Health Consultation

Apple Trees Recreational Area
(PICA Site 192)

PICATINNY ARSENAL
ROCKAWAY TOWNSHIP, MORRIS COUNTY, NEW JERSEY

EPA FACILITY ID: NJ3210020704

OCTOBER 16, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR 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 which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared By:

Division of Health Assessment and Consultation
Site and Radiation Assessment Branch
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Health Consultation

Picatinny Arsenal

Rockaway Township, Morris County, New Jersey

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ATSDR's evaluation indicates that exposure to arsenic levels in soils of the Apple Trees Recreation Area is not expected to result in adverse health effects based on current recreational land use. Estimated doses associated with exposure to the maximum detected levels of arsenic in soils are lower than those expected to result in illness or disease. None-the-less, to prevent exposure to arsenic in soil and dust, under current conditions, ATSDR recommends that the current grass or other covering be maintained in this area.

I. Background and Statement of Issues

The Agency for Toxic Substances and Disease Registry (ATSDR) is completing a follow-up evaluation of recommendations made in the July 20, 2001 public health assessment. During this process, the Environmental Protection Agency (EPA) asked the ATSDR to evaluate arsenic in soils at the Apple Trees Recreation Area (personnel communication with B. Roach, 07/26/2007). The following health consultation is our response to this request.

II. Discussion - Exposure to Arsenic in Surface Soils of the Apple Trees Recreation Area

The Apple Trees Recreation Area is located in a high-use area near several base housing units, a cafeteria, a tennis court, and golf course. The site is currently covered with grass and mowed regularly. This maintenance is expected to continue in the future [Figures 1 and 2] (Shaw Environmental, Inc. 2004).

Arsenic was detected in surface soil at concentrations ranging from 5.40–251 parts per million (ppm) and in subsurface soil at concentrations ranging from 4.38–22.3 ppm. The source of arsenic at the Apple Trees Recreation Area is believed to be arsenic-based pesticides (specifically lead arsenate) sprayed on apples, not from hazardous waste disposal practices (Shaw Environmental, Inc. 2004). The higher concentrations being located in surface soils is consistent with spray application of pesticides. The contaminated area is estimated at 58,000 square feet (approximately 1.32 acres) with 3,225 cubic yards of soils above 20 ppm arsenic.

At the Apple Trees Recreation Area, exposure could occur via direct or indirect contact with soils containing arsenic—primarily surface soils. During normal activities, people can accidentally ingest soil and dust generated from soils. In fact, everyone ingests some soil or dust every day. The amount of grass cover in an area, the amount of time spent outdoors and indoors, and weather conditions influence how much soil and dust contact people might have.

ATSDR used available soil sampling data from the Apple Trees Recreation Area to estimate site-specific exposure doses. Both adults and children were considered. We focused on the possible ingestion of soil, because dermal (skin) uptake of arsenic from soils is considered negligible (ATSDR 2000a).

Table 1. Arsenic in Picatinny Apple Trees Recreation Area (Site 192)

Surface or subsurface	Maximum value (ppm)	Frequency of Detection > 20 ppm (Detects/Samples)	Ingestion Comparison Value (ppm)*	Comparison Value Source
Surface 0-1'	251 157	63/76 19/29	200 20	EMEG-Adult EMEG-Child
Subsurface 2-3'	22	1/7		

EMEG: Environmental Media Evaluation Guide. EMEGs are based on ATSDR minimal risk levels (MRLs) that consider body weight and ingestion rates. An EMEG is an estimate of daily human exposure to a chemical that is likely to be without noncarcinogenic health effects over a specified duration of exposure to include acute, intermediate, and chronic exposures. The EMEGs presented here are for chronic (daily exposures).

Because the arsenic concentrations exceeded ATSDR's screening values, ATSDR estimated human exposure doses using site-specific exposure conditions.

As an initial evaluation, ATSDR made several assumptions when estimating site exposure doses. These assumptions were based on a hypothetical exposure scenario and the assumptions on soil concentration, exposure frequency, and bioavailability probably overestimate actual exposure. Our general assumptions and findings are discussed below and presented in Table 2.

- *Soil arsenic concentration.* Because residences are less than 100 feet to the north of the recreational area (Shaw Environmental, Inc. 2004), we considered chronic ingestion of the maximum arsenic concentration which was 251 ppm. Actual exposure to soil concentrations may be as low as 5.40 ppm.
- *Soil intake.* We assumed soil ingestion rates of 100 and 200 mg/day for adults and children, respectively. These rates are standard defaults used by health scientists and represent the amount of soil that might be incidentally ingested on a daily basis (EPA 1997b); 200 mg/day equates to ingesting approximately 1/16 of a teaspoon.

  Some children have a much higher tendency to ingest soil and other non-food items. This is known as pica behavior which results in higher than normal soil consumption rates (an ingestion rate of 5,000 mg/day or approximately one teaspoon/day). Pica children could conceivably consume a teaspoon or more of contaminated soil each day. No documentation of pica exposure has been identified, to our knowledge, at the Picatinny Apple Trees Recreation Area so we did not consider pica consumption rates.
- *Exposure duration and frequency.* ATSDR estimated exposure doses assuming daily exposure. In reality, persons would not be exposed to contaminated soil every day

because they would not be at the recreation area every day and in the winter, the site would be covered with snow.

- *Bioavailability.* Arsenic in water has been shown to be easily absorbed across the gastrointestinal tract (ATSDR 2000b). However, this is not so with arsenic in soil. Extensive studies of arsenic bioavailability reveal that the human body absorbs only a portion of the arsenic that is present in a soil matrix. Bioavailability is dependent on the specific arsenic form and soil type. The best measure of bioavailability is testing designed to quantify uptake under site-specific conditions (Battelle and Exponent 2000). Because no site-specific bioavailability factors are available, ATSDR assumed that 50% of the arsenic in soil would actually be absorbed in the body once ingested. The selected value represents the high end of the range of "bioavailability factors" reported in the scientific literature (ATSDR 2000b; Oomen et al. 2002; Ruby et al. 1999; WHO 2001). Using the high end of this bioavailability range probably overestimates exposure.

Using the above assumptions, ATSDR estimated the exposure doses for adults and children to be 0.0002 and 0.002 mg/kg/day, respectively. As shown in Table 2, these estimated exposure doses are safer than ATSDR's minimal risk level (MRL), the No-Observed-Adverse-Effect-Level (NOAEL), and the Lowest-Observed-Adverse-Effect-Level (LOAEL).

Table 2. Estimated Arsenic Exposure Doses Compared to Screening Values and Observed Effect Levels

Exposure Situation	Exposure Concentration	Estimated Exposure Dose (mg/kg/day)		MRL (mg/kg/day)	NOAEL* (mg/kg/day)	LOAEL* (mg/kg/day)
		Adult	Child			
Chronic Exposure to Maximum concentration	251 ppm	0.0002	0.002	0.0003	0.0008	0.014
Chronic Exposure to Screening Value concentration	20 ppm**	0.00001	0.0001	0.0003	0.0008	0.014

* Screening levels and observed effect levels are based on the following principle studies: Mizuta et al. 1956 and Tseng et al. 1968.

** The arsenic soil EMEG of 20 ppm is shown for comparison purposes because 20 ppm is the soil concentration that is used by ATSDR as a screening value for a child's exposure to arsenic.

ppm: parts per million

MRL: Minimal Risk Level. 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) non-cancerous effects.

NOAEL: No-Observed-Adverse-Effect-Level. The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects in people or animals.

LOAEL: Lowest-Observed-Adverse-Effect-Level. The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Interpreting Arsenic Exposures

While researchers have studied situations in which people have been exposed to arsenic in drinking water, little data exist specifically describing the effects resulting from exposure to arsenic in soils. Further, deficiencies in the drinking water studies make interpretation difficult. Examples of such deficiencies include:

- exposure levels are not well documented,
- the studies fail to account for a number of complicating factors, including exposure to other sources of arsenic or genetic susceptibility to arsenic, and
- nutritional status of the exposed populations is missing.

Although exposure situations described in the literature might not be fully analogous and soil exposure data might be sparse, the available health effects data provide a relative sense of the magnitude of arsenic exposures shown to result in harmful effects.

An understanding of how arsenic behaves once it is ingested provides additional perspective on the estimated arsenic exposure doses. Once a substance enters the body, it is absorbed, metabolized (i.e., changed or broken down), distributed through the body, and then excreted.

Various studies indicate that at low-level exposures, arsenic compounds are detoxified (or metabolized)—that is, changed into less harmful forms—and then excreted in the urine. More specifically, once arsenic is absorbed into the bloodstream, it eventually passes through the liver where some of the inorganic arsenic is changed into organic forms of arsenic (a process known as methylation).

When the body's capacity to detoxify is exceeded, blood levels of arsenic increase and adverse health effects can occur. Limited data suggest that the dose at which this happens is somewhere between 0.003–0.015 mg/kg/day (ATSDR 2000a). ATSDR's estimated site-specific exposure doses (0.0002 mg/kg/day for an adult and 0.002 mg/kg/day for a child) fall below this range, indicating that effective breakdown and excretion of arsenic should occur at the exposure levels estimated for the Apple Trees Recreation Area.

The Body's Ability to Detoxify Arsenic

As noted in the text, our bodies have the ability to change inorganic arsenic into less harmful forms and excrete it. This occurs through a process known as "methylation." Recent data suggest that arsenic affects some people more than others. This could be due to genetic differences related to methylation capacities. Differences in individual sensitivities, however, have not been quantified (Chung et al. 2002). While capacity questions clearly remain, the available data indicate that the body can safely handle exposures to the levels of arsenic measured in Apple Orchard soils.

Health Effects Evaluation Findings

ATSDR evaluated possible non-cancer and cancer effects. In all cases, estimated arsenic doses fall below the lowest dose shown to be associated with adverse health effects. The lowest-observed-adverse-effect level (LOAEL) represents the lowest tested use of a substance that has been reported to cause harmful (adverse) health effects. The LOAEL reported in the literature for arsenic is associated with skin lesions observed in people drinking arsenic-contaminated water. Cancer outcomes have been reported at comparable and higher levels.

How estimated arsenic doses compare to MRLs and observed effect levels

Whether harmful effects will occur depends—as with all toxicants—on both the intensity (how much) and duration (how long) of the exposure. Much of what is known about arsenic toxicity relates to high or "poisonous" levels of exposure (e.g., occupational exposures following an accidental release). Health effects associated with arsenic have been relatively well studied. But much uncertainty still exists regarding the effects caused by arsenic at relatively low environmental exposures, such as those associated with the Apple Trees Recreation Area.

Inorganic arsenic has been shown to affect multiple systems in the human body, including the gastrointestinal (stomach and intestines), hepatic (liver), renal (kidney), cardiovascular (heart and circulatory), blood and bone marrow, central nervous, skin, respiratory, and reproductive systems.

The hallmarks of chronic (long-term) inorganic soluble arsenic ingestion include skin changes, peripheral neuropathy (a condition characterized by weakness in the extremities caused by

damage to the nerves leading to these areas), and anemia (ATSDR 2000b). Hyperpigmentation (darkening of the skin in small blotches) and hyperkeratosis (the formation of excess keratin, in the form of warts or corns) are the most common or characteristic effects of arsenic ingestion. The lowest dose at which hyperpigmentation and hyperkeratosis has been reported in the literature is 0.014 mg/kg/day. This value is based on observations in a Taiwanese population exposed to arsenic in drinking water for about 45 years (Tseng et al. 1968). Note also that exposure has to occur for 10 to 40 years before damage to the skin occurs.

Estimated cancer risk

EPA, IARC, and NTP have classified arsenic as a known human carcinogen. Chronic ingestion of soluble forms of inorganic arsenic is strongly associated with an increased risk of skin cancer. Arsenic is possibly associated with cancers of the lung, liver, bladder, kidney, and colon, but less is known about the association between inorganic arsenic and these internal organ cancers.

The estimated increase in cancer risk depends on the land use, which in turn determines the frequency of exposure. Because current land use is for recreation activities, EPA conducted a risk assessment for *recreational* exposure in the Apple Trees Recreation Area. EPA's risk assessment estimated cancer risk levels below 10^{-4}, EPA's acceptable risk range (personnel communication with B. Roach, EPA RPM, on 7/26/07). Because land use could change in the future, ATSDR considered estimated risks for future residential exposures. The Army's estimated risks for future residential exposures were 2.9×10^{-4} for an adult and 2.5×10^{-4} for a child with a total adult and child resident estimated cancer risk of 5.4×10^{-4} (Shaw Environmental, Inc. 2004). Although these estimated risks would exceed EPA's acceptable risk range, ATSDR's estimated exposure dose of arsenic for adults (0.0002 mg/kg/day) is safer (70 times lower) than the lowest dose of arsenic (0.014 mg/kg/day) that has been shown to cause cancer in humans (Tseng et al. 1968).

III. Conclusions

ATSDR's evaluation indicates that exposure to arsenic levels in soils of the Apple Trees Recreation Area is not expected to result in adverse health effects based on current land use as *recreational*. Estimated arsenic doses for site contamination fall below the lowest dose shown to be associated with adverse health effects. Effective breakdown and excretion of arsenic should occur at the exposure doses documented for the Apple Trees Recreation Area.

Even for a *residential* land use scenario, no adverse health effects are expected for children with a chronic soil ingestion rate of 200 mg/day or approximately 1/16 of a teaspoon (the standard default amount used for incidental ingestion by children).

IV. Recommendation

To minimize exposure to arsenic in soil and dust, under current conditions, ATSDR recommends that a grass or other covering be maintained in this area.

If the land use is altered to allow more frequent exposure to soils, additional risk mitigation procedures may be necessary.

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VI. References

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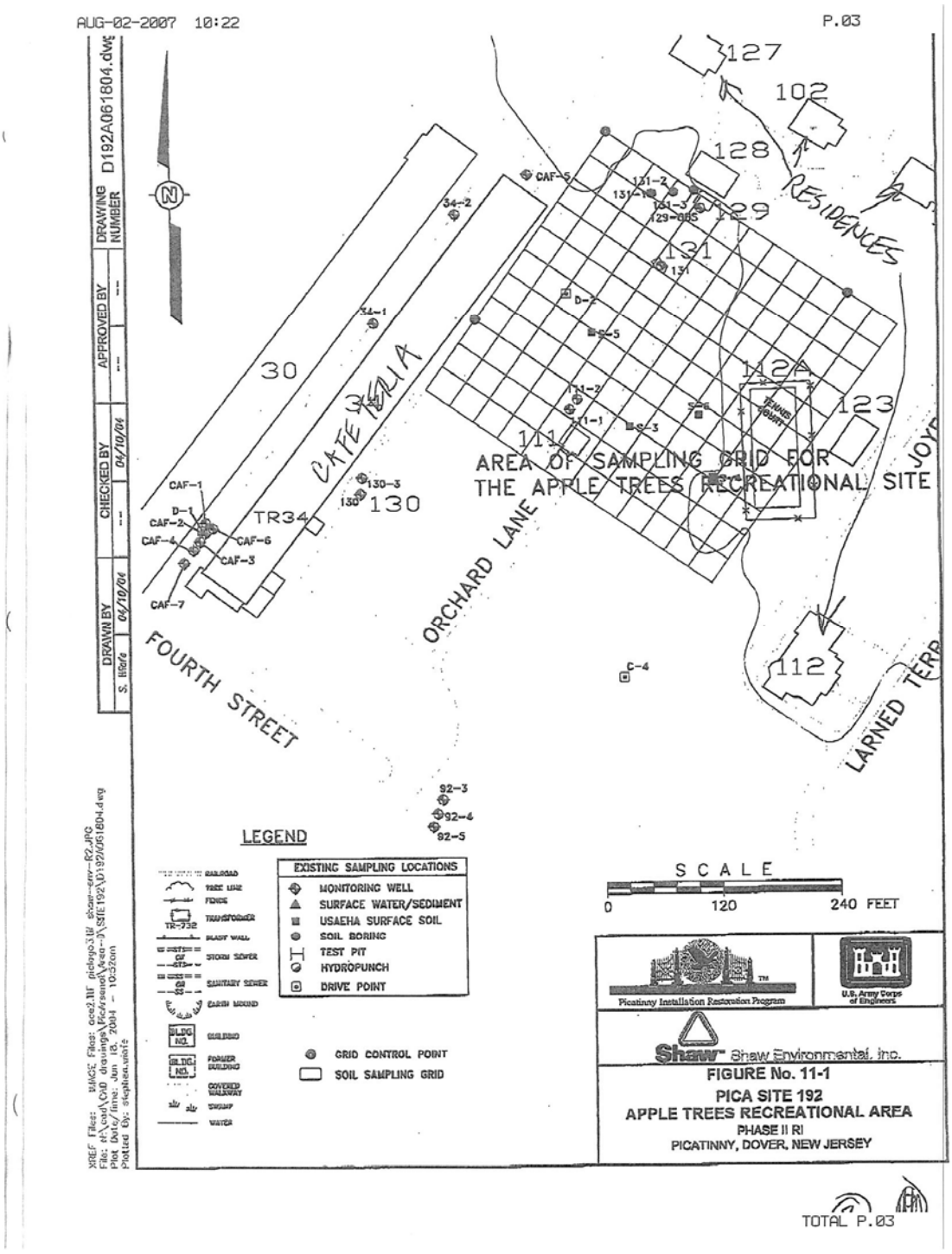

Figure 1 Sampling Grid for the Apple Trees Recreational Site

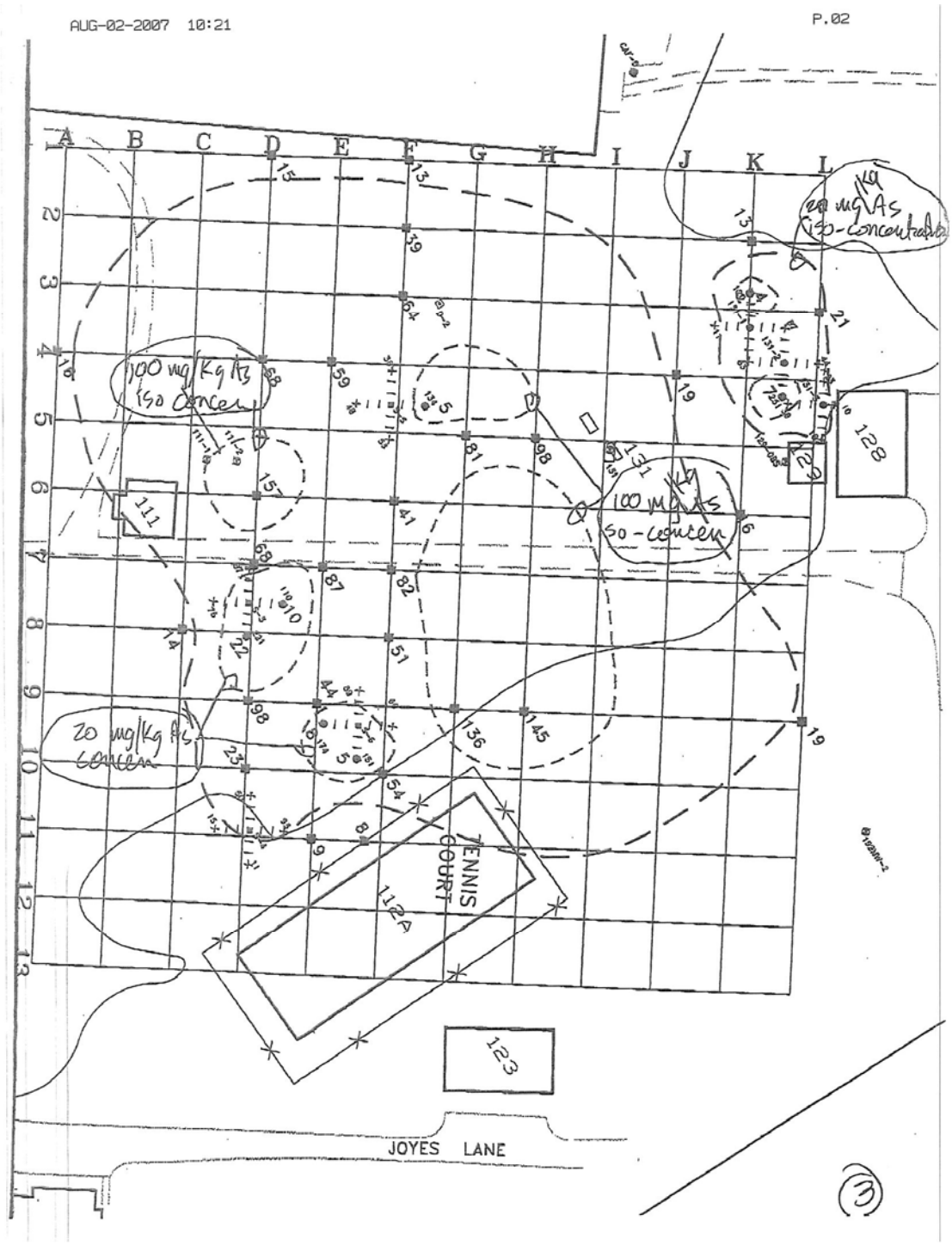

Figure 2 Contaminated Areas within the Sampling Grid

Appendix I.
Approach to Comparison Values

To study possible health effects one needs to understand the amount of arsenic that people might have come in contact with or might have been exposed to. This is done by looking at detected arsenic concentrations and applying various "exposure factors" (e.g., intake rate, exposure duration, etc.) and estimating "exposure doses." Many of the studies in the scientific literature relate exposure doses to observed health effects. Evaluating exposure doses under site-specific but conservative (protective) exposure conditions allows comparisons between site doses and doses reported in the scientific literature that are associated with harmful effects.

Using Exposure Doses to Evaluate Potential Health Hazards

ATSDR performs an evaluation to determine whether exposures might be associated with adverse health effects (non-cancer and cancer). As part of this process, ATSDR examines relevant toxicologic, medical, and epidemiologic data to determine whether estimated doses are likely to result in adverse health effects. As a first step in evaluating non-cancer effects, ATSDR compares estimated exposure doses to standard health guideline values, including ATSDR's minimal risk levels (MRLs) and the U.S. Environmental Protection Agency's (EPA's) reference doses (RfDs). The MRLs and RfDs are estimates of daily human exposure to substances that are unlikely to result in non-cancer effects over a specified duration. Estimated exposure doses that are less than these values are not considered to be of health concern. To be very protective of human health, MRLs and RfDs have built in "uncertainty" or "safety" factors that make them much lower than levels at which health effects have been observed. Therefore, if an exposure dose is much higher than the MRL or RfD, it does not necessarily follow that adverse health effects will occur.

To evaluate carcinogens, ATSDR compares the exposure levels to cancer effect levels that have been shown to cause cancer in animals or humans. In addition, ATSDR may calculate quantitative estimates of risk using EPA's cancer slope factors. These cancer estimates are based on conservative models and assumptions, so the actual risk may be substantially less than the calculated value.

If health guideline values are exceeded, ATSDR examines the effect levels seen in the literature and more fully reviews exposure potential to help predict the likelihood of adverse health outcomes. Specifically, ATSDR examines "no-observed-adverse-effect levels" (NOAELs) or the "lowest-observed-adverse-effect levels" (LOAELs) for the most sensitive outcome for a given route of exposure (e.g., ingestion or skin contact). ATSDR looks at human studies, when available, as well as experimental animal studies. In the case of arsenic, a great deal of human data is available, though most is related to water and air exposures versus soil exposures. For cancer effects, ATSDR also reviews genotoxicity studies to further understand the extent to which a contaminant might be associated with cancer outcomes. This process enables ATSDR to weigh the available

evidence, in light of uncertainties, and offer perspective on the plausibility of adverse health outcomes under site-specific conditions. Reviewing the scientific literature in this way enabled ATSDR to evaluate the range of dose levels that may be associated with the substance being evaluated and the characteristics of that substance that may make adverse health effects less or more likely.