Site: Former Mohr Orchard
Location: Schnecksville, Lehigh County, PA
Cost Recovery #: 3ALG
Requester and Affiliation: OSC Richard Fetzer, EPA R3
Activity: ATSDR Record of Activity (AROA) Health Consultation
Author: Robert Helverson, ATSDR Division of Regional Operations, R3
Date: 6/22/2009

I. Statement of Request

U.S. Environmental Protection Agency (EPA) On-Scene Coordinator, Rich Fetzer, has requested ATSDR evaluate the data obtained from randomly selected, 10-point, composite, surface soil samples collected from 200 ft^2 grids at the Former Mohr Orchards site, located in Schnecksville, Lehigh County, Pennsylvania. The purpose of ATSDR's evaluation is to determine whether this "survey" sampling warrants further evaluation and if additional sampling is needed. The specific focus of this health consultation is on the arsenic and lead in surface soils found in residential properties that were formerly orchard lands.

II. Narrative

A. Site Location and Description

The Former Mohr Orchards site is located in a mixed use (commercial, residential, agricultural, and industrial) area on the east and west sides of state route 309 in Schnecksville, Lehigh County, Pennsylvania. The former orchard is approximately 1.5 square miles in area and the current site 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) (see Attachment B). The site topography is generally defined as rolling hills with a number of small creeks and tributaries in the valleys of these hills. Large portions of the land remain undeveloped or agricultural, including substantial portions that are undeveloped, former orchards. The Lehigh County Community College (LCCC) and KidsPeace properties occupy large tracts of land within the site boundaries. KidsPeace is a private charity 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, where the land is mixed residential, commercial and industrial.

B. Background and Site History

The orchards in Schnecksville operated through the 1900s growing apples, peaches and pears. Pesticides commonly applied on orchards during this period included lead arsenate compounds. Around the 1980s, the orchards in Schnecksville were marketed for redevelopment, with the local fire department developing one of the first tracts (www.schnecksvillefair.com, accessed online 01/09/2009). More recently, further residential and commercial development of former orchards led a local resident to investigate the quality of the surface soil on his property. This resident's property was formerly orchard and still has some orchard trees. The resident sampled his soil for lead and arsenic, and his results included maximum concentrations of lead and arsenic at 245 parts per million (ppm) and 140 ppm, respectively (Benchmark Analytics, Inc., 2008). The resident contacted ATSDR to request guidance and assistance. ATSDR staff contacted EPA and the PADEP requesting additional assessment actions to determine whether arsenic and lead in the area may be at concentrations which could adversely affect public health.

C. Assessment Activities

The EPA is taking a number of steps to evaluate the environment formerly used as orchards in the Schnecksville area. These steps include:

- A multi-phased soils assessment,
- An evaluation of public water supplies which use the local aquifer,
- Sampling of private residential wells in the area,
- Conducting a bioavailability study for lead and arsenic with site soils,
- Conducting additional research through reviews of historical photographs, and
- Conducting interviews of residents and former orchard employees to determine whether specific areas, such as former pesticide mixing areas or drainage areas, can be identified and further assessed.

Recently, ATSDR and PADOH have assisted EPA with the assessment of residential properties or public lands which were former Mohr Orchards agricultural lands. ATSDR and PADOH have provided continuous technical assistance to the EPA, including site visits, community outreach, health-care provider fact sheets, and technical assistance documents summarizing conclusions regarding specific concerns. ATSDR and PADOH will remain involved with this site during EPA activities, and will provide technical assistance and environmental health evaluation support as necessary.

D. Specific Issue for this Health Consultation

This health consultation focuses on the data from the Phase I portion of a multi-phased soils assessment, and evaluates the validated surface soil lead and arsenic data set, which conformed to EPA's Method 6200 for analysis of metals by XRF. The EPA's objective of the Phase I sampling was to determine whether or not arsenic or lead concentrations are present in the former orchard areas and currently residential or public use areas at levels which could pose a threat to human health. EPA stated that engineering controls in place, access and the analytical data will be considered when evaluating whether a removal action is necessary

Since the random grids sampled included multiple properties with varying uses and soil activities, the grid data has the potential to mask higher or lower concentrations within the grid. Phase II sampling activities are designed to obtain more specific sampling data which can be used for evaluating contaminant exposures. The Pennsylvania Department of Health, through a cooperative agreement with ATSDR, may use the Phase II data in an additional health consultation which discusses exposures at specific residences at the site, incorporating this soil-specific health consultation and additional exposure pathways, including groundwater.

III. Data Objectives and Limitations

EPA excluded industrial and agricultural grids from the sampling event. Eligible grids were at least partly residential or public use. EPA utilized an adaptive cluster sampling strategy and requested access to collect surface soil composite samples from a random 23% of all sampling grids. Each surface soil sample was taken at 0-3 inches and consisted of 10 randomly selected points within the 200 foot by 200 foot sampling grid (see Attachment B). A 10-point composite sample was determined to be a cost-effective balance between collecting enough points to acquire an adequate representation from each grid cell, while not causing too great a dilution within the sample. The initial random 23% of sampling grids were selected using a geographic information system (GIS) tool which selects random grids while keeping a statistically significant distribution of grids throughout the site. 327 grids were sampled and the composited, homogenized, dried and sieved samples were analyzed ex-situ by x-ray fluorescence (XRF) for lead and arsenic. To confirm the arsenic and lead results by XRF, about 9% of the prepared samples were sent to a fixed laboratory for standard EPA metals analysis.

The XRF methodology allowed for accurate analyses by x-ray fluorescence (XRF) technology to a lower limit of detection of approximately 40 parts per million (ppm). For the purpose of this evaluation, the limit of detection for arsenic of 40 ppm was used as an initial screening value. The initial screening value used for lead, was 400 ppm, a value commonly employed when evaluating residential soils.

ATSDR made conservative approximations with this grid-based data set to evaluate potential residential parcel exposures. For this preliminary review, ATSDR evaluated each composite sampling grid result as though the arsenic and lead result applied to the entire 200' square grid. ATSDR acknowledges that this approach might mask differences in concentrations at the residential property level. ATSDR also acknowledges that routine lawn maintenance activities (e.g., soil tilling, treatments, addition of high-quality topsoil or sod, lawn watering, etc.) on residential parcels might influence (i.e. decrease) the concentrations of pesticide contaminants in the top three inches of soil relative to the non-residential parcels. ATSDR expects that these limitations will be addressed via future sampling efforts at the residential parcel level.

Given the limitations of the data evaluated in this health consultation, only general conclusions relating to exposures are provided. ATSDR or PADOH will develop a follow-up document which provides estimated exposure doses from parcel-specific composite sampling results gathered in Phase II of EPA's assessment activities.

IV. Summary of Available Data

From August to December 2008, U.S. EPA's technical consultant (START) collected and analyzed by ex situ XRF approximately 401 composite samples from 327 grids. Validated results for these samples were provided to ATSDR on January 7, 2009 (see Attachment C). Soil samples were composed of 10 aliquots collected at random from surface soils (i.e. top 0-3 inches of soil) in a 200 square foot grid. The aliquots were homogenized into one composite sample per grid before being dried and sieved for XRF analysis. In addition to collecting one 10-point composite sample from the 200 square foot grids, START also performed replicate grid sampling and duplicate sampling which confirmed the representativeness of the composite samples. `All sample analytical data was validated by START. The following data summary discussion is based on the validated data package provided to ATSDR.

A. Arsenic Soil Results

Historic use of arsenic-based pesticides in fruit orchards has impacted surface soil in the North Whitehall Township area. Residential development of these former orchard properties has resulted in a change in land use and exposure potential (i.e., from agricultural to residential).

Arsenic concentrations at the Former Mohr Orchards site range from 7 ppm to 149 ppm. The following bullets summarize all of the Phase I sample 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

- 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.

B. Lead Soil Results

Lead concentrations at the Former Mohr Orchards site range from 35 ppm to 1,950 ppm. The following bullets summarize all of the Phase I sample results:

- 81 composite samples (25% of total) were above 400 ppm lead

- 33 composite samples (10% of total) were above 800 ppm lead

- The maximum lead level found at the site was 1,950 ppm from grid 328, a public use grid.

At the request of ATSDR, PADOH compiled blood lead data for persons residing in the 18069 zip code from Pennsylvania's National Electronic Disease Surveillance System database for the year 2008 through December 9, 2008. All persons less than 18 years of age, living in the 18069 zip code, and whose blood lead level (BLL) was reported to the database had a blood lead level less than 10 micrograms per deciliter (μg/dL) (see Table 1). Ten μg/dl is the level that CDC recommends as an action level for primary prevention activities focused on reducing children's BLLs. Of those who were tested and are over 18 years of age, 7 individuals were reported to have BLLs at or exceeding the CDC screening level for adults of 25 μg/dL. Six of those seven individuals were identified as living within the boundaries of the site, as determined by the EPA. Of those six individuals, 3 were identified as being serviced by a public water system or community drinking water provider which is regulated and compliant with the lead standard as specified under the Safe Drinking Water Act. One of the three remaining individuals with a blood lead test result of 25 μg/dL or above stated that he consumes well water that was tested by the EPA and is below their action level (11 parts per billion) for the site. The two remaining individuals, identified as having a residential well within the site boundaries, were provided health information and a property access form in order for EPA to sample their well water for lead. PADOH confirmed that the adults with elevated BLLs were tested by their employer, a company which uses lead in its operations.

Table 1

Blood Lead Levels for Individuals by Age (in years) and Reported for the 18069 Zip Code from 1/1/08 - 12/9/08

BLL in mg/dL	AGE <5	AGE 6 - 18	AGE >18
0 to 5	21	29	1
6 to 10	1	1	0
11 to 15			
16 to 20			
21 to 25			1
26 to 30			2
31 to 35			2
36 to 40			
41 to 45			2
46 and over			

Notes:
mg/dL = Micrograms mercury per deciliter blood
BLL = Blood lead level

C. Co-Location of Lead and Arsenic

The Phase I sample results found that 80 samples (25% of total) had both lead levels above 400 ppm and arsenic above 40 ppm. See Appendix for further discussion.

V. Exposure Pathway Analysis

Residents living on former orchard lands in the area may come into contact with arsenic and lead contaminated soils on their property due to the historic use of pesticides that included lead and arsenic. The specific exposure pathway to be evaluated in this health consultation is incidental ingestion of lead or arsenic contaminated soils. It is important to note that residential parcels where an intact vegetative cover, such as a lawn, is present will result in the reduced likelihood and frequency of exposure to contaminated soils. Conversely, residential parcels which have areas of exposed soils with no vegetation will have an increased likelihood and frequency of exposures to contaminated soils.

VI. Discussion

The ability of arsenic or lead to cause adverse health effects from ingestion of soils depends on several factors, including the (1) concentration of arsenic or lead in the surface soil, (2) quantity and frequency of soil ingestion, (3) duration of the exposure (i.e. number of years living at residence where soil has elevated lead or arsenic concentrations), (4) specific characteristics of the exposed individual (i.e. weight, age, occupation, additional exposure pathways, health), and (5) bioavailability of the arsenic or lead in the soil.

Attachment A provides further information related to exposure issues concerning arsenic in soil.

VII. Toxicological Implications

Because composite sample results are not specific to a residential parcel, they do not support the development of exposure doses. Future health evaluations, including exposure dose estimates, are expected be conducted with Phase II, parcel-specific, sampling results. The data evaluations in this health consultation are therefore focused on the percent of samples that exceed screening values.

For Arsenic, the available XRF data indicate 57% of samples exceed 40 ppm. While the XRF data may not be reliable for values under 40 ppm, it is noted that 89% of all samples had values of 20 ppm or higher, and that ATSDR's recommended CV is 20 ppm. The commonly used screening value of 400 ppm for lead at residential properties was exceeded at 25% of the sampling grids. Collectively, these data indicate that the majority of the sampled grids have either arsenic or lead at levels that exceed a minimal level of concern.

VIII. Conclusions

The available data show the majority of the sampled grids contain either, or both, arsenic or lead at levels that exceeded the screening values used to evaluate the site (40 ppm for arsenic and 400 ppm for lead). Fifty grids which are at least partially residential have arsenic levels greater that 40 ppm and/or lead greater than 400 ppm.

Some of the survey sampling data indicate that residential properties contain lead and arsenic at levels that exceed values that are commonly used to direct residential soil clean-up programs. Collectively, the available data indicate further site characterization is warranted.

PADOH investigated elevated adult blood lead levels, and, it appears that the elevated BLLs are not related to site contaminants and may be the result of occupational exposures.

1. A total of **19** grids with residential parcels had arsenic concentrations greater than 60 ppm in the top 3" of soil, with most of these grids containing lead above 400 ppm. **2** grids with residential parcels had lead concentrations greater than 400 ppm in the top 3" of the soil with arsenic concentrations between 40 and 60 ppm. An additional **29** grids with residential parcels had arsenic concentrations in the top 3" of soil between 40 ppm and 60 ppm, but the lead concentrations were below 400 ppm.

IX. Recommendations

1. Additional Assessment Activities – ATSDR recommends a more focused assessment of residential parcels at the Mohr Orchards site. 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. Addressing special situations involving increased exposures to contaminated soils (e.g., students practicing farming activities) should be considered. ATSDR and/or PADOH should visually inspect the vegetative coverage in the grids with elevated arsenic and/or lead concentrations that include residential parcels, and make recommendations to EPA for priority sampling at individual parcels.

2. Arsenic Bioavailability Study: ATSDR recommends that EPA conduct site-specific arsenic and lead bioavailability studies. (ATSDR supports the initial efforts to conduct those studies.)

3. Environmental Health Education: Residents in the site area should be kept informed of the ongoing environmental investigation results and public health evaluations of this information. Public use areas of the site have the highest concentrations of lead and arsenic in the topsoil. Users of these areas should be made aware of the contaminated soils and informed of ways to reduce their exposures. (ATSDR and PADOH are working with EPA to implement this recommendation.)

4. Blood lead testing and follow up: ATSDR and our cooperative agreement partners at PADOH recommend that concerned residents consider having their blood lead levels tested. This testing can be performed by family medicine practitioners or through a state-sponsored blood lead testing program. (PADOH is also following up with residents in the site area which have reported elevated Blood lead levels. ATSDR and PADOH are working with EPA to implement this recommendation.)

Signatures:

Signature: ____________________ Date: 6-24-09

Robert Helverson, Environmental Health Scientist, ATSDR R3

Concurrence: ____________________ Date: 6/24/09

Lora Siegmann Werner, MPH Senior Regional Representative, ATSDR R3

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Appendix

Additional Arsenic and Lead Discussion

(4 pages)

Arsenic Results Discussion

The maximum arsenic concentration (149 ppm) was identified in grid 054, a grid characterized as former orchard and currently undisturbed open space (i.e. public use) with a small portion of the southwest corner of the grid on a residential property. Approximately 189 of the 327 grids sampled (57 %) had arsenic above 40 ppm. Table 1 provides a summary of grid results which have residential parcels within the grid boundaries. Fifty-nine grids, or approximately 18% of the grids sampled, had arsenic concentrations in composite samples between 60 and 80 ppm. Twelve of these 59 grids included residential parcels, with the remainder of the parcels characterized as public use.

Table 1
Composite Sample Results Greater Than 60 ppm Arsenic from Grids with Residential Parcels

Grid ID	Arsenic Result	Lead Result
054	149	1833
070	75	426
066	67	259
069	87	379
072	78	604
073	121	1012
048	78	582
046	64	359
065	67	252
067	66	262
050	88	815
049	78	630
044	60	289
040	62	224
047	62	431
007	138	1239
005	87	416
006	92	820
012	73	236

Notes: ID = Identifier, ppm = parts per million

Eighty-nine grids, or approximately 27%, had arsenic concentrations in composite samples between 40 and 60 ppm, with lead concentrations below 400 ppm. Twenty-nine of these grids (approximately 9% of all grids) included residential parcels, with the remainder of the grids characterized as public use. Table 2 provides a summary of the arsenic results between 40 and 60 ppm with lead below 400 ppm for grids which included residential parcels.

Table 2
Composite Sample Results between 40 and 60 ppm Arsenic with Lead Below 400 ppm from Grids with Residential Parcels

Grid ID	Arsenic Result	Grid ID	Arsenic Result	Grid ID	Arsenic Result
[redacted]	58	062	45	045	56
041	51	061	49	063	49
032	55	029	45	068	59
060	49	036	44	035	44
033	41	039	51	034	56
043	55	042	45	051	41
075	46	076	44	177	45
017	53	010	53	018	50
013	58	015	52	014	56
003	54	064	57		

Notes: ID = Identifier, ppm = parts per million, lead concentration below 400 ppm

Arsenic Toxicology Discussion

CVs for arsenic range from 20 ppm arsenic in soil for children who are chronically exposed (i.e. greater than 364 days), to 200 ppm arsenic in soil for adults chronically exposed. An acute CV for children exhibiting pica behavior (i.e. a tendency to intentionally ingest non-food items, such as soil) is set at 10 ppm. Arsenic is considered a human carcinogen. ATSDR's recommended CV for arsenic in soil is 20 ppm. Arsenic concentrations at the Former Mohr Orchards site range from 7 ppm to 149 ppm. 84% of the grids sampled (275 out of 327 grids) had arsenic exceeding the ATSDR chronic CV for children (20 ppm). As discussed previously, results obtained by XRF which are below 40 ppm are estimated results. The XRF becomes inaccurate at levels below this concentration.

Arsenic occurs naturally in soil and minerals. People normally take in small amounts of arsenic in air, water, soil, and food. Of these, food is usually the most common source of arsenic for people (ATSDR 2007a).

The primary exposure route of concern for arsenic in surface soil is ingestion (oral exposure). This ingestion could occur by the inadvertent consumption of soil on hands or food items, mouthing of objects, or intentional ingestion (pica behavior).

Inorganic forms of arsenic predominate in groundwater and soils and are generally more toxic than organic forms (Suk et al.1998). When humans and other animals are exposed to inorganic arsenic, their bodies change it to the much less toxic methylated organic form, which is readily excreted from the body. ATSDR's review of the toxicity of arsenic suggests that 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. Arsenic, like some other chemicals, does not seem to cause adverse health effects until a certain amount, or threshold, of the chemical has entered the body. Once the threshold, also known as the minimal effective dose, is reached, and the body is no longer able to detoxify arsenic compounds, adverse health effects may result (ATSDR 2007a).

Lead Results Discussion

Environmental and public health agencies often use 400 ppm lead as a screening value for lead in play areas in residential soils. In general, at this site higher soil lead concentrations were collocated with higher soil arsenic concentrations. A majority of the lead results which were above 400 ppm were collocated with arsenic concentrations above 60 ppm. Table 3 provides a summary of the lead results for grids with arsenic between 40 and 60 ppm.

- All but one grid with arsenic concentrations between 40 and 60 ppm had lead concentrations exceeding 400 ppm.
- Grid 071, characterized as residential, had a lead result of 550 ppm but no detectable arsenic.
- Only two of the grids with lead results above 400 ppm and arsenic less than 60 ppm included residential parcels (053 and 052). All other grids with lead above 400 ppm that were not collocated with arsenic concentrations above 40 ppm consisted of non-residential parcels (i.e. public use lands).

The maximum lead concentrations identified from grid sampling were located in one area of the site, on the west side of Jordan Creek along Old Packhouse Road and Jordan Road. Twenty-three of 25 grids in this area had lead concentrations greater than 500 ppm. The mean lead concentration in this area is 1,013 ppm. This area is characterized as undeveloped, former orchards currently accessible to the public for bow hunting. The area is located east and down gradient of residential parcels along Jordan Road. Very small portions of some of these grids included these residential areas, although none of the composite sample aliquots were actually collected from the residential parcels. The maximum lead concentration from this assessment of 1,950 ppm from grid 328 (arsenic concentration of 133.5 ppm) is located adjacent to grid 054, which had the maximum arsenic concentration of 149 ppm.

Table 3
Grid Results over 400 ppm lead with Arsenic under 60 ppm

Grid ID	Lead Result	Arsenic Result	Residential?
264	425	50	No
053	867	43	Yes
052	558	55	Yes
293	561	50	No
295	738	55	No
269	467	55	No
308	935	56	No
297	722	55	No
261	402	47	No
313	1005	53	No
267	447	54	No
279	534	56	No
274	514	54	No
304	835	58	No

Notes: ID = Identifier, ppm = parts per million

Lead Toxicology Discussion

Epidemiologic studies have found that children's blood lead levels (BLLs) increase by about 3.5 micrograms per deciliter for every 1,000 ppm increase in soil lead levels (Lanphear et al 1998). Based on observations of enzymatic abnormalities in the red blood cells at blood lead levels below 25 µg/dL and observations of neurologic and cognitive dysfunction in children with blood lead levels from 10-15 µg/dL, the CDC has determined that a blood lead level >10 µg/dL in children indicates excessive lead absorption and constitutes the grounds for intervention (CDC 1991). The relationship between soil lead levels and blood lead levels is affected by factors such as the age of the population exposed to the contaminated soil, the physical availability of the contaminated soil, the bioavailability of the lead in the soil, and differences in individual behavioral patterns. While there is no clear relationship applicable to all sites, a number of models have been developed to estimate the potential impact that soil lead could have on the blood lead levels in different populations. In general, soil lead will have the greatest impact on the blood lead levels of preschool-age children. These children are more likely to play in dirt and to place their hands and other contaminated objects in their mouths. They are better at absorbing lead through the gastrointestinal tract than adults, and they are more likely to exhibit the types of nutritional deficiencies that facilitate the absorption of lead.

Lead can affect almost every organ and system in your body. The main target for lead toxicity is the nervous system, both in adults and children. Long-term exposure of adults can result in decreased performance in some tests that measure functions of the nervous system. It may also cause weakness in fingers, wrists, or ankles. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people and can cause anemia (ATSDR 2007b).

Children are more vulnerable to lead poisoning than adults. A child who swallows large amounts of lead may develop blood anemia, severe stomachache, muscle weakness, and brain damage. If a child swallows smaller amounts of lead, much less severe effects on blood and brain function may occur. Even at much lower levels of exposure, lead can affect a child's mental and physical growth (ATSDR 2007b).

Exposure to lead is more dangerous for young and unborn children. Unborn children can be exposed to lead through their mothers. Harmful effects include premature births, smaller babies, decreased mental ability in the infant, learning difficulties, and reduced growth in young children. These effects are more common if the mother or baby was exposed to high levels of lead. Some of these effects may persist beyond childhood (ATSDR 2007b).

References

(See main document for all references)

ATTACHMENT A

Arsenic Soil Bioavailability

(2 pages)

Arsenic Soil Bioavailability

Exposure to arsenic in soil occurs, for example, from ingesting soil that clings to people's hands. Not all the arsenic that is swallowed, however, actually gets absorbed into the body—some arsenic will pass through the digestive system without being absorbed. For example, some arsenic is bound so tightly to soil particles that it is less likely to be absorbed by the lining of the intestinal tract (the gut) than is arsenic bound loosely to soil particles. This process of how much arsenic actually crosses the gut and gets into the body is known as *bioavailability*. For example, if only half of the arsenic in soil is capable of passing from the gut and into someone's body, the soil arsenic bioavailability would be 50 percent.

The bioavailability of arsenic in soil varies depending upon the source of arsenic (e.g., mines, pesticide application, smelters). Studies have shown soil arsenic bioavailability to range from very little arsenic absorption to approximately 80% (Roberts 2002, 2006; Casteel 1997; Casteel 2001; Freeman 1993; Freeman 1995; Lorenzana 1996). Several of these studies investigated soil contaminated with an arsenic-based herbicide or pesticide. One study (Roberts 2002) collected soil samples from five waste sites in Florida (one from an electrical substation, one from a wood preservative treatment site, two from pesticide sites, and one from a cattle-dip vat site). Relative bioavailability (RBA) was assessed based on urinary excretion of arsenic following the soil dose compared with excretion following an oral dose of arsenic in solution. Differences in bioavailability were observed for different sites, with RBA ranging from 10.7 ± 4.9% (mean ± standard deviation) to 24.7 ± 3.2% for the five soil samples. Of the two pesticides sites, the arsenic in one soil sample had an average relative bioavailability of 10.7 ± 4.9% while the other soil sample had an average relative bioavailability of 17 ± 10%. Because only one soil sample was tested from each location and because the standard deviation is large, some uncertainty exists in the reported RBA of 10.7% and 17% for these two pesticide locations. In a more recent study (Roberts 2006), urinary recovery of arsenic following doses of contaminated soil were compared with urinary recovery following oral administration of sodium arsenate in water in order to determine the RBA of each soil. RBA of arsenic in 14 soil samples from 12 different sites ranged from 5 to 31%, with most RBA values in the 10 to 20% range. Two of the sites selected were "orchard sites" with historic use of arsenical pesticides. The RBA values from orchard sites in New York and Washington were 15 and 25%.

EPA studied arsenic bioavailability in residential soil from the Vasquez Boulevard and I-70 (VBI70) Site in Denver, Colorado. Residential properties with high levels of arsenic are randomly distributed in neighborhoods, and the predominant form of arsenic is arsenic trioxide, a form typically found in arsenic-based pesticides. EPA tested five composite soil samples from several residential neighborhoods in the VBI70 study area and reported the following RBA for arsenic: 18%, 18%, 23%, 37%, 37%, and 43%. Using a statistical method, EPA estimated the 95th upper confidence limit of the average relative bioavailability to be 42% for this study (Casteel 2001; EPA 2001).

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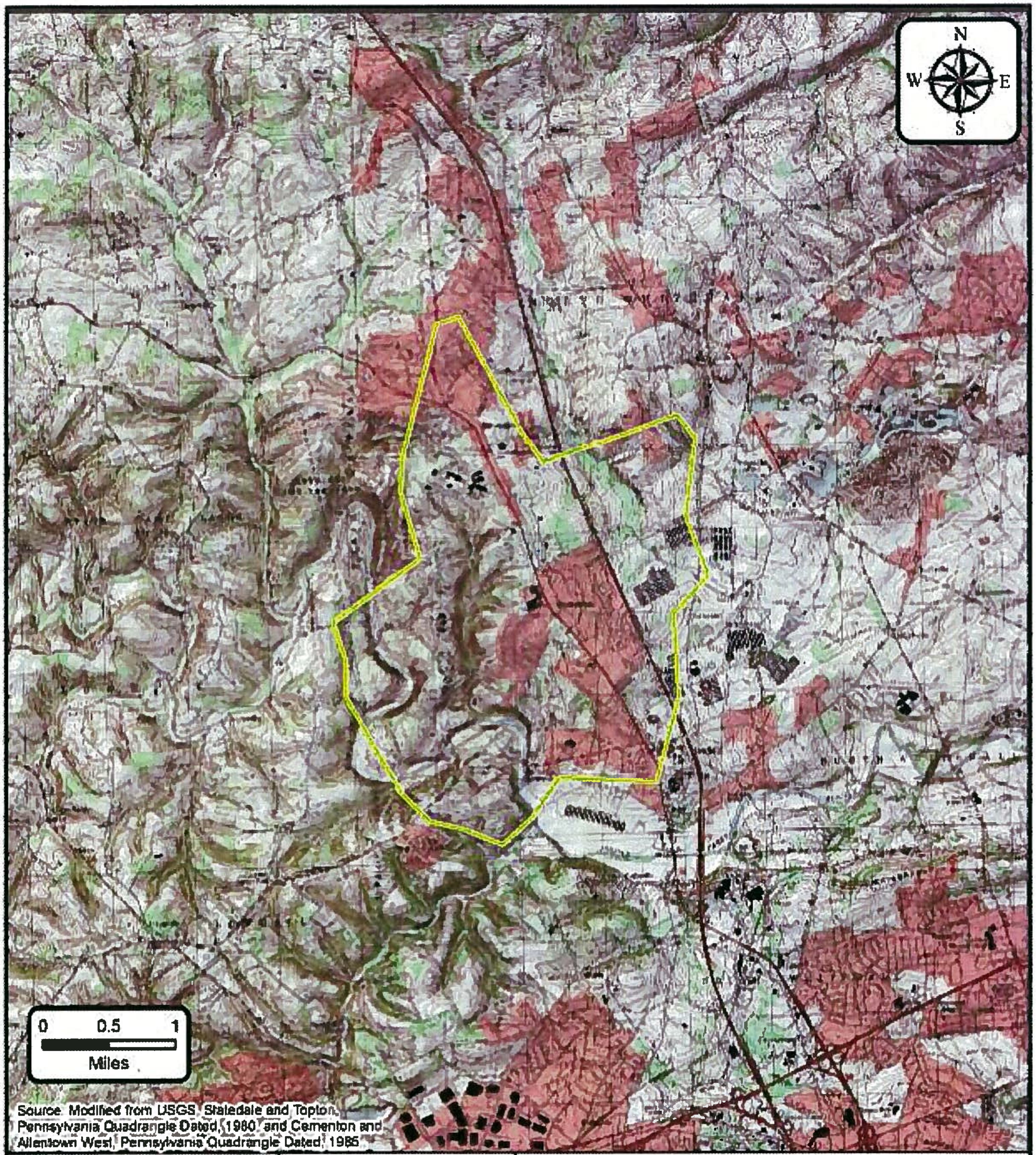
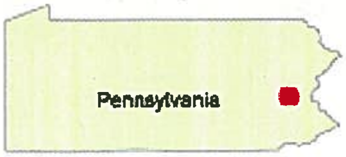
ATTACHMENT B

Maps
(3 pages)



Approximate Site Location =



Legend

Site Boundary

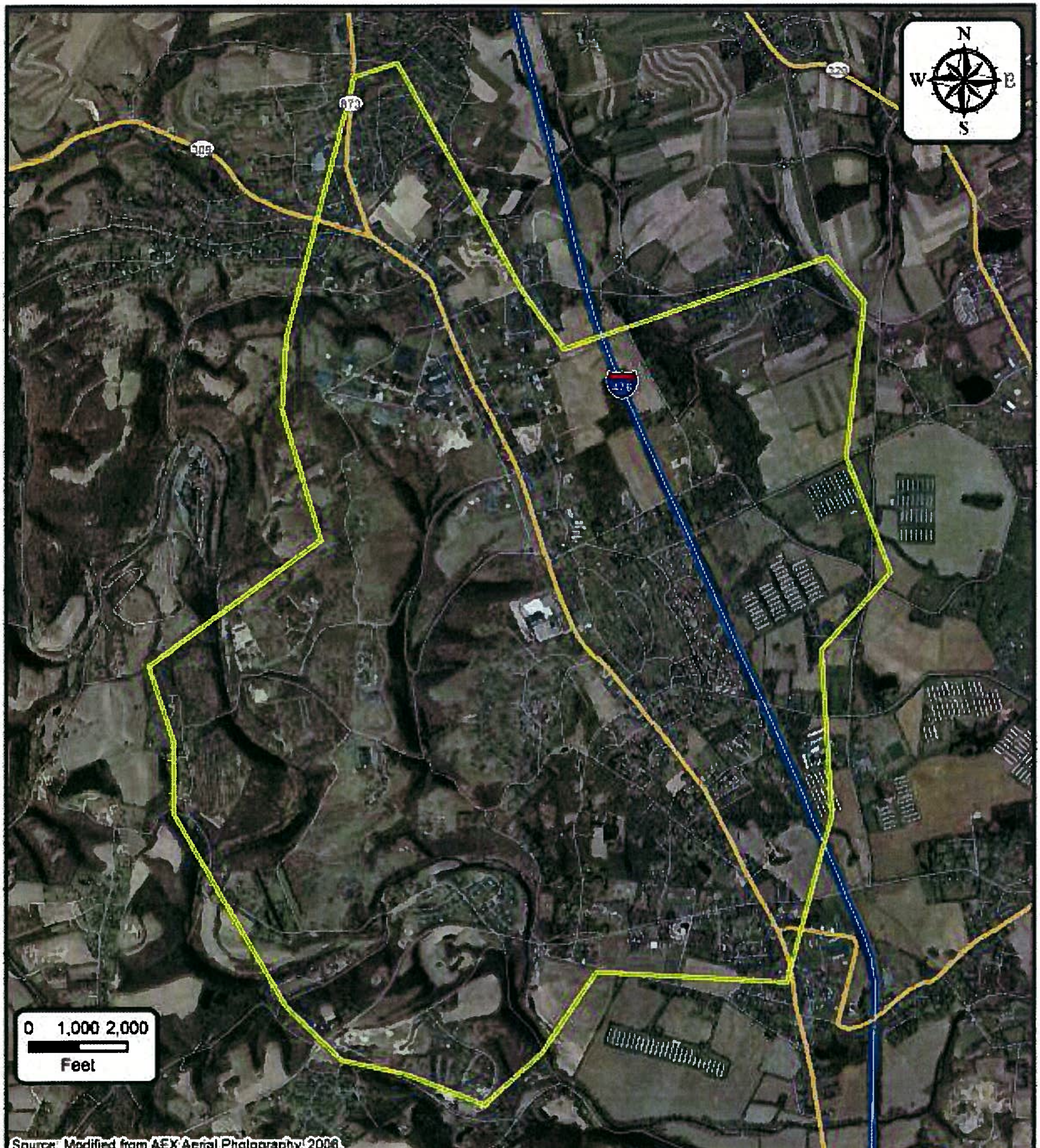
Former Mohr Orchard
North Whitehall Township, Pennsylvania

Figure 1
Site Location Map

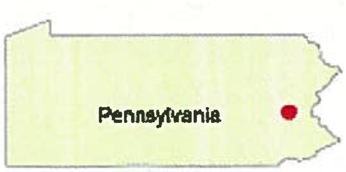
TDD No. 0210200807025
EPA Contract No. EP-S3-05-02

Map created on July 25, 2008
by A. Dye, Tetra Tech EMI

TETRA TECH



Approximate Site Location = ▢



Legend

▢ Site Boundary

Former Mohr Orchard
North Whitehall Township, Pennsylvania

Figure 2
Aerial Photograph

TDD No. 0210200807025
EPA Contract No. EP-S3-05-02

Map created on July 25, 2008
by A. Dye, Tetra Tech EMI

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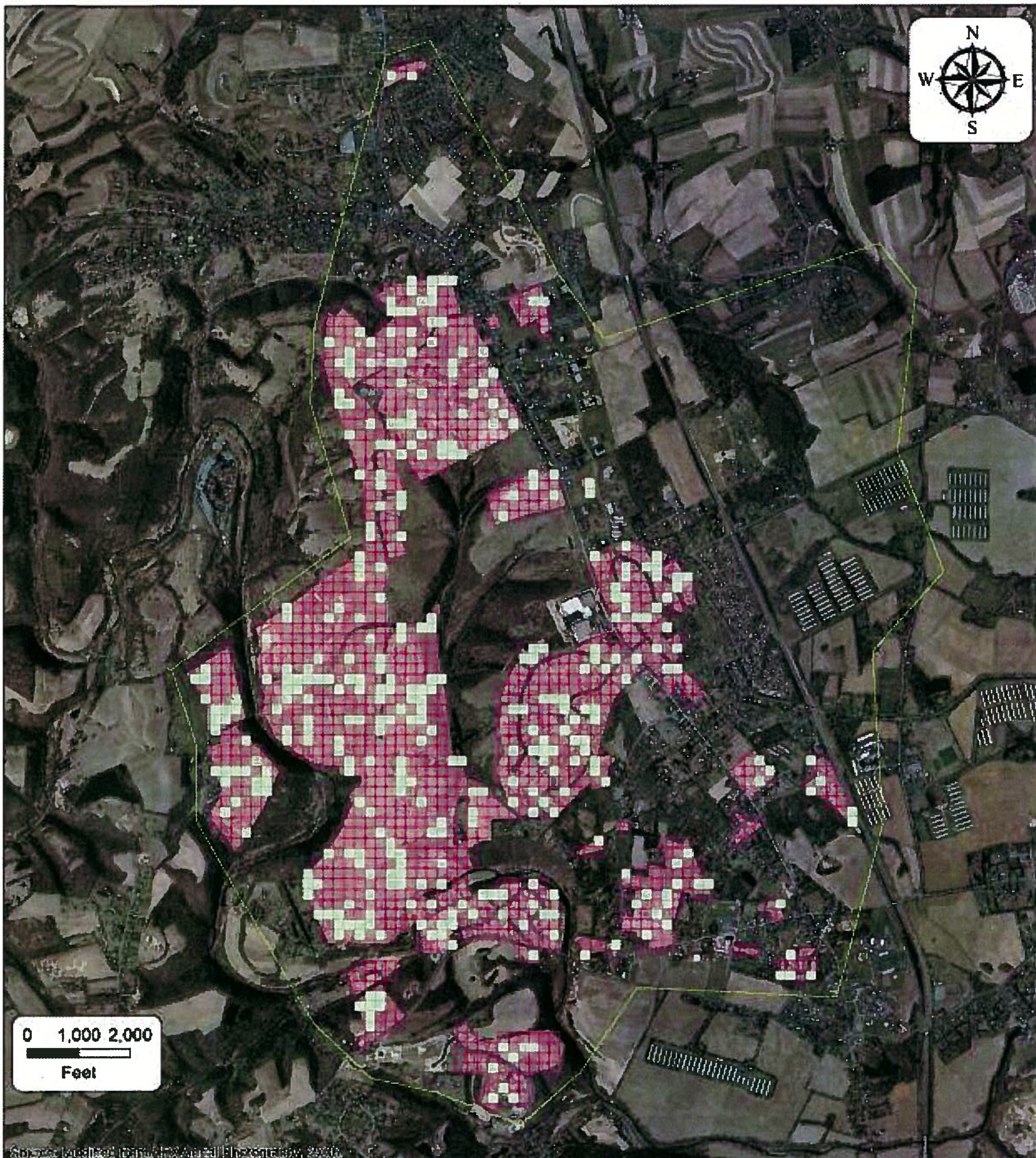

Approximate Site Location = □

Legend

- Random_Grids
- 200' x 200' Sampling Grid
- Former Orchard Area
- Site Boundary

Former Mohr Orchard
North Whitehall Township, Pennsylvania

Figure 4
Sampling Grid Map

TDD No. 0210200807025
EPA Contract No. EP-S3-06-02

Map created on July 28, 2008
by A. Dye, Tetra Tech EMI

TETRA TECH

ATTACHMENT C

Data Summary Table
(7 pages)

UNIQUE ID	PPM PB	PB Qualifier	PPM As	As Qualifier	Grid Type	Area No.
001	74.12		17.68	J	R	2
002	165.36		22.76		R	2
003	268.08		53.9		R	2
004	272		22.79		R	2
005	416.17		86.7		R	2
006	820.43		92.32		R	2
007	1238.74		138.09		R	2
008	Not recorded		10.2		R	2
009	156.17		27.24		R	3
010	219.14		53.17		R	3
011	229.55		39.46		R	3
012	235.92		73		R	3
013	240.22		58.33		R	3
014	262.09		55.94		R	3
015	266.08		57.76		R	3
016	280.49		37		R	3
017	300.75		53.25		R	3
018	344.85		47.98		R	3
019	71.4		24.69		R	4
020	89.02		18.59	J	R	4
021	100.41		25.07		R	4
022	101.72		27.43		R	4
023	118.58		31.64		R	4
024	151.64		37.77		R	4
025	174.16		15.4	J	R	4
026	76.54		19.93	J	R	5
027	89.07		29.37		R	5
028	93.88		26.78		R	5
029	143.79		30.75		R	5
030	155.89		37.53		R	5
031	167.15		27.54		R	5
032	178.64		55.44		R	5
033	186.37		41.37		R	5
034	192.74		56.52		R	5
035	193.68		45.44		R	5
036	203.5		43.5		R	5
037	209.83		25.29		R	5
038	212.66		35.71		R	5
039	229.39		51.45		R	5
040	230.74		51.59		R	5
041	259.21		51.26		R	5
042	267.46		44.91		R	5
043	284		54.8		R	5
044	288.54		60.04		R	5
045	302.44		50.3		R	5
046	359.1		64.2		R	5
047	426.01		58.94		R	5
048	581.69		77.45		R	5
049	629.93		77.63		R	5
050	814.5		87.99		R	5
051	234.58		38.09		R	6

UNIQUE ID	PPM PB	PB Qualifier	PPM As	As Qualifier	Grid Type	Area No.
052	526.49		55.21	J	R	6
053	809.66		44.26	J	R	6
054	1833.36		148.93	J	R	6
055	52.88		17.66	J	R	8
056	63.59		13.36	J	R	8
057	66.36		10.03	J	R	8
058	39.39		< LOD	U	R	10
059	48.87		11.38	J	R	10
060	155.4		49.1		R	10
061	177.32		39.54		R	10
062	189.21		44.48		R	10
063	193.45		49.43		R	10
064	201.2		58.6		R	10
065	251.95		66.98		R	10
066	256.62		67.38		R	10
067	261.82		66.06		R	10
068	298.82		58.76		R	10
069	379.17		86.94		R	10
070	425.59		74.52		R	10
071	549.4		< LOD	U	R	10
072	604.4		77.89		R	10
073	1012.64		120.68		R	10
074	182.11		36.22		R	14
075	215.6		45.66		R	14
076	231.63		44.23		R	14
077	35.02		7.77	J	PU	N/A
078	40.64		13.95	J	PU	N/A
079	42.96		18.23	J	PU	N/A
080	44.39		< LOD	U	PU	N/A
081	46.83		7.96	J	PU	N/A
082	49.09		11.69	J	PU	N/A
083	49.2		16.54	J	PU	N/A
084	50.14		9.85	J	PU	N/A
085	50.49		14.27	J	PU	N/A
086	52.29		9.83	J	PU	N/A
087	54.62		11.85	J	PU	N/A
088	56.44		17.14	J	PU	N/A
089	56.76		11.06	J	PU	N/A
090	57.15		23.36		PU	N/A
091	62.88		20.25		PU	N/A
092	63.28		15.69	J	PU	N/A
093	63.73		19.86	J	PU	N/A
094	64.88		15.09	J	PU	N/A
095	65.39		11.28	J	PU	N/A
096	65.79		18.74	J	PU	N/A
097	66.21		18.44	J	PU	N/A
098	66.96		13.68	J	PU	N/A
099	67.17		14.17	J	PU	N/A
100	68.09		22.97		PU	N/A
101	69.02		12.69	J	PU	N/A
102	69.3		21.83		PU	N/A

UNIQUE ID	PPM PB	PB Qualifier	PPM As	As Qualifier	Grid Type	Area No.
103	72.34		11.31	J	PU	N/A
104	77.93		16.72	J	PU	N/A
105	78.82		21.21		PU	N/A
106	78.83		16.58	J	PU	N/A
107	80.01		19.6	J	PU	N/A
108	82.14		22.44		PU	N/A
109	85.52		21.2		PU	N/A
110	88.99		15.36	J	PU	N/A
111	91.6		14.04	J	PU	N/A
112	91.74		28.74		PU	N/A
113	93.87		24.12		PU	N/A
114	101.33		19.94	J	PU	N/A
115	102.48		20.15		PU	N/A
116	104.46		11.96	J	PU	N/A
117	106.35		19.11	J	PU	N/A
118	109.43		26.17		PU	N/A
119	111.27		24.45		PU	N/A
120	113.46		16.27	J	R	N/A
121	113.5		29.32		PU	N/A
122	114.33		24.39		PU	N/A
123	119.11		18.38	J	PU	N/A
124	120.05		29.36		PU	N/A
125	122.61		19.72	J	PU	N/A
126	124.57		21.18		PU	N/A
127	124.69		26.81		PU	N/A
128	125.58		35.78		PU	N/A
129	127.56		15.75	J	PU	N/A
130	131.39		29.8		PU	N/A
131	131.5		17.41	J	PU	N/A
132	131.83		25.62		PU	N/A
133	132.48		21.01		PU	N/A
134	133.48		28.99		PU	N/A
135	135.98		36.64		PU	N/A
136	138.36		27.93		PU	N/A
137	140.98		17.07	J	PU	N/A
138	142.82		23.39		PU	N/A
139	143.5		25.12		PU	N/A
140	146.31		19.33	J	PU	N/A
141	146.39		24.21		PU	N/A
142	148.66		22.4		PU	N/A
143	153.34		28.81		PU	N/A
144	154.66		25.11		PU	N/A
145	157.3		31.67		PU	N/A
146	159.57		33.86		PU	N/A
147	162.86		26.45		PU	N/A
148	167.01		41.12		PU	N/A
149	168.52		19.72	J	PU	N/A
150	169.22		26.26		PU	N/A
151	172.87		22.18		PU	N/A
152	174.02		39.54		PU	N/A
153	174.24		46.76		PU	N/A

UNIQUE ID	PPM PB	PB Qualifier	PPM As	As Qualifier	Grid Type	Area No.
154	175.91		41.26		PU	N/A
155	177.08		30.25		PU	N/A
156	177.3		19.74	J	PU	N/A
157	178		24.88		R	N/A
158	184.29		39.07		PU	N/A
159	184.48		35.7		PU	N/A
160	184.75		24.69		PU	N/A
161	187.61		36.54		PU	N/A
162	188		45.98		PU	N/A
163	190.71		17.95	J	PU	N/A
164	190.73		39.3	J	PU	N/A
165	193.77		60.65		PU	N/A
166	195.26		27.66		PU	N/A
167	195.56		47.14		PU	N/A
168	200.58		40.64		PU	N/A
169	204.3		29.64		PU	N/A
170	206.27		30.36		PU	N/A
171	207.01		26.19		PU	N/A
172	208.5		42.18		PU	N/A
173	210.08		41.66		PU	N/A
174	212.98		28.41		PU	N/A
175	213.7		30.47		PU	N/A
176	215.05		34.45		PU	N/A
177	215.22		45.32		PU	N/A
178	215.5		38.42		PU	N/A
179	216.65		23.05		R	N/A
180	218.58		35.52		PU	N/A
181	220.26		33.5		PU	N/A
182	220.52		48.21		PU	N/A
183	220.87		51.29		PU	N/A
184	221.86		35.37		PU	N/A
185	227.6		46.98		PU	N/A
186	228.46		25.4		PU	N/A
187	229.08		56.41		PU	N/A
188	231.18		38.34		PU	N/A
189	232.34		27.21		PU	N/A
190	234.7		53.23	J	PU	N/A
191	235.17		67.93		PU	N/A
192	236.63		58.8		PU	N/A
193	237.39		49.39		PU	N/A
194	239.2		49.14		PU	N/A
195	241.38		27.87		PU	N/A
196	242.09		59.04		PU	N/A
197	242.45		49.13		PU	N/A
198	244.15		39.34		PU	N/A
199	244.18		47.97		PU	N/A
200	245.34		39.34		PU	N/A
201	246.03		68.74		PU	N/A
202	246.35		74.71		PU	N/A
203	246.82		44.63		PU	N/A
204	248.6		55.9		PU	N/A

UNIQUE ID	PPM PB	PB Qualifier	PPM As	As Qualifier	Grid Type	Area No.
205	248.72		40.55		PU	N/A
206	249.24		35.67		PU	N/A
207	252.44		40.93		PU	N/A
208	253.02		57.66		PU	N/A
209	254.2		40.63		PU	N/A
210	256.67		36.29		PU	N/A
211	257.48		54.01		PU	N/A
212	258.61		53.63	J	PU	N/A
213	259.21		55.98	J	PU	N/A
214	260.95		43.36		PU	N/A
215	260.98		57.5		PU	N/A
216	262.89		60.13		PU	N/A
217	270.43		43.88		PU	N/A
218	272.72		66.68		PU	N/A
219	275.48		39.12		PU	N/A
220	276.33		55.74		PU	N/A
221	276.52		51.93		PU	N/A
222	277.9		46.44		PU	N/A
223	280.74		64.64		PU	N/A
224	286.29		71.89		PU	N/A
225	288.63		47.39		PU	N/A
226	291.88		45.84		PU	N/A
227	294.47		57.81		PU	N/A
228	295.05		47.16		PU	N/A
229	299.33		59.65		PU	N/A
230	304.05		27.3		PU	N/A
231	305.54		41.75		PU	N/A
232	308.29		69.84		PU	N/A
233	309.61		47.9		PU	N/A
234	310.19		76.02		PU	N/A
235	312.73		51.06		PU	N/A
236	314.18		28.18		PU	N/A
237	314.24		35.95		PU	N/A
238	315.62		65.55		PU	N/A
239	315.95		44.79		PU	N/A
240	318.08		41.77		PU	N/A
241	319.77		63.24		PU	N/A
242	319.88		92.39	J	Biased	N/A
243	320.57		71.5		PU	N/A
244	335.83		67.82		PU	N/A
245	336.08		56.52		PU	N/A
246	336.46		57.18		PU	N/A
247	337.13		68.95		PU	N/A
248	341.15		57.01		PU	N/A
249	344.93		66.89		PU	N/A
250	349.99		55.5		PU	N/A
251	352.11		66.35		PU	N/A
252	352.65		57.75		PU	N/A
253	355.58		63.51		PU	N/A
254	360.87		66.92		PU	N/A
255	368.22		70		PU	N/A

UNIQUE ID	PPM PB	PB Qualifier	PPM As	As Qualifier	Grid Type	Area No.
256	371.15		47		R	N/A
257	371.9		46.45		PU	N/A
258	381.79		85.5		PU	N/A
259	382.84		44.68		PU	N/A
260	385.63		58.71		PU	N/A
261	385.95		47.71		PU	N/A
262	394.8		76.85		PU	N/A
263	424.44		64.84		PU	N/A
264	424.97		49.65		PU	N/A
265	437.2		69.94		PU	N/A
266	439.97		72.47		PU	N/A
267	447.16		53.79		PU	N/A
268	465.81		65.12	J	PU	N/A
269	466.79		54.51	J	PU	N/A
270	475.56		70.66		PU	N/A
271	480.76		87.22		PU	N/A
272	495.68		61.53	J	PU	N/A
273	497.88		64.12		PU	N/A
274	513.51	J	53.7	J	PU	N/A
275	514.45		77.08		PU	N/A
276	515.08		65.34		PU	N/A
277	521.81		71.16		PU	N/A
278	526.5		60	J	PU	N/A
279	534.23		55.89		PU	N/A
280	536.37		104.96		PU	N/A
281	539.18		93.91		PU	N/A
282	557.66		82.07		PU	N/A
283	601.31		61.33	J	PU	N/A
284	606.9		96.87	J	PU	N/A
285	617.65		131.52		PU	N/A
286	628.54		96.42	J	PU	N/A
287	634.33		77.66		PU	N/A
288	649.14		76.13		PU	N/A
289	649.68		111.8		PU	N/A
290	651.84		69.46		PU	N/A
291	662.78		126.57		PU	N/A
292	666.21		72.94		PU	N/A
293	667.57		82.92		PU	N/A
294	689.7		78.38	J	PU	N/A
295	700.85		55.31	J	PU	N/A
296	716.61		113.93	J	PU	N/A
297	722.04		54.75	J	PU	N/A
298	724.79		85.59		PU	N/A
299	739.8		81.79		PU	N/A
300	785.28		85.3		PU	N/A
301	795.67		60.69	J	PU	N/A
302	818.52		71.1		PU	N/A
303	824.06		80.89	J	PU	N/A
304	835.27		57.61		PU	N/A
305	866.72		92.24		PU	N/A
306	871.57		128.69		PU	N/A

UNIQUE ID	PPM PB	PB Qualifier	PPM As	As Qualifier	Grid Type	Area No.
307	894.31		73.54		PU	N/A
308	909.46		56.3		PU	N/A
309	917.06		132.55		PU	N/A
310	936.35		94.36		PU	N/A
311	961.02		68.86		PU	N/A
312	972.16		75.72		PU	N/A
313	976.59		54.37		PU	N/A
314	983.31		98.26		PU	N/A
315	1003.42		77.59	J	PU	N/A
316	1088.96		91.57		R	N/A
317	1142.49		140.39	J	PU	N/A
318	1168.02		72.42		PU	N/A
319	1223.85		68	J	PU	N/A
320	1236.73		122.57		PU	N/A
321	1319.74		103.13	J	PU	N/A
322	1353.8		133.14	J	PU	N/A
323	1400.82		106.19		PU	N/A
324	1689.66		129.45	J	PU	N/A
325	1795.68		93.15	J	PU	N/A
326	1834.87		99.28		PU	N/A
327	1863.59		120		PU	N/A
328	1950.84		133.51		PU	N/A

As - Arsenic
Grid Identifiers removed due to privacy regulations.
J - Estimated Value
Notes:
Pb - Lead
ppm - parts per million
U - not detected