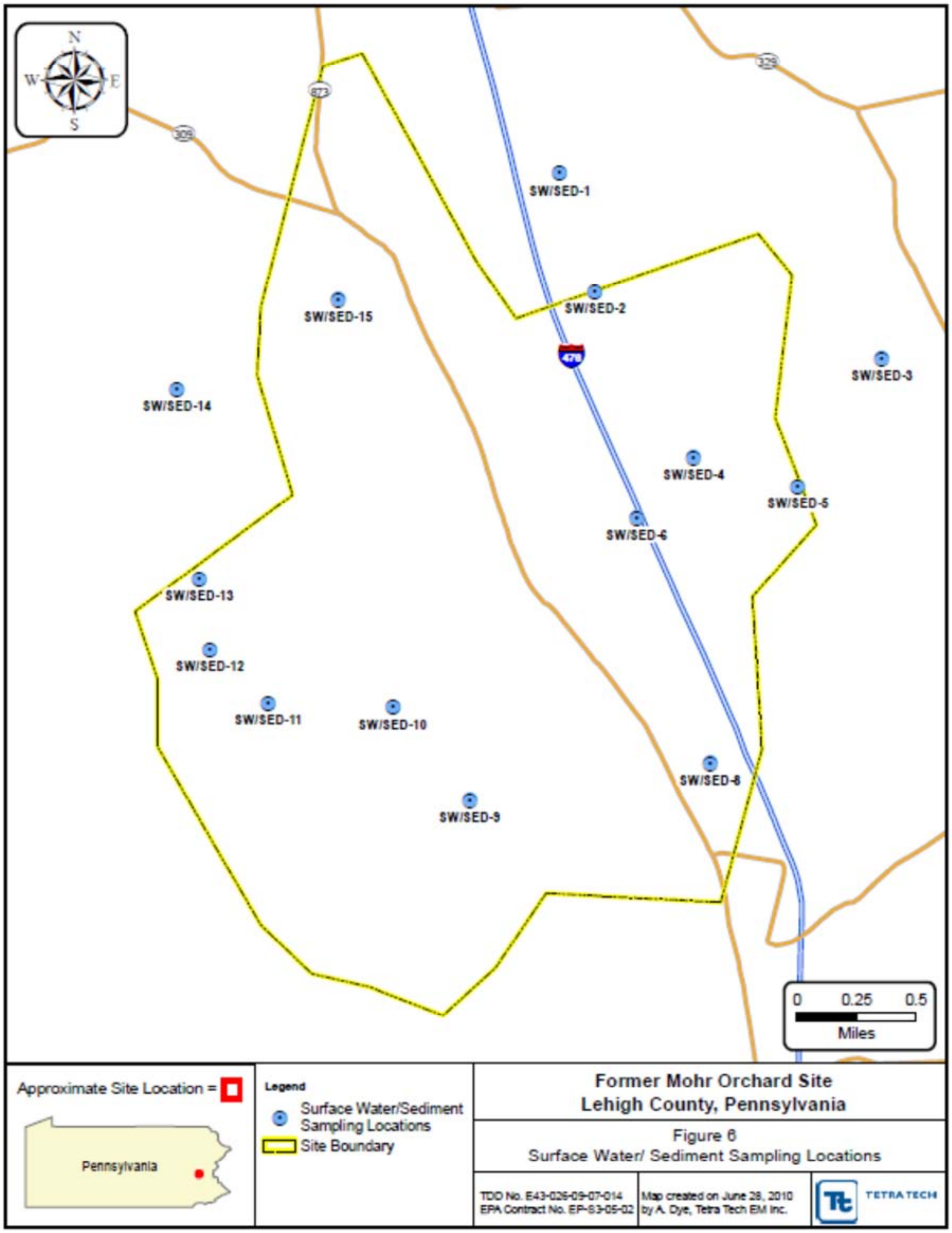


Table 1- 2009 Residential (0-3") soil samples results (ppm)* collected on the Former Mohr Orchard site analyzed for lead and arsenic.

Sampling location	Front Yard Lead	Back Yard Lead	Garden Area Lead	Toddler Play Area Lead	Front Yard Arsenic	Back Yard Arsenic	Garden Area Arsenic	Toddler Play Area Arsenic
11	53.4	37.5	38	28.7	9.2 J	9.4 J	12.8 J	20.7 J
13	403.5	172.6	87.03	727.94	90.47	35.68	22.49 J	130.89
14	42.02	73.15	42.4	30.29	9.5 J	16.44 J	14.23 J	7.02 U
16	223.73 274.89	193.06 198.85	67.42	40.11	14.59 U 16.35 U	13.79 U 16.66 J	15.9 J	10.97 J
17	90.05	82.65	80.16	NS	23.43 J	27.2	24.17 J	NS
18	44.97	51.28	49.93	51.87	7.83 U	14.05 J	14.37 J	17.8 J
32	47.35	40.38	37.45	43.44	11.82 J	10.97 J	13.34 J	9.11 J
37	54.18	47.74	94.93	176.23	8.59 U	11.12 J	14.27 J	55.05
38	48.71	106.85	40.86	41.54	21.65 J	23.9 J	30.13	10.25 J
137	45.38 52.50	124.56	61.95	NS	20.12 J 21.24 J	23.63 J	22.54 J	NS
139	102.40 100.87	115.16	95.62	117.56	28.55 33.94	30.43	21.53	46.56
140	172.33	92.39	107.7	NS	46.32	22.48	17.43	NS
148	192.1	313.33 341.46	151.25	391.78	60.51	59.02 75.60	42.53	70.24
149	165.32	182.21	172.01	NS	38.43	35.19	54.03	NS
152	69.3	68.5	73	NS	7.0 J	16.9 J	16.0 J	NS
166	51.5	38.5	36.8	55.1	13.3 J	11.6 J	14.0 J	13.9 J
367	41.99	33.73	40.59	41.08	16.12 J	15.79 J	19.23 J	21.19 J
388	69.42	97.65	142.65	103.66	23.9 J	37.92	53.27	30.71
389	48.02	48.8	77.75	134.81	14.6 J	15.78 J	18.45 J	40.89
390	111.69	100.11	88.76	166.61	37.84	36.43	20.19 J	36.2
391	170.25	205.95	573.35	205.21	49.42	55.71	180.44	60.71
395	299.24	45.63	91.76	NS	61.02	17.53 J	39.88	NS
397	41.61	98.07	24.22 J	99.64	14.98 J	30.6	6.71 U	94.05
400	149.58	30.04	112.15	33.31	37.48	14.11 J	36.96	12.03 J
401	105.4	114.26	345.16	NS	31	28.73	88.52	NS
402	257.64	116.19	187.48	NS	70.08	32.22	47.6	NS
419	279.9	183.7	118.6	135.6	81.7	47	29.9	45.9
421	192.2	173.7	206.2	NS	58.4	47.4	54.7	NS
424	109.2 193.0	198.2	121.8	238.2	29.6 50.7	54.5	34.2	73.1
432	254.86	246.34	124.51	59.08	55.53	41.72	22.46 J	12.36 J
439	299.9	262.8	161.6	397.8	63	45.2	47.5	88.6
444	71	93.2	188.5	NS	20.3 J	25.9	66.7 J	NS
446	185.27	196.8	152.58	134.92	55.19	61.34	45.75	38.46
449	67.1	90.8	64.7	86.7	17.9 J	21.1 J	13.5 J	16.1 J
450	81.7	65.9 70.6	50.5	81.4	20.1 J	20.8 J 20.2 J	15.8 J	38.8
452	405.94	369.67	515.32	347.41	93.55	80.98	113.72	212.08
457	239.28	196.03 243.3	179.91	61.13	51.6	54.53 49.71	46.15	20.39 J

Sampling location	Front Yard Lead	Back Yard Lead	Garden Area Lead	Toddler Play Area Lead	Front Yard Arsenic	Back Yard Arsenic	Garden Area Arsenic	Toddler Play Area Arsenic
459	227.41 218.65	425.11	25.07	82.43	52.24 37.34	83.59	19.44 J	42.31
462	395.28	179.41	427.69	83.18	106.5	46.22	97.64	26.84
464	162.86	164.71	176.17	NS	42.02	56.35	57.55	NS
465	230.17	194.38	261.27	NS	65.35	66.7	69.06	NS
469	39.6	35	30.9	30	8.1 J	13.5 J	13.1 J	24.9 J
471	178.9	220.3	42	285.5	36.1	43.8	12.9 J	57.7
476	265.1	88.7	121.3	107.7 112.0	66.5	25.8	42.8	23.2 J 30.0
480	45.3	111.92 108.41	64.6	NS	15.54	27.46 29.05	21.69	NS
481	165.6	213.9	86.1	200.6	39.8	43.5	25.4	47.2
482	146.3	75.5 76.9	96.2	151.2	39	19.7 J 22.3 J	29.2	34.7
488	194.38	124.26	67.45	157.00 159.70	43.69	36.17	24.85 J	46.89 48.27
490	237.3 218.7	201.7	305.5	NS	48.9 45.4	46.3	57.6	NS
496	224.86	228.74	39.69	266.16	68.37	71.3	18.93 J	95.07
498	251.18	195.93	247.59 258.60	NS	84.47	65.25	71.51 71.59	NS
499	182.15	171.42	117.29	61.29	57.04	41.77	30.86	13.36 J
506	289.75 219.92	165.65 144.71	44.02	163.69	56.61 85.98	52.03 47.24	26.82	57.77
513	63.88	113.94	174.05	370.08	18.68 J	34.47	38.89	72.88
514	124.5	118.4	99.2	141	24.6 J	32.7	34.7	40.9
515	128.4 126.9	145	99.8	154.5	25.9 22.3 J	32.4	28.4	37.1
516	107.82	146.59	80.35	NS	25.92 J	28.33	23.51 J	NS
517	125.12	195.72	248.79	214.65	32.53	45.12	61.39	43.26
519	115.55	168.93	48.03	135.7	25.13	39.59	13.34	44.04
520	75.68	92.59 95.89	99.17	198.44	27.15	31.31 31.22	24.85	39.49
525	221.5	293.9	373.9	216.9	62.7	87.1	82.6	69.7
528	136.99 135.06	219.33	29.85	NS	21.57 J 28.77	46.44	8.09	NS
532	138.62	113.8	81.66	NS	42.41	36.12	30.83	NS
533	109.57	93.53	59.82	175.02	27.13	32.04	19.46	26.23
535	285.31	256.52	319.48 300.61	179.78	69.01	50.73	52.54 39.18	50.81
536	189.13	198.07	131.71	NS	52.84	65.97	38.27	NS
537	164.24	199.29	135.8	NS	37.17	53.31	35.79	NS
539	137.3	147.3 140.3	140.9	217.5 J	32.9	38.7 38.4	57.5	64.2
540	197.91	172.31	109.14	NS	59.73	46.46	25.55	NS
541	140.94	142.92 183.94	192.7	255.62	33.74	32.86 47.35	36.62	50.86
543	198.9	245.66	71.33	187.43	47.39	60.25	17.7	206.74
546	82.75	150.44	264.14	22.34	19.7	30.47	66.95	7.06 U
549	183.98	50.57 53.46	51.1	54.54	38.63	19.07 J 19.56 J	20.06	19.43

Sampling location	Front Yard Lead	Back Yard Lead	Garden Area Lead	Toddler Play Area Lead	Front Yard Arsenic	Back Yard Arsenic	Garden Area Arsenic	Toddler Play Area Arsenic
550	332.51	249.75	116.18	NS	55.18	39.08	27.65	NS
552	180.19	129.98	198.14	81.14	47.9	69.19	49.26	80.53
553	117.7	95.1	97.1	97.1	35.6	41.5	25.0 J+	60.9
578	55.2	45.7	457.3	NS	16.5 J+	12.9 J+	27.7	NS
582	54.2 52.5	51.2	57.9	NS	10.8 J+ 13.2 J+	19.2 J+	14.1 J+	NS
585	272.89	183.62	61.86	NS	32.03	20.47 J	15.12 J	NS
594	204.84	217.89	245.68	192.61	48.84	52.95	57.86	43.42
595	142.02	106.12 85.72	459.17	710.83	31.14	26.92 29.10	53.6	88.33
605	335.21 335.41	185.63 205.10	153.73	139.13	66.76 69.78	46.10 44.88	29.24	33.8
606	93.9	122.61	156.44	96.03	25.24	33.89	39.48	22.41
608	182.52	82.97 81.83	176.8	612.83	49.34	24.68 J 28.03	107.08	98.17
609	96.68	110.32 103.58	97.82	NS	30.1	24.67 J 23.66 J	28.02	NS
610	91.89	64.91 68.37	50.05	NS	27.34	23.43 J 21.90 J	17.07	NS
612	149.59	112.03	117.25	104.86	44.7	22.14	32.88	41.9
613	88.3	99.7	91.2	NS	21.2 J+	23.9 J+	32.4	NS
617	89.8	77.4 84.6	184.2	NS	20.7 J	21.7 J 18.7 J	34.4	NS
618	130.89	120.56	175.03	NS	20.9	30.24	41.12	NS
622	68.6	44.7 49.9	94.5	199	15.4 J	15.6 J 13.1 J	20.4 J	14.0 J
623	88.77	80.12	96.19	NS	20.38 J	24.02 J	21.85 J	NS
627	78.97	103.1	96.37	NS	24.0 J	28.43	27.17	NS
644	190.04	810.01	370.61	NS	28.04	54.27	17.23 J	NS
704	102.79	99.34	182.56	103.4	30.83	29.46	55.2	38.05
705	109.24	113.18	178.91	170.16	37.62	31.87	41.79	51.16
724	229.83 214.69	185.08	207.85	183.9	24.25 J 18.50 J	17.63 J	33.19	15.00 J
743	60.5	77.4 77.3	88.3	NS	15.5 J	15.1 J 20.6 J	10.9 J	NS
746	74.8	71.1	99.9 101.7	NS	13.7 J	15.1 J	11.0 J 12.3 J	NS
754	54.3 47.9	45.2	71.5	42.1	18.2 J 16.1 J	19.9 J	15.6 J	17.7 J
833	45.2	38.1	42.4	NS	13.7 J	14.9 J	17.3 J	NS
837	47.3	64.6	48	NS	13.9 J+	19.2 J	18.0 J	NS
866	108	100.3	431.8	103.5 104.4	13.9 J+	16.0 J	37.9	12.5 J+ 15.5 J
991	70.2	64.5	71.6	NS	15.3 J	25	20.5 J	NS
1037	45.01 38.16	38.45 39.52	39.89	42.98 43.59	9.31 J 14.36 J	17.47 J 13.68 J	13.38	16.12 J 15.34 J
1062	NS	201.62	326.6	NS	NS	18.27 J	33.05	NS
1096	547.04	219.69	110.1	NS	46.17	31.27	19.86	NS
1097	977.33	521.2	495.89	NS	33.26	39.66	22.2 U	NS
1198	71.39	150.71	56.88	NS	11.32 B	26.05	17.38 J	NS

Sampling location	Front Yard Lead	Back Yard Lead	Garden Area Lead	Toddler Play Area Lead	Front Yard Arsenic	Back Yard Arsenic	Garden Area Arsenic	Toddler Play Area Arsenic
1203	426.24	418.46	266.81	NS	29.73	19.25 U	15.11 U	NS
1215	84.72	95.24	104.72	NS	15.14 J	14.55 J	13.95 J	NS
1359	39.1	40.2	44.2	NS	17.5 J	18.2 J	18.8 J	NS
1444	36.3	31.6	52.3	NS	14.0 J+	16.7 J	16.3 J	NS
1495	138.01 119.64	101.83	48.31	NS	17.77 J 13.17 J	18.1 J	16.78 J	NS
1721	253.28	251.95	112.87 73.66	NS	22.74 J	17.83 J	23.06 J 20.94 J	NS
1722	161.15	120.42	133.8	NS	26.87	19.97 J	19.46 J	NS
1723	111.4 113.54	104.94	71.61	NS	21.98 J 22.56 J	15.96 J	18.34 J	NS
1737	134.75	165.03	84.46 95.44	175.57	17.53 J	17.7 J	22.85 J 10.29 U	21.14 J
1750	153	129.8	115.85	67.02	25.4	22.74 J	16.79 J	17.89 J
1826	266.44	285.23	109.91	NS	24.99 J	24.53 J	16.29 J	NS
1828	142.7	144.97	109.24	NS	24.01 J	26.53	27.53	NS
2431	43.66	62.51	52.37	NS	16.94 J	19.61 J	14.56 J	NS
2433	46.21	30.67	54.2	NS	8.71 J	11.31 J	24.55 J	NS
2434	47.94	45.69	45.1	50.53	26.33	27.36	25.88	27.46
2445	63.46	41.85 34.89	35.36	NS	12.45 J	7.35 U 10 J	10.59 J	NS
2448	41.59	39.91	44.32	NS	15.28 J	17.36 J	19.54 J	NS
2449	55.94	68.91	80.42	NS	17.97 J	21.41 J	17.75 J	NS
2459	495.95	414.96	125.96	NS	23.27 J	30.3	26.36	NS
2460	62.3	54.8	150.7 160.1	NS	11.1 J	11.6 J	9 U 10 U	NS
2461	45.97	52.91	46.3	45.79 47.57	25.88	30.22	29.68	30.53 28.37
2463	70.1	95.4	57	NS	11.8 J	13.9 J	13.9 J	NS

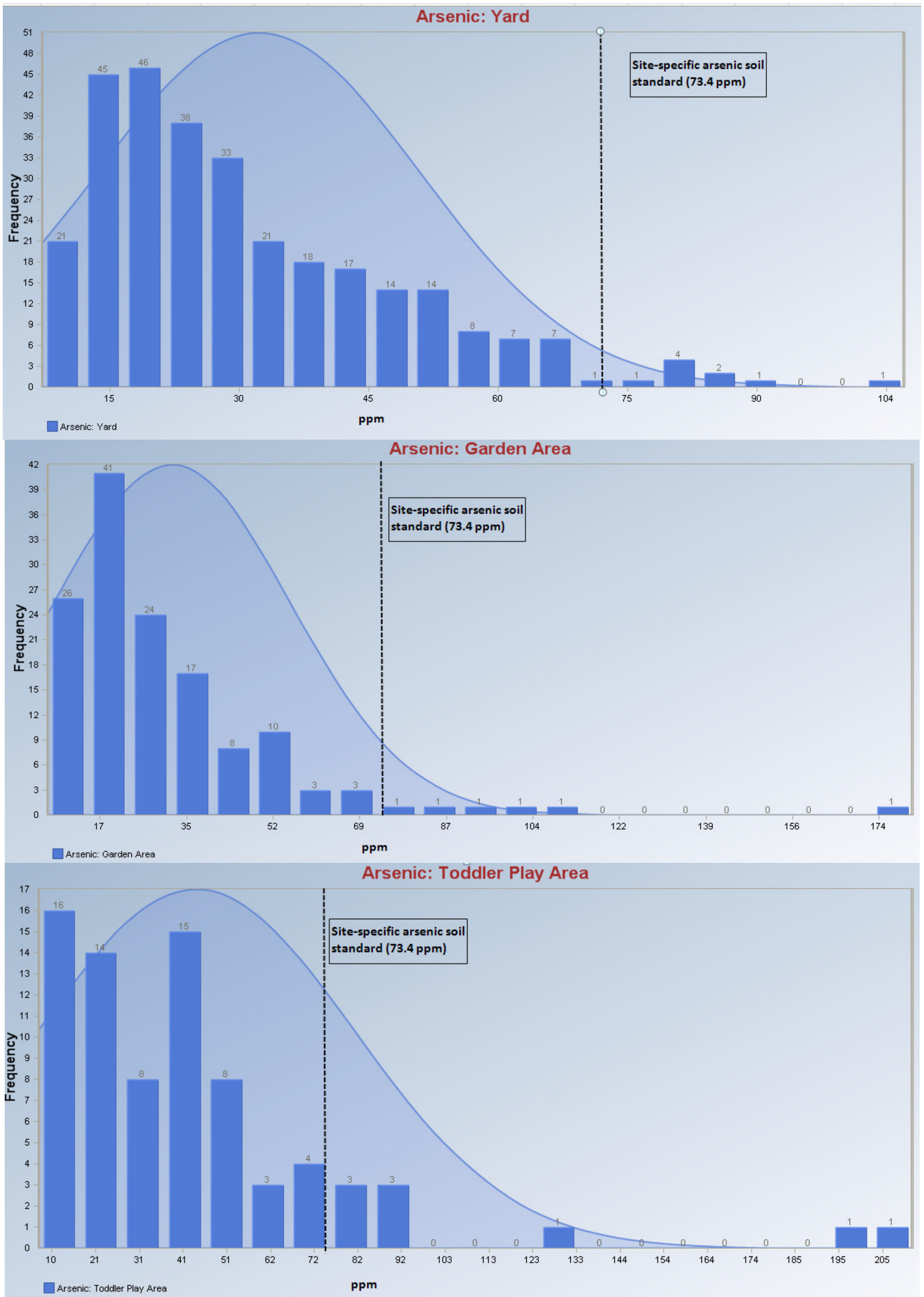
J - Analyte present. Concentration may be inaccurate or imprecise. All positive results less than 25 ppm were flagged "J" to indicate that they are estimated due to the inherent uncertainty caused by the counting error at concentrations near the detection level.
NS - Not Sampled
U - Not detected. The associated number indicates approximate sample concentration necessary to be detected.
Lead levels above 400 ppm (EPA lead in soil screening level)
Arsenic levels above 20 ppm ATSDR chronic child Environmental Media Evaluation Guide (EMEG) and recommended Comparison Value (CV))
Arsenic levels above 200 ppm ATSDR chronic adult EMEG)
*Site specific arsenic clean-up level is 73 ppm

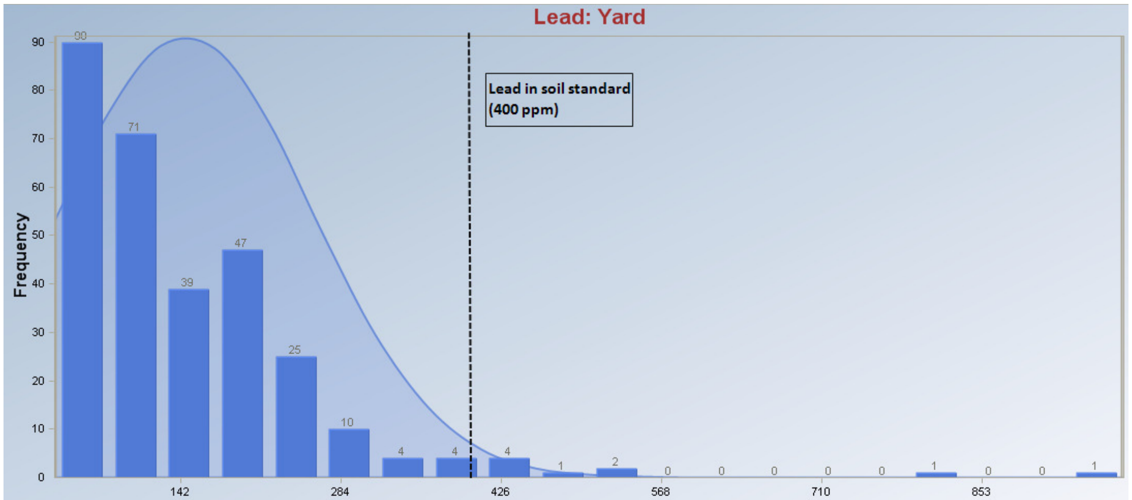
Table 2- Mean, median, minimum and maximum values for lead and arsenic residential soil levels (ppm) collected from the Former Mohr Orchard in 2009-2010┴

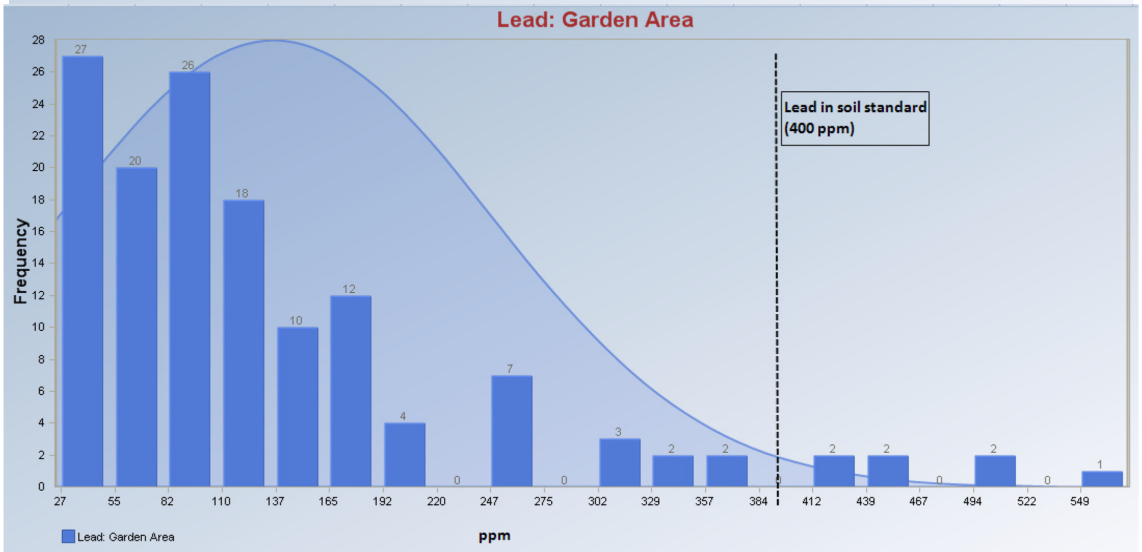
	Yard Lead	Garden Area Lead	Toddler Play Area Lead	Yard Arsenic	Garden Area Arsenic	Toddler Play Area Arsenic
Mean	174.50	152.50	180.70	34.07	34.46	50.76
Median	114.71	99.20	126.19	26.70	24.55	37.58
Minimum	30.04	24.22	22.34	7	6.71	7.02
Maximum	977.33	573.35	727.94	106.5	180.44	212.08
# Over Standard	11 (3.69 %)*	7 (5.11%)*	3 (3.95%)*	10 (3.36%)**	6 (7.89%)**	9 (6.57%)**

*Number samples exceeding the EPA screening level for lead in soil is 400 ppm
** Number samples exceeding the EPA site-specific action level for arsenic in soil is 73 ppm. However, the ATSDR CV for arsenic is 20 ppm, and therefore additional evaluation is required.
┴ Total samples collected were 298 in the yard, 137 in the garden areas and 76 in the toddler play areas.

Table 3– Frequency distribution for lead and arsenic showing sampling results over action level for arsenic and lead in soil on the former Mohr Orchard site




Lead: Yard
Frequency
Lead in soil standard
(400 ppm)
142
284
426
568
710
853


Lead: Garden Area
Frequency
Lead in soil standard
(400 ppm)
Lead: Garden Area
ppm

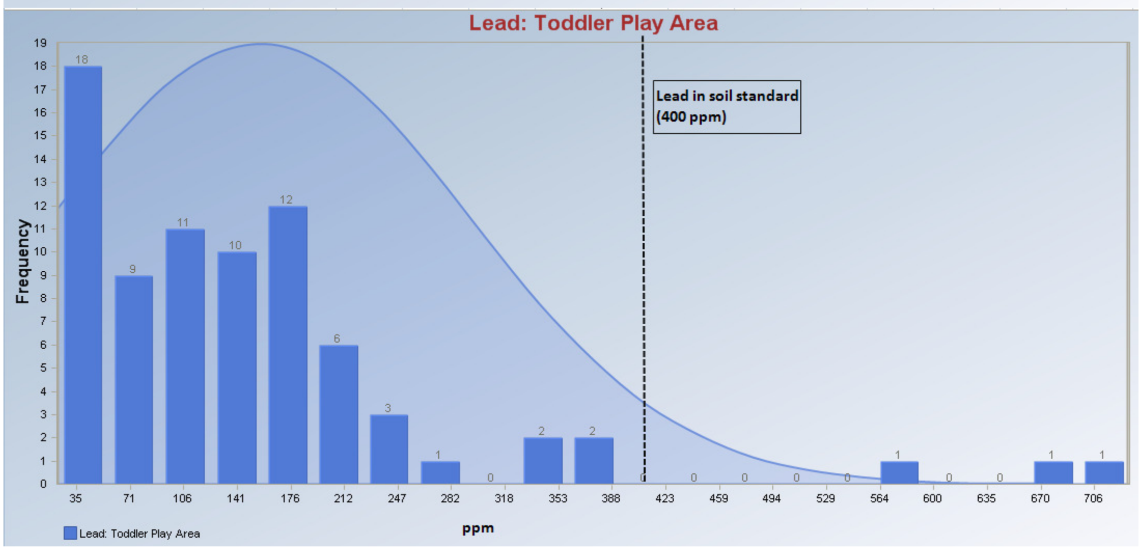

Lead: Toddler Play Area
Frequency
Lead in soil standard
(400 ppm)
Lead: Toddler Play Area
ppm

Table 4 – 2008-2009 residential water sample results collected (tap water, non-tap and holding tank/groundwater samples) for arsenic and lead on the former Mohr Orchard site.

	Arsenic (ppb)⊥	**Lead (ppb)±**
Tap water samples		
Mean	0.101	1.805
Max value	0.9	16
# Over standard/CV	8 (19.5%)	1 (2.4%)
# Samples	41	41
Non-tap/spigot samples		
Mean	0.097	6.94
Max value	1.4	95
# Over standard/CV	8 (13.2%)	5 (21%)
# Samples	38	38
Tank/groundwater samples		
Mean	0.419	56.3
Max value	9.5	1600
# Over standard/CV	160 (23%)	357 (51%)
# Samples	695	695

⊥ ATSDR Cancer Risk Evaluation Guide (CREG) CV and EPA MRL for arsenic in drinking water is 0.02 µg/L and 10 µg/L, respectively
± Site-specific intervention guideline of 11 µg/L of lead

Table 5- 2008-2009 residential tap water sampling results for arsenic and lead on the former Mohr Orchard site.

Home	Sample Location	Arsenic in Tap water (µg/L)	Arsenic in tank sample (µg/L) - if collected	Lead in Tap water (µg/L)	Lead in tank sample (µg/L) - if collected
1	First Draw - Tap	0	0.49	4.5	206
2	First Draw - Tap	0.65	1.3	0.5	604
3	First Draw - Tap	0	1.2	4.6	386
4	First Draw - Tap	0.56	1.3	16	264
5	First Draw - Tap	0	0.49	1.3	277
6	First Draw - Tap	0	0.3	0.31	239
7	First Draw - Tap	0	0.64	0.62	366
8	First Draw - Tap	0.49	3.1	0.75	398
9	First Draw - Tap	0.42	134	0.28	103
10	First Draw - Tap	0	1.2	5.6	308
11	First Draw - Tap	0	1.4	1.1	486
12	Kitchen Tap	0	NS	3.2	NS
13	Kitchen Tap	0	NS	0	NS
14	Kitchen Tap	0	NS	1.4	NS
15	Kitchen Tap	0	NS	0	NS
16	Kitchen Tap	0	NS	0	NS
17	Kitchen Tap	0	1.4	1.1	486
18	Kitchen Tap	0	NS	0	NS
19	Kitchen Tap	0	NS	0	NS
20	Kitchen Tap	0	NS	0	NS
21	Kitchen Tap	0	NS	0	NS
22	Kitchen Tap	0	NS	0	NS
23	Kitchen Tap	0	NS	0.94	NS
24	Kitchen Tap	0	NS	0	NS
25	Kitchen Tap	0.4	NS	0.65	NS
26	Kitchen Tap	0	NS	0	NS
27	Kitchen Tap	0	NS	0	NS
28	Kitchen Tap	0	NS	4.4	NS
29	Kitchen Tap	0.73	NS	0	NS
30	Kitchen Tap	0	NS	6.8	NS
31	Kitchen Tap	0	NS	0.47	NS
32	Kitchen Tap	0	NS	0	NS
33	Kitchen Tap	0	NS	0	NS
34	Kitchen Tap	0.9	NS	1.7	NS
35	Kitchen Tap	0	NS	0	NS
36	Kitchen Tap	0.3	NS	0	NS
37	Apartment sink	0	NS	2.1	NS
38	Prior to treatment, from kitchen sink	0	NS	0	NS
39	Bathroom sink in basement	0	NS	0	NS
40	Bathroom sink in basement	0	NS	0.58	NS
41	Bathroom sink in basement	0	NS	0.4	NS

NS = not sampled; 0 is below detection limit

Table 6– ATSDR Health guidelines for arsenic exposure (non-cancerous health effects), used to compare against exposure dose calculations (Ingestion pathway)

Health Guideline	Dose (mg/kg/day)
Acute MRL	5.00E-03
Acute LOAEL	5.00E-02
Chronic MRL	3.00E-04
Chronic LOAEL	1.40E-02
Chronic NOAEL	8.00E-04

Table 7 – Estimated Arsenic exposure dose calculations for children and soil pica children for the former Mohr Orchard site *

Arsenic Soil Concentration (mg/kg)	Childhood dose arsenic in soil and tap water - (mg/kg/day)	Exceeds Acute MRL	Soil Pica Childhood dose arsenic in soil and tap water (mg/kg/day)	Exceeds Acute MRL	ATSDR's Provisional Acute Oral MRL(mg/kg/day)
212	1.04E-03	No	2.48E-02	Yes	5.00E-03
150	7.54E-04	No	1.76E-02	Yes	5.00E-03
100	5.21E-04	No	1.17E-02	Yes	5.00E-03
75	4.04E-04	No	8.82E-03	Yes	5.00E-03
50	2.87E-04	No	5.90E-03	No	5.00E-03
25	1.70E-04	No	2.98E-03	No	5.00E-03

*ED soil+tap water = $\frac{C \times IR \times EF \times CF \times BF}{BW}$

Child dose (soil) = Maximum in toddler play area (212 mg/kg) x 200 mg/kg x 9 months/12 months x 1x10 -6 kg/mg x 53%/17 kg

Soil pica dose = Estimated exposure dose based on both acute (e.g., 2 weeks), assuming pica behavior 3 days per week

Soil pica dose = Maximum in toddler play area (212 mg/kg) x 5,000 mg/kg x 0.429 x 1x10 -6 kg/mg x 53%/17 kg

ED (tap water) = Maximum tap water concentration for arsenic (mg/L) x Ingestion Rate/ body weight (kg):
= (0.0009 mg/L x 1 L/day)/17 kg

Estimated Exposure Dose Equation* (D) = C × IR × EF × CF x BF/ BW

D = exposure dose, milligrams per kilogram per day (mg/kg/day); C = contaminant concentration (mg/kg); IR = ingestion (mg/day); EF = exposure frequency (unitless); BF = bioavailability factor; CF = conversion factor, 1×10^{-6} kilograms/milligram (kg/mg); BW = body weight (kg)

Table 8 – Estimated chronic arsenic exposure dose calculations for adolescents and adults* for the former Mohr Orchard site

Arsenic Soil Concentration (mg/kg)	**Childhood dose to arsenic in soil and tap water (mg/kg/day)**	**Exceeds Chronic MRL**	**Adolescent Dose to arsenic in soil and tap water (mg/kg/day)**	**Exceeds Chronic MRL**	**Adult arsenic in soil and tap water Dose (mg/kg/day)**	**Exceeds Chronic MRL**	**Chronic Oral MRL (mg/kg/day)**
212	1.04E-03	Yes	1.87E-04	No	1.28E-04	No	3.00E-04
150	7.54E-04	Yes	1.62E-04	No	1.35E-04	No	3.00E-04
100	5.21E-04	Yes	1.20E-04	No	1.10E-04	No	3.00E-04
75	4.04E-04	Yes	9.96E-05	No	9.73E-05	No	3.00E-04
50	2.87E-04	No	7.89E-05	No	8.48E-05	No	3.00E-04
25	1.70E-04	No	5.82E-05	No	7.24E-05	No	3.00E-04

* ED soil+tapwater = $\frac{C \times IR \times EF \times CF \times BF}{BW}$

ED (soil) = exposure dose (mg/kg/day); C = contaminant concentration (mg/kg); IR = intake rate (mg/day); EF = exposure factor (unitless); CF = conversion factor, 1×10^{-6} (kg/mg); BF = bioavailability factor (unitless); BW = body weight (kg)

Child dose (soil) = 212 mg/kg x 100 mg/kg x 9 months/12 months x 1x10 -6 kg/mg x 53%/17 kg
Adolescent dose (soil)= 212 mg/kg x 100 mg/kg x 9 months/12 months x 1x10 -6 kg/mg x 53%/48kg
Adult dose (soil)= 212 mg/kg x 100 mg/kg x 9 months/12 months x 1x10 -6 kg/mg x 53%/80 kg

ED (tap water) = Maximum tap water concentration for arsenic (mg/L) x Ingestion Rate/ body weight (kg):
Child dose (tap water) =(0.0009 mg/L x 1 L/day/17kg
Adolescent dose (tap water) = (0.0009 mg/L x 2 L/day)/48 kg
Adult dose (tap water) = (0.0009 mg /L x 2 L/day)/80 kg

Table 9– Estimated cancer risk calculation for exposure to arsenic in residential soil and tap water*, based on the above exposure dose calculations, for the former Mohr Orchard site

Arsenic Soil Concentration (mg/kg)	**Adult Dose -soil and tap water(mg/kg/day)**	**Lifetime adult cancer risk**
212	1.28E-04	7.88E-05
150	1.35E-04	8.31E-05
100	1.10E-04	6.77E-05
75	9.73E-05	5.99E-05
50	8.48E-05	5.22E-05
25	7.24E-05	4.46E-05

***** Based on a range of soil arsenic levels, a tap water concentration of 0.9 ppb and the following equation:

Adult estimated cancer risk = Dose (mg/kg/day) x Cancer Slope Factor $(mg/kg/day)^{1}$ x Exposure Frequency (years)

Adult estimated cancer risk = 1.28E-04 x 1.5 $(mg/kg/day)^{-1}$ x (32 years/78 years)

Appendix B: Toxicological Information

Additional Information on Lead and Arsenic

This section provides more detailed information on lead and arsenic. The majority of the information summarized below has been extracted from ATDSR's chemical-specific Toxicological Profile for lead and arsenic. For more information, please refer to the online ATSDR Toxicological Profiles at: http://www.atsdr.cdc.gov/toxprofiles/index.asp

As explained in the document, based on an evaluation of the environmental sampling data, PADOH would not expect exposure to site contaminants would harm people's health. That being said, the adverse health effects documented in the toxicological literature and summarized here are based on much higher levels than were observed at the site, often times in an occupational setting. Lastly, simply being exposed to a hazardous substance does not make it a hazard. The magnitude, frequency, timing, and duration of exposure and the toxicity characteristics of individual substances affect the degree of hazard, if any (ATSDR, 2005).

Evaluation of Non-cancer Health Hazards Associated with Lead Exposure

Exposure Assessment

Lead exposure can occur via multiple pathways (air inhalation and ingestion of water, food, soil, and dust). Therefore, exposure to lead is assessed based on total exposure through all pathways rather than site-specific exposures. However, a primary human exposure pathway to lead is through ingestion of soil and dust. Current knowledge of lead pharmacokinetics indicates that risk values derived by standard procedures would not truly indicate the potential risk, because of the difficulty in accounting for pre-existing body burdens of lead. Lead bioaccumulates in the body, primarily in the skeleton. Lead body burdens vary significantly with age, health status, nutritional state, maternal body burden during gestation and lactation, etc. For this reason, and because of the continued apparent lack of threshold, it is still inappropriate to develop reference values for lead (CDC; EPA, 2004). Therefore, estimation of exposure and risk from lead in soil also requires assumptions about the level of lead in other media, and also requires use of pharmacokinetic parameters and assumptions that are not needed traditionally. Thus, EPA has adopted a method that entails modeling total lead exposure (uptake/biokinetic) by incorporating input data on the levels of lead in soil, dust, water, air, and diet from multiple sources in addition to site soils. These models are discussed

Lead has particularly significant effects in children, well before the usual term of chronic exposure can take place (USEPA 2004). Children under 7 years old have a high risk of exposure because of their more frequent hand-to-mouth behavior and they absorb more lead than adults. Pregnant women and women of child bearing age should also be aware of lead in their environment because lead ingested by a mother can affect the fetus. Thus, the population of most concern is young children for residential and recreational use, and pregnant women for nonresidential use (e.g., occupational and recreational) (CDC, 1991).

Health Effects /Blood Lead Levels of Concern

That risk of adverse health effects from lead exposure are not based on theoretical calculations and are not extrapolated from data on lab animals or high-dose occupational exposures. Health effects of lead are well known from studies of children. Lead affects virtually every organ and system in the body and exhibits a broad range of health effects. The most sensitive among these are the central nervous system, hematological, and cardiovascular systems, and the kidney. However, it is particularly harmful to the developing brain and nervous system of fetuses and young children (CDC, 1991; ATSDR, 2007c). It should be noted that many health effects of lead may occur without overt signs of toxicity, i.e. most poisoned children have no symptoms. Extremely high levels of lead in children (BLL of 380 µg/dL) can cause coma, convulsions, and even death. Lower levels of blood lead cause effects on the central nervous system, kidney, and hematopoietic system. Blood lead levels which do not cause distinct symptoms, are associated with decreased intelligence and impaired neurobehavioral development (CDC, 1991). A growing body of research has shown that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1 µg/dL (USEPA, 2003a). EPA believes that effects may occur at blood levels so low that there is essentially no threshold or "safe" level of lead (USEPA, 2004). Although the concentration of lead in blood is an important indicator of risk, it reflects only current exposures. Lead is also accumulated in bone. Recent research suggests that lead concentrations in bone may be related to adverse health effects in children.

Lead is classified as a probable human carcinogen by the EPA based on sufficient evidence of carcinogenicity in animals and inadequate evidence in humans. However, no toxicity value has been derived for cancer effects and EPA has determined that non-cancer effects discussed above provide a more sensitive endpoint than cancer effects to assess health risks from exposure to lead.

EPA Models and Health Risk Assessment

Health risks of exposure to lead are determined using predictive modeling. 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 (USEPA, 2010f), and the adult lead model; ALM (USEPA, 2003b) for adolescents and adults. Some of the variables in both models can be changed based on site-specific scenarios (e.g., exposure frequency, lead bioavailability, etc.). 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. The IEUBK model calculates the expected distribution of blood lead and estimates the probability that any random child might have a blood lead value over 5 µg/dL from exposure to lead in soil. The EPA's Adult Lead Model (ALM) is used to estimate the blood lead level in fetuses from the predicted blood lead level of the pregnant mother. The evaluation of susceptible subpopulations to lead exposure, such as the fetus, is also considered protective of the general population. Whether lead risk is deemed acceptable or unacceptable is determined by comparing the predicted BLLs with target BLLs of 5 µg/dL (for fetuses and young children), adopted by the CDC (2012b).

Primary Prevention

In the absence of an identified BLL without deleterious effects combined with the evidence that these effects, in the absence of other interventions, appear to be irreversible, underscores the critical importance of primary prevention. Primary prevention is a strategy that emphasizes the prevention of lead exposure, rather than a response to exposure after it has taken place. Primary prevention is necessary because the effects of lead appear to be irreversible. Screening children for elevated BLLs and determining and removing sources of lead exposure when their BLL is already elevated should no longer be acceptable practice. The goal is to ensure that all homes become lead-safe and do not contribute to childhood lead exposure. Prevention requires that we reduce environmental exposures from soil, dust, paint and water, before children are exposed to these hazards. Efforts to increase awareness of lead hazards and ameliorative nutritional interventions are also key components of a successful prevention policy.

In the pediatric primary care office, primary prevention must start with counseling – even prenatally when possible. This includes recommending environmental assessments for children PRIOR to screening BLLs in children at risk for lead exposure. After confirmatory testing, children at or above the reference value of 5 µg/dL must undergo ongoing monitoring of BLLs. These children should also be assessed for iron deficiency and general nutrition (*e.g.* calcium and vitamin C levels), consistent with American Academy of Pediatrics (AAP) guidelines. Iron-deficient children should be provided with iron supplements. All BLL test results should be communicated to families in a timely and appropriate manner. Children with elevated BLLs will need to be followed over time until the environmental investigations and subsequent responses are complete (CDC, 2012b).

Arsenic

Arsenic is a naturally occurring element, present at low levels in soil, water, food, and air. Historically, inorganic arsenic compounds were used as pesticides, primarily on cotton fields and in orchards. People normally take in small amounts of arsenic in air, water, soil, and food. At low-level exposures, arsenic compounds are detoxified and excreted in the urine. At higher-level exposures, however, the body may not have the ability to detoxify the increased amount of arsenic. When this overload happens, blood levels of arsenic increase and adverse health effects may occur. Studies have shown that 45 to 85 percent of an ingested dose of arsenic is eliminated within 1 to 3 days; however, some remains for several months or longer (ATSDR, 2007a).

Several studies have shown that ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. At low-level chronic exposure (usually from water), skin lesions appear to be the most sensitive indication of exposure with other effects including darkening of the skin and the appearance of corn- or wart-like growths on the palms, soles of the feet, or torso. ATSDR considered this end point the most appropriate basis for establishing a chronic oral minimal risk level (MRL) for inorganic arsenic of 0.0003 mg/kg/day. The chronic MRL represents the dose of arsenic, in milligrams per kilogram of body weight that a person could ingest on a daily basis (for periods greater than 365 days) with no adverse health effects. The chronic MRL is based on a no effect level of 0.0008 mg/kg/day in a study of skin lesions and Blackfoot disease in a Taiwanese population exposed to high levels of arsenic in drinking water. The Department of Health and Human Services (DHHS), the International Agency for Research on Cancer, the National Toxicology Program, and the EPA has determined that inorganic arsenic is known to be a human carcinogen (a chemical that causes cancer) (ATSDR, 2007a)

Appendix C: Childhood Blood Lead Data

Table 1 – Childhood blood lead level (BLL) data from The Pennsylvania National Electronic Disease Surveillance System (PA-NEDSS) for ZIP codes 18069 and 18078 (2007-2010, which encompasses the former Mohr Orchard site*

Children ≤6 years old By Max BLL						
2007						
Geographic Level	Total Lows	Total Highs	Total Nulls[i]	Total Children Tested	Number of Confirmed Elevated Children**	Percentage Confirmed Elevated
	< 10 µg/dL	≥10 µg/dL				
ZC 18069	15	0	0	15	0	0.00%
ZC 18078	17	0	1	18	0	0.00%
Lehigh County	3,539	116	11	3,666	52	1.42%
Pennsylvania	120,925	5,670	845	127,440	2,770	2.17%
2008						
ZC 18069	27	0	0	27	0	0.00%
ZC 18078	15	0	0	15	0	0.00%
Lehigh County	3,731	129	6	3,866	49	1.27%
Pennsylvania	128,071	4,971	1,076	134,118	2,898	2.16%
2009						
ZC 18069	18	1	0	19	0	0.00%
ZC 18078	18	0	0	18	0	0.00%
Lehigh County	3,860	114	7	3,981	59	1.48%
Pennsylvania	137,120	4,405	862	142,387	2,657	1.87%
2010						
ZC 18069	15	0	0	15	0	0.00%
ZC 18078	12	0	0	12	0	0.00%
Lehigh County	3,503	87	3	3,592	44	1.22%
Pennsylvania	140,594	4,095	939	146,628	2,521	1.72%

Table 2 - Mean childhood BLL (µg/dL) for the respective reporting years and area, based on the data obtained from PA-NEDSS and presented in Table 1.

	2007	2008	2009	2010	2011
18069	3.6	3.4	4.1	2.4	3.2
18078	3.5	4.3	3.5	3.1	3.3
Lehigh County	3.2	3.1	2.9	2.8	2.9
Commonwealth wide	3.1	2.9	2.8	2.7	NA

Table 3 – t-test results to determine the statistical difference between childhood BLL in the community compared to the Lehigh County and Commonwealth levels, based on the data in Table 2.

	Community compared to Lehigh County	**Community compared to Commonwealth**
Means	3.44(Community) 2.98 (County)	3.44 (Community) 2.875 (Commonwealth)
Mean difference	0.46	0.565
p-value* **	0.0826	0.0614
Interval of difference	-0.068 to 0.988	-0.032 to 1.162
Conclusion	Difference is not statistically significant	Difference is not statistically significant

Notes:

*Source: PADOH Childhood Lead Surveillance Annual Reports for 2007, 2008, 2009, 2010 and The Pennsylvania National Electronic Disease Surveillance System (PA-NEDSS).

**Number of children reported to have been tested for lead and reported to PA-NEDSS in by maximum blood lead level (BLL). When children were tested more than one time during the year (which is quite common), each child's maximum (highest) blood lead level was used for categorizing. A Confirmed Elevated is defined by the Council for State & Territorial Epidemiologists (CSTE) as: A child with one venous blood specimen greater than or equal to than 10 micrograms per deciliter (≥10µg/dl) of blood, or any combination of two capillary and/or unknown blood specimens greater than or equal to 10 µg /dl of blood drawn within 12 weeks of each other.

*******p-value and statistical significance- the two-tailed p- values from the t-test for the community were 0.0826 and 0.0614, compared to Lehigh County and the Commonwealth, respectively. Using a 95% Confidence Interval, these differences are considered to be not statistically significant (since p-values were greater than 0.05)

Appendix D: Glossary of Terms

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Adverse health effects
A change in body functions or cell structure that might lead to disease or health problems.

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Cancer
Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
An estimated risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

EPA
United States Environmental Protection Agency.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health

assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

ppb
Parts per billion.

ppm
Parts per million.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public health action
A list of steps to protect public health.

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Risk
The probability that something will cause injury or harm.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Substance
A chemical.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].