Health Consultation

Review of Environmental Sampling Data

PORTSMOUTH MANUFACTURED GAS PLANT SITE
(a/k/a COMMONWEALTH GAS SERVICES)

PORTSMOUTH, PORTSMOUTH COUNTY, VIRGINIA

EPA FACILITY ID: VA0001142215

APRIL 24, 2003

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:

Exposure Investigation and Consultation Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

Background and Statement of Issues

The Virginia Department of Environmental Quality (DEQ) requested that the Agency for Toxic Substances and Disease Registry (ATSDR) review environmental sampling data collected on and near the site of the former Portsmouth Manufactured Gas Plant, Portsmouth, Virginia, and identify potential health hazards to past and current residents [1].

The site is located northwest of the intersection of Effingham Street and Crawford Parkway, with Washington Street to the east and the U.S. Naval hospital to the north (Figure 1). A manufactured gas plant was operated on the site from 1856 through 1956. In the early 1960s, residential apartments and single -family houses were built on and near the decommissioned site. Environmental activities including investigations, assessments, and remediations have been conducted at the site since 1992 [2-3]. Following are descriptions of some of these activities.

- Phase I and II investigations—In 1992, MARCOR Delmarva, Inc., conducted limited investigation and surface soil sampling for one of the apartment complexes on the site.
- Initial site investigation and health risk assessment—In 1993, Geraghty & Miller, Inc., (G&M) collected soil vapor samples, surface soil samples, and groundwater samples to evaluate human health risks for current residents.
- Remedial investigation and corrective measures study—In 1993 and 1994, G&M collected additional samples of groundwater, subsurface soil, and storm sewer water to complete the human health risk evaluation, and to identify and select appropriate remedial actions for the site.
- Supplemental groundwater sampling and monitoring—In 1995 and 1999, Environmental Resources Management (ERM) collected additional groundwater samples from both monitoring and nonpotable wells to confirm findings observed previously.
- Surface and residential soil sampling—In 1998 and 1999, ERM collected more surface soil samples (0-6 inches) to better define the concentrations of contaminants at exposure points.
- Indoor and outdoor air sampling—In 2000 and 2001, indoor and outdoor samples were collected from different locations at the site to evaluate risks associated with inhalation exposures from soil gas migration.
- Site investigation and confirmation sampling—From fall 2001 to summer 2002, the RETEC Group, Inc. (RETEC), conducted a comprehensive site investigation that included more than 500 samples for soil, groundwater, and air.
- Remediation activities—Remediation activities conducted at the site include free product (mainly diesel fuel) recovery from monitoring wells, storm sewer pipe lining to reduce odors and sheens observed at the storm sewer outfall in the Elizabeth River, irrigation well replacement with deeper wells or connections to the public water system, and surface soil removal in the Patio Plaza courtyard area and in the backyards of some residential houses on Washington Street.

Table 1 is a summary of sampling activities and chemical analysis for all media samples at the site. The purpose of this health consultation is to review environmental sampling data and identify potential health hazards associated with air, groundwater, and surface soil exposure pathways for specific locations on the site.

ATSDR's Evaluation Process

The potential health effects from environmental exposures depend on many factors such as type and amount of contaminants, route and duration of exposure, amount of contaminants absorbed by the body, site-specific conditions, genetic factors, and individual lifestyles. ATSDR provides public health advice on the basis of a review of the toxicologic literature, a comparison of levels of environmental contaminants to published health standards, an evaluation of exposure routes and duration, and the populations exposed.

Contaminants may be contacted through activities that involve touching them (dermal contact), breathing them in (inhalation), or accidentally drinking or eating them (ingestion). A completed exposure pathway is said to exist when information shows that people have come into contact with a contaminant in soil, air, or water. Completed exposure pathways can be either in the past or the present.

ATSDR uses different comparison values (chemical-specific, health-based standards and guidelines) derived by various government agencies to screen contaminants and identify those that could require further evaluation of their potential to cause adverse health effects. While concentrations at or below the relevant comparison values might reasonably be considered safe, concentrations above these values will not necessarily cause harm. ATSDR uses site-specific exposure scenarios and performs a more in-depth evaluation for substances with detected concentration levels above the screening values.

Information on ATSDR comparison values and definitions is provided in Appendix A.

Discussion

Environmental sampling results were grouped into three categories: air, groundwater, and surface soil. The results are discussed in the following paragraphs.

Air Sampling Results

Since 1993, ninety-five samples have been taken of soil vapor and indoor and outdoor air at the site. Air samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), total petroleum hydrocarbons, and mercury vapor. Air sampling included soil vapor sampling and indoor and outdoor air sampling for the Patio Plaza Apartments and Gates Apartments, air sampling during the site investigation, and mercury vapor sampling for one residence.

Soil vapor sampling

During the initial site investigation and health risk assessment in 1993, there were 34 soil vapor samples (also known as soil gas samples) collected to characterize the concentrations of site-related chemicals volatilized from soil. Additional soil vapor samples (6) were collected in early 2001 at the Patio Plaza Apartments and the Gates Apartments to verify the potential for gas migration. Site-related chemicals identified include BTEX compounds (benzene, toluene, ethylbenzene, and xylenes), polycyclic aromatic hydrocarbons (PAHs), and other VOCs and SVOCs. Soil vapors can enter residences and other buildings through foundation cracks and gaps, mechanical ventilation systems, and leakage areas (for example, utility entry points, construction joints, and drainage systems). They can also enter though mechanical ventilation systems and are affected by pressure differences between the inside and outside of buildings. Soil vapor monitoring results do not provide actual measurements of concentrations of contaminants that people may inhale. Therefore, the results of the soil vapor monitoring were used in setting up both indoor and outdoor air monitoring to evaluate air contamination at points of exposure.

Indoor and outdoor air sampling for the Patio Plaza and Gates apartments

In November 2000 and January 2001, indoor and outdoor samples were collected from different site locations to evaluate hazards associated with inhalation exposures from soil gas migration. Three background samples were taken outdoors. Six indoor air samples were collected at the Patio Plaza and Gates apartment complexes. Samples were analyzed for VOCs following EPA method TO-14A guidelines. BTEX and 13 other VOCs were detected. With the exception of benzene and methylene chloride, all of the chemicals detected were below their applicable health-based guidelines. Benzene and methylene chloride were detected at average levels of 0.89 $\mu g/m^3$ and 10.97 $\mu g/m^3$, respectively. ATSDR established acute and intermediate environmental media evaluation guides (EMEGs)/minimal risk levels (MRLs) for benzene as 160 $\mu g/m^3$ and 13 $\mu g/m^3$, respectively [4]. The ATSDR acute EMEG/ MRL for methylene chloride is 2,084 $\mu g/m^3$, and the intermediate and chronic EMEG/MRL is 1,042 $\mu g/m^3$. Therefore, the levels of benzene and methylene chloride detected in samples from the Patio Plaza and Gates apartments were not at levels likely to cause adverse noncarcinogenic health effects for short-term, intermediate term, or long-term exposures.

ATSDR has developed cancer risk evaluation guides (CREGs) to aid in evaluating carcinogenic effects. The CREG for benzene is 0.1 $\mu g/m^3$, and the CREG for methylene chloride is 3 $\mu g/m^3$ [4]. CREGs are estimated contaminant concentrations in air that would be expected to cause no more than one excess case of cancer in a million persons exposed over a lifetime. ATSDR used the EPA region 3 cancer slope factors (CSFs) for a cancer risk evaluation. CSFs are based on conservative models and assume continuous, lifetime exposure. A conservative risk evaluation concluded that residents exposed through inhalation to these two chemicals at these levels throughout their lifetimes would have no apparent increased risk of developing cancer. This conservative risk evaluation is discussed in more detail in Appendix B.

Air sampling during the site investigation

The most recent air sampling data was collected by RETEC during the site investigation and confirmation sampling conducted from fall 2001 to the summer of 2002. Forty-two samples were collected for VOC analysis following EPA method TO-14A guidelines. The air samples were analyzed for 64 compounds. Thirty-seven of these 64 compounds (57%) were detected. Table 2 provides a summary of all air data for the site investigation and confirmation sampling.

All VOCs were detected at levels below those likely to cause adverse noncarcinogenic health effects for short-term, intermediate term, and long-term exposures. However, concentrations of five VOCs (1,3-butadiane, benzene, chloroform, methylene chloride, and tetrahydrofuran) exceeded their respective CREGs. The Virginia Department of Environmental Quality specified as an area of special concern the indoor air quality at the Patio Plaza apartments. Table 3 provides a list of the locations of the indoor air sampling at the Patio Plaza apartments. On the basis of the following site-specific exposure scenarios and the conservative risk evaluation, it is unlikely that an increase in cancer incidence would occur in the community.

- The average concentrations of benzene and chloroform are 5.46 $\mu g/m^3$ and 5.86 $\mu g/m^3$, respectively, for the Patio Plaza area.
- 1,3-butadiene (11 $\mu g/m^3$) and tetrahydrofuran (27 $\mu g/m^3$) were detected only once at one sampling location (IAPP31) in the Patio Plaza area. Continuous lifetime exposure to 1,3-butadiene is highly unlikely as this chemical was detected in only one sample. Short-term, intermittent exposures to the reported concentration of 1,3-butadiene would not be expected to pose a health hazard.
- The highest concentrations (9,900 $\mu g/m^3$, 590 $\mu g/m^3$, and 520 $\mu g/m^3$) of methylene chloride were found in one sampling location (IAPPD). The average concentration of methylene chloride for all other sampling locations was below the level of health concern.
- Previous air samples taken from the same building in which the IAPPD sample was taken detected concentrations of methylene chloride below the level of health concern.
- Methylene chloride is a colorless liquid used widely as an industrial solvent and as a paint stripper. The chemical may be found in some spray paints, automotive cleaners, pesticides, and in other household products [5]. Methylene chloride is the most common laboratory analysis artifact introduced in laboratory sample preparation [6]. Therefore, multiple sources may contribute to the high concentrations of methylene chloride in the IAPPD sample.
- There were other VOCs (for example, 2-proponol, acetone, ethanol, and toluene) detected at relatively high concentrations from sampling locations IAPP31 and IAPPD. Although it is possible that high VOC concentrations were caused by recent building maintenance activities (for example, applying pesticides, painting, or installing new carpets) during the time of sampling, additional samples should be taken to ensure that the levels of VOCs are safe for future residents.

Mercury vapor sampling

Mercury occurs naturally in several forms and is typically found in the environment at very low levels. The average ambient air concentration of mercury reported values in the United States. range from approximately 0.010 $\mu g/m^3$ to 0.020 $\mu g/m^3$ [7]. In December 2001, four vapor samples were collected from one residence and analyzed for total mercury following NIOSH (National Institute for Occupational Safety and Health) method 6009. The average mercury concentration was 0.9 $\mu g/m^3$. ATSDR's inhalation MRL for chronic mercury exposure is 0.2 $\mu g/m^3$ [4]. This chronic MRL is an estimate of daily human exposure to mercury that is likely to be without an appreciable risk of adverse noncarcinogenic health effects for the entire life of a person (estimated as 70 years). It is based on a lowest-observed-adverse-effect level (LOAEL) for hand tremor induced by industrial exposure in humans, with a safety factor of 30 for human variability and use of a minimal LOAEL [7]. Although the average mercury concentration is above the respective MRL, actual exposure to mercury in this home would likely be less than the measured level for the following reasons.

1. Indoor air samples were taken when indoor-outdoor air exchange was low (the house was not occupied and the doors and windows were kept closed during the sampling); the results therefore represent a worst-case scenario. The actual average daily mercury exposure for residents would be less than that indicated by the sample results.
2. Mercury vapor concentration is likely to be higher near the floor. Adults with higher breathing zones may be exposed to lower concentrations of mercury. When the house was occupied, there were no children living there.
3. It is unlikely that residents would be exposed throughout their entire lifetimes. Their risk of adverse health effects from exposure to mercury at the location would therefore be reduced.
4. Recent remediation activities in the backyard (surface soil removal and replacement) could reduce the level of mercury concentration in the house. However, the level of mercury concentration in the house should be verified for the safety of future residents, especially for young children and pregnant women. Additional information on exposure and children is given in the Child Health Consideration section.

Epidemiologic studies found no evidence that linked inhaling metallic mercury to cancer in humans [7].

Groundwater Sampling Results

One hundred and twenty-four groundwater samples have been taken on the site since 1993. The samples were collected from 26 monitoring wells and 13 residential irrigation wells. Water samples were analyzed for 182 substances including metals, VOCs, SVOCs, total petroleum hydrocarbons, diesel range organics, gasoline range organics, and cyanide. Of the 182 substances, 49 (27%) were detected in the irrigation wells. Shallow groundwater (4 feet below ground surface) was heavily impacted by past operations and is not the source of drinking water for the community. Area groundwater in the area is used for limited residential irrigation.

ATSDR was asked specifically to evaluate past exposure for an abandoned irrigation well. The well was sampled in June 1993 and November 1999 (sample location NPW214WAS). Of the 34 substances analyzed for, 16 different substances (47%) were detected. Among the detected chemicals, nine were VOCs. With the exception of benzene, concentrations of all detected chemicals were below their applicable health-based guidelines. Benzene was detected at concentrations of 200 $\mu g/m^3$ and 270 micrograms per liter ($\mu g/L$). The ATSDR drinking water CREG for benzene is 0.6 $\mu g/L$. The CREG represents an estimated benzene concentration in water that would be expected to cause no more than one excess case of cancer in a million persons exposed using default exposure assumptions (such as an ingestion rate of two liters of water per day over a lifetime for adults). However, the most likely exposures to contaminated groundwater at the location in the past were through infrequent dermal contact and through inhalation of vaporized VOCs by residents working in their yards. Following are site-specific exposure scenarios. Infrequent exposures occurring in these situations were not likely to cause any adverse health effects.

- People who use groundwater from shallow wells for watering plants or gardens or in doing other yard work might have occasional dermal contact. Using conservative exposure risk assumptions, the levels to which persons would be exposed were found to be far below the applicable health-based guidelines. (Appendix B provides information on exposure dose calculations.)
- Water might be sprayed into the air during gardening or other watering activities. This could result in the transfer of benzene from water to air and subsequent inhalation exposure. This exposure pathway is not considered to be significant, however, because the small amount of benzene in the water would be dissipated into a large volume of outdoor air.

Table 4 provides a summary of all water data for sample location NPW214WAS.

Surface Soil Sampling Results

A potential exposure pathway for residents at the site is the accidental ingestion (swallowing) of contaminated soil. This exposure can occur when people have direct contact with soil in their environment. For instance, children playing outside or crawling on floors and adults working in yards and gardens may get contaminated soil or dust on their hands. These individuals can then accidentally swallow contaminants when they put their hands on or into their mouths. Because both people and pets can track contaminated soil into their homes, exposure can occur while people are in their homes as well as when they are outside. Factors that affect whether or not people have contact with contaminated soil include the amount of grass cover, weather conditions, the amount of time spent outside, and personal habits. While dermal and inhalation exposure can sometimes be a concern for soil and dust, the primary pathway of concern in a nonoccupational setting is ingestion.

Approximately 600 soil samples, both surface and subsurface, were taken at this site, starting in 1992. Soil samples were analyzed for VOCs, SVOCs, total petroleum hydrocarbons, metals, and total and free cyanide. ATSDR evaluated surface soil (0-12″ deep) sample results for locations of concern at the site. Surface soil sample data are grouped into three categories (arsenic; lead and mercury; and all chemicals in the Patio Plaza area) and discussed in the following sections.

Arsenic

Arsenic is a naturally occurring element, present at low levels in soil, water, food, and air throughout the world. The U.S. Geological Survey reports the background range of arsenic in soil and other surficial materials in the United States as less than 0.1 mg/kg to 97 mg/kg, with a mean value of 7.2 mg/kg [8]. The background level for arsenic in soil in Virginia ranges from 3 mg/kg to 7 mg/kg (Figure 2) [9].

Twenty-four surface soil samples were taken from July 1998 to August 2001 from a private residence that was a location of concern [1]. Arsenic concentrations ranged from 6.6 mg/kg to 110 mg/kg, with an average of 37.5 mg/kg (Table 5).

The ATSDR chronic EMEGs for adults and children are 200 mg/kg and 20 mg/kg, respectively [4]. There were 10 surface soil samples (42%) that contained arsenic at levels above 20 mg/kg, exceeding the chronic EMEG for children. ATSDR used information from a Taiwanese drinking water study to develop this EMEG and determine the lowest intake amount likely to result in an adverse noncancerous health effect (lowest-observed-adverse-effect level or LOAEL). In this case, the LOAEL is a daily intake of about 800 micrograms of arsenic a day. Because arsenic is more bioavailable in drinking water than in soil, the soil EMEGs for arsenic, which do not take bioavailability into account, are more conservative than the drinking water EMEGs. In addition, most of the residential yard was well covered by vegetation. Therefore, ATSDR does not expect adverse health effects to occur in either children or adults who were exposed in the past to the levels of arsenic found in the soil at the residence.

To prevent current and future exposure, the surface soil in this location was recently removed and replaced with clean fill material as part of the site remediation activities. Four confirmation samples and two backfill material samples taken after the removal indicated that the arsenic concentrations (estimated highest value is 2.6 mg/kg) were well below levels of health concern.

Lead and Mercury

Lead is another naturally occurring element found in small amounts in the earth's crust. The general population in the United States is exposed to lead in air, food, drinking water, soil, and dust. Multimedia contamination of lead in residential areas results from many different sources such as lead-based paint, old plumbing fixtures, and from soil and dust contaminated by combustion of leaded gasoline and other industrial sources [10]. The background level for lead in soil in Virginia ranges from approximately 13 mg/kg to 23 mg/kg (Figure 3) [9].

Health effects of lead exposure depend on the concentration of the lead, the amount of lead absorbed by the body, the duration of the exposure, and on the age and nutritional status of the exposed individual. The main target for lead toxicity is the nervous system [10]. For adults, long-term exposure to high levels of lead, mainly through occupational exposure, has resulted in brain and kidney damage; weakness in fingers, wrists, or ankles; decreased performance on nervous system function tests; and a lower than normal number of blood cells [10]. Some human studies have suggested that lead exposure may increase blood pressure, but the evidence is inconclusive. However, the connection between all of these health effects and exposure to low levels of lead is not certain [10]. There is no evidence that lead causes cancer in humans [10]. Children are more vulnerable to lead poisoning than adults are. Additional information on the unique vulnerability of children is provided in the Child Health Consideration section of this document.

Since 1998, 29 samples of surface soil have been collected from the residence of concern [1] and analyzed for lead contamination [1]. Lead concentrations ranged from 12.2 mg/kg to 1,500 mg/kg, with an average of 385 mg/kg (Table 6).

ATSDR considers levels of lead above 400 mg/kg in residential soil to need further evaluation because of children's unique susceptibility (discussed in the Child Health Initiative section) [10]. EPA defines health hazard levels for lead as follows: (1) more than 400 mg/kg of lead in play areas of bare, residential surface soil; (2) 1,200 mg/kg of lead (average) in bare soil in the remainder of the yard [11].

Of the 36 surface soil samples, 8 (22%,) were found to have lead levels above 400 mg/kg. Representatives of ATSDR, the Virginia Department of Environmental Quality, NiSource (previous owner of MTG), and the RETEC Group (NiSource's consulting firm) conducted a site visit to the residence. They observed that the backyard was not well covered with grass and that some sampling locations that had been detected as having lead levels above 400 mg/kg were relatively close to the back porch of the house, providing children with relatively easy access to

the "hot spots." Therefore, for past exposures, lead-contamination in surface soil at the location presented a potential health hazard for children, particularly those younger than 2 years of age. Surface soil in this location was removed and replaced with clean fill material as part of the site remediation activities conducted in the spring of 2002. Two confirmation samples and two backfill material samples taken after the removal indicated that the lead concentrations were well below levels of health concern (Table 6).

Mercury also occurs naturally in the environment and exists in several forms (metallic, inorganic, and organic mercury). The U.S. Geological Survey reports that the background range of mercury in soil and other surficial materials in the United States is less than 0.01 mg/kg to 4.6 mg/kg, with a mean value of 0.09 mg/kg [9]. Because most of the mercury found in soil is in the form of metallic mercury (that is, elemental mercury) and inorganic mercury (elemental mercury combined with elements such as chlorine, sulfur, or oxygen), health-related comparison values used in this document are for inorganic mercury. Thirty-six surface soil samples were taken from the residence from July 1998 to August 2001 [1]. Mercury concentrations ranged from 0.29 mg/kg to 360 mg/kg, with an average of 42.8 mg/kg (Table 6).

Children who ingested this soil could have exceeded the acute and intermediate MRLs for mercury. (Appendix B provides information on the dose calculations on which this determination was based.) Mercury contamination in soil at the residence, however, was reportedly in the form of elemental mercury. Elemental mercury is poorly absorbed from the gastrointestinal tract, so the actual absorbed dose of mercury would be much less than the calculated amount. In addition, the oral MRLs for mercury were derived on the basis of studies in which laboratory animals were given mercuric chloride dissolved in water. Use of these MRLs would overestimate the risk of ingesting elemental mercury, which, as mentioned previously, is poorly absorbed through the gastrointestinal tract. For adults, the estimated doses are less than the oral MRLs. This would indicate that no adverse health effects would result from past exposure to surface soil through ingestion. Furthermore, the soil at the residence has been remediated and current and future exposure to the soil does not pose a health hazard.

Chemicals in the Patio Plaza Apartments

The Patio Plaza Apartments are multifamily apartment buildings that were built on the former MGP property. Overlay maps of the apartments and former MGP operations indicate that some MGP structures had been underground in the apartment area (for example, gas holders, relief holders, purifiers, and oil storage tanks). Approximately 81 surface soil samples have been taken in the Patio Plaza apartment area since 1992. Those surface soil samples were analyzed for metals, VOCs, SVOCs, and total petroleum hydrocarbons.

In 2000, surface soil in the Patio Plaza courtyard area was removed to a depth of one foot and replaced with clean fill material. Small areas of surface soil between the sidewalk and building were not replaced.

ATSDR reviewed available data for the years 1993 to 2001 to evaluate exposure prior to the remediation and exposure to soil at locations that were not remediated. Table 7 provides a summary of surface soil data for samples taken at the Patio Plaza apartment area before the removal. Table 8 provides a summary of surface soil data for samples taken at locations that were not remediated.

Before the surface soil removal, 38 surface soil samples were taken during the time period of 1993 to 1999 at the Patio Plaza apartment area. Of the 92 substances analyzed for, 52 different substances (57%) were detected in the surface soil samples. All chemicals were detected at levels below those likely to cause adverse health effects (noncarcinogenic) for short-term, intermediate term, and long-term exposure. However, concentrations of five chemicals exceeded their respective CREGs or risk-based concentrations (RBCs) [12]. These chemicals are arsenic, benzo(a)anthracene, benzo(a)pryene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene. Conservative risk evaluation indicates that residents who have a continuous lifetime exposure to those chemicals via ingestion have no apparent increased risk of developing cancer; therefore, it is unlikely that an increase in cancer incidence would be observed in the community.

After the surface soil removal in August 2001, 15 soil samples were taken at locations that were not included in the remediation. Of the 46 substances analyzed for, 26 different substances (57%) were detected in the surface soil samples. Except for lead, all chemicals were detected at levels below those likely to cause adverse health effects (noncarcinogenic) for short-term, intermediate term, and long-term exposure.

Lead concentrations ranged from 20 mg/kg to 1300 mg/kg, with an average of 216 mg/kg. Only one sample indicated a lead level higher than 400 mg/kg (1300 mg/kg at location GPPP01). Lead contamination of the surface soil at that sample location could pose a potential health hazard to young children if the surface soil was uncovered and the children had access to it.

In regard to cancer effects, the surface soil samples indicated that concentrations of the same five chemicals (arsenic, benzo(a)anthracene, benzo(a)pryene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene) were higher than their respective CREGs or RBCs. However, conservative risk evaluation (described in Appendix B) indicates that residents who have a continuous lifetime exposure to those chemicals via ingestion have no apparent increased risk of developing cancer; therefore, it is unlikely that an increase in cancer incidence would occur in the community.

Child Health Considerations

ATSDR considers children in the evaluation of all exposures, and the agency uses health guidelines that are protective for children. In general, ATSDR assumes that children are more susceptible than adults to chemical exposures. In evaluating health effects from the site-specific environmental exposures, children were considered as a special population because of their size, body weight, frequent hand-to-mouth activity, and unique susceptibility to lead and mercury

exposures.

In the case of mercury exposure, children are at greater risk because mercury vapor is dense and settles near the floor in children's playing and breathing zones, and more mercury can easily pass into the developing brain of young children [13-17].

For lead and arsenic exposures, ATSDR has taken into account that children are at a greater risk for arsenic and lead poisoning than adolescents or adults on the basis of the following factors: (1) the normal behavior of children might result in higher rates of ingestion of arsenic and lead-contaminated soil and dust; (2) children might receive a higher dose of lead because they absorb more lead into their blood after ingestion and they have lower body weights than adults; (3) some children might eat soil excessively (pica behavior); and (4) the Centers for Disease Control and Prevention (CDC) and ATSDR report that blood levels in young children have been raised, on average, 5 micrograms per deciliter of blood for every 1,000 mg/kg of lead in residential soil or dust [18-19]. ATSDR has taken these factors into account in developing the conclusions and recommendations for this site.

Conclusions

Because of the lead contamination of the surface soil on the site, ATSDR has categorized this site as a potential Public Health Hazard. (See definition in Appendix C)

Lead contamination of the surface soil at location GPPP01 of the Patio Plaza apartment area poses a potential health hazard to young children if they have access to the area.

Past exposure to lead at the residence of concern presented a health hazard for children, particularly for children less than 2 years old. However, for adults, past exposure to lead in surface soil was unlikely to result in any adverse health effects. The soil contamination has been remediated, so current and future exposure to the soil does not pose a health hazard.

VOC concentrations (for example, 1, 3-butadiane, tetrahydrofuran, and methylene chloride) were relatively high at some Patio Plaza apartment locations. However, no adverse health effects (noncarcinogenic and carcinogenic) would be expected to result from indoor air exposures for residents who live in the Patio Plaza apartments. Additional samples should be taken to ensure that VOC concentrations are at safe levels for all residents, especially for residents at sampling locations IAPPD and IAPP31.

The average mercury vapor concentration at the residence of concern was 0.9 $\mu g/m^3$. On the basis of site-specific exposure scenarios, past exposure to mercury vapor at this residence was unlikely to cause adverse health effects. However, the level of mercury concentration in the house should be verified for the safety of future residents, especially for young children and for pregnant women.

Benzene was detected at levels that exceeded the ATSDR drinking water CREG of 0.6 µg/L at sample location NPW214WAS. However, this was not a drinking water well. Water from this well used for irrigation purposes would not pose a health hazard.

The average arsenic concentration was 37.5 mg/kg at the residence of concern. Arsenic found in the surface soil did not pose a health hazard for residents. The soil contamination has been remediated, so current and future exposure to the soil does not pose a health hazard.

Recommendations

Collect additional indoor air samples at the Patio Plaza Apartments to verify that VOC concentrations are at safe levels for all residents.

Ensure that concentrations of mercury vapor at the residence of concern are at safe levels for future residents, especially for young children and pregnant women.

Minimize any possible exposure to lead from surface soil through a comprehensive approach such as health education, community involvement, surveillance programs, and covering of contaminated areas.

Prepared by

Jane Zhu, MPH
Health Consultation Section
Exposure Investigation and Consultation Branch
Division of Health Assessment and Consultation

Technical Assistance

Jenny Wu, MS
Mathematical Statistician
Exposure and Disease Registries Branch
Division of Health Studies

Reviewers

John E. Abraham, PhD
Chief, Exposure Investigation and Consultation Branch
Division of Health Assessment and Consultation

Susan Moore
Chief, Consultation Section
Exposure Investigation and Consultation Branch
Division of Health Assessment and Consultation

Kenneth G. Orloff, PhD
Toxicologist
Exposure Investigation and Consultation Branch
Division of Health Assessment and Consultation

Tomas Stukas
Regional Representative
Office of Regional Operations, Region 3
Agency for Toxic Substances and Disease Registry

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Table 1. Summary of sampling activities and chemical analysis for environmental samples

Media	Event	Date	Number of Samples	Analytes	Analytical Methods
Soil	Phase I and II investigations	10/1992	28	NA	NA
	Initial site investigation and health risk assessment	8/1993	24	VOCs, metals, cyanide	NA
	Remedial investigation and corrective measures study	1993 & 1994		VOCs, SVOCs, metals	NA
	Surface soil sampling	1998	26	VOCs, SVOCs, metals, PAHs	NA
	Residential surface soil sampling	2000	32	Metals	NA
	Site investigation	2001 & 2002	351	BTEX, PAHs, metals, cyanide	8020, 8270, 6010, 7471, 9010
	Confirmation sampling	5/08/2002	128	BTEX, PAHs, metals, cyanide	6010, 6020, 7471, 8015, 8021, 8082, 8270, 9010, 9023
Total			589		
Water	Initial site investigation and health risk assessment	10/1992	3	VOCs, SVOCs, metals, TRPH, cyanide	
	Remedial investigation and corrective measures study	1993 & 1994	23	VOCs, SVOCs, metals, TRPH, cyanide	
	Supplemental groundwater sampling and monitoring	4/1995	11	BTEX, SVOCs	
	Supplemental groundwater sampling and monitoring	12/1999	24		
	Site investigation	2001 & 2002	52	VOCs, SVOCs, metals TRPH, cyanide, GRO, DRO	8020, 6010, 7471, 9010, 4181, 8015, 8015b
	Groundwater monitoring	7/2002	11		6010, 7470 8021, 8270, 9010
Total			124		
Air	Initial site investigation and health risk assessment	8/1993	34 (soil gas)	BTEX, PAHS, total hydrocarbons	
	Indoor and outdoor air sampling	2000 & 2001	9 6 (soil gas)	BTEX, PAHs, VOCs	TO-14
	Mercury sampling	2001	4	Mercury	NIOSH 6009
	Site investigation	2001 & 2002	31		
	Sampling of Washington Street houses	5/08/2002	11	BTEX, PAHs, VOCs	TO-14
Total			95		

BTEX: benzene, toluene, ethylbenzene, and xylenes
DRO: diesel range organics
GRO: gasoline range organics
NA: not available
PAHs: polycylic aromatic hydrocarbons
SVOCs: semivolatile organic compounds
TRPH: total petroleum hydrocarbons
VOCs: volatile organic compounds

Table 2. Summary of Air Data for the Site Investigation and Confirmation Sampling*

Chemical	Maximum	Minimum	Average	Detection	CV	CV Type
1,1,1-trichloroethane	41	3.7	6.73	Y	2,300	RBC
1,1,2,2-tetrachloroethane	52	4.6	8.75	N	0.02	CREG
1,1,2-trichloroethane	41	3.7	6.93	N	0.06	CREG
1,1-dichloroethane	31	2.7	5.17	N	510	RBC
1,1-dichloroethene	30	2.7	5.04	N	0.02	CREG
1,2,4-trichlorobenzene	56	5	18.74	N	210	RBC
1,2,4-trimethylbenzene	**37**	**3.4**	**7.02**	**Y**	**6.2**	**RBC**
1,2-dichlorobenzene	170	4	29.11	Y	150	RBC
1,2-dichloroethane	31	2.7	5.17	N	0.04	CREG
1,2-dichloroethane-d4	117	85	103.65	Y	NA	NA
1,2-dichloropropane	35	3.1	5.89	N	4	RMEG
1,2-dimethylbenzene	18	3.3	6.31	Y	7,300	RBC
1,3,5-trimethylbenzene	37	3.3	6.14	Y	6.2	RBC
1,3-butadiene	**67**	**5.9**	**11.26 (11.00)**	**Y**	**0.004**	**CREG**
1,3-dichlorobenzene	46	4	7.69	Y	110	RBC
1,4-dichlorobenzene	99	4	18.4	Y	100	CEMEG/MRL
1,4-dioxane	110	9.7	18.22	Y	3,600	REL-TWA
2-butanone (methyl ethyl ketone)	110	8.9	22	Y	1,000	RBC
2-hexanone	120	11	20.5	N	4,000	REL-TWA
2-proponol	10,000	7.4	462.91	Y	NA	NA
4-bromofluorobenzene	103	86	95.5	Y	NA	NA
4-ethyltoluene	150	13	25.19	N	NA	NA
4-methyl 2pentanone	190	11	24.88	Y	73	RBC
acetone	570	8.4	73.19	Y	370	RBC
alpha-chlorotoluene	5.2	4.5	4.93	N	1,000	REL-TWA
benzene	**24**	**2.4**	**5.03 (5.46)**	**Y**	**0.1**	**CREG**
bromodichloromethane	200	18	34	N	0.1	RBC
bromoform	310	28	52.5	N	0.9	CREG
bromomethane	29	2.6	4.93	N	5.1	RBC
carbon disulfide	94	8.4	16.22	Y	730	RBC
carbon tetrachloride	48	4.2	8.06	N	0.12	RBC
chlorobenzene	35	3.1	5.89	N	62	RBC
chloroethane	20	1.8	3.74	N	10,000	CRMEG
chloroform	**37**	**3.3**	**6.11 (5.86)**	**Y**	**0.04**	**CREG**
chloromethane	16	1.4	2.95	Y	90	CRMEG
chlorotoluene	39	3.5	7.88	Y	NA	NA
cis-1,2-dichloroethene	30	2.6	5.04	N	37	RBC
cis-1,3-dichloropropene	34	3	5.75	N	NA	NA
cyclohexane	100	9.2	17.58	Y	3.4E+5	TLV-TWA
dichlorodifluoromethane	260	23	43.56	N	4.95E+6	REL-TWA

Chemical	Maximum	Minimum	Average	Detection	CV	CV Type
ethanol	21,000	5.8	973.28	Y	18,842	TLV-TWA
ethylbenzene	33	2.9	6.06	Y	1,000	CRMEG/Rfc
ethylene dibromide	58	5.2	9.78	N	0.005	CREG
freon 113	58	5.1	9.77	N	31,000	RBC
freon 114	53	4.7	8.93	N	7E+6	REL-TWA
freon 12	37	3.6	5.58	Y	180	RBC
heptane	120	11	20.28	Y	3.5E+5	REL-TWA
hexachlorobutadiene	81	7.2	26.75	N	0.05	CREG
hexane	110	9.4	18.77	Y	210	RBC
m,p-xylene	33	3.3	5.96	Y	4.35E+5	REL-TWA
methyl tert-butyl ether	250	9.7	39.19	Y	3,000	CRMEG/Rfc
methylene chloride	**9,900**	**2.8**	**370.58 (504.15)**	**Y**	**3**	**CREG**
propylene	52	4.6	8.75	N	9,901	TLV-TWA
styrene	32	2.8	5.14	Y	1,000	RBC
tetrachloroethene	51	4.6	8.32	Y	271	CEMEG/MRL
tetrahydrofuran	**89**	**7.9**	**15.69 (27)**	**Y**	**0.92**	**RBC**
toluene	4,700	2.7	168.29	Y	420	RBC
toluene-d8	111	93	101.85	Y	420	RBC
trans-1,2-dichloroethene	120	11	20.31	N	73	RBC
trans-1,3-dichloropropene	34	3	5.75	N	NA	NA
trichloroethene	41	3.6	7.21	Y	40	CRMEG/Rfc
vinyl acetate	110	9.4	18.15	N	210	RBC
vinyl chloride	19	1.7	3.23	N	0.1	CREG
xylenes, total	48	2.9	11.86	Y	7,300	RBC

* Data used in this table came from a database provided by RETEC on 8/29/2002 of the results of analysis of samples taken from 8/2001 to 7/2002. Results indicating no detected chemicals were not used in the statistics. Values in parentheses denote average concentrations for locations in the Patio Plaza area. Bold text denotes chemicals with average concentrations exceeding their respective comparison values. All concentrations are in micrograms per cubic meter.

CEMEG: chronic environmental media evaluation guide
CREG: cancer risk evaluation guide for 1×10^{-6} excess cancer risk
CRMEG: chronic reference dose media evaluation guide
EMEG: environmental media evaluation guide
MRL: minimal risk level
N: no, not detected. Associated values are detection limits or surrogate spikes.
NA: not available
RBC: risk based concentration
REL-TWA: recommended exposure level – time-weighted average
RfC: reference concentration
SSL: soil screen level
TLV-TWA: threshold limit value – time-weighted average
Y: yes, detected

Table 3. Indoor air sampling locations at the Patio Plaza apartments

Sample ID	Sampling Date	Location	Comments
IAPP31	8/20/2001	Inside occupied apartment unit 301-31	None
IAPP31	8/28/2001	Inside occupied apartment unit 301-31	None
IAPPA	12/5/2001	Inside occupied apartment unit 700-9	None
IAPPB	12/5/2001	Inside occupied apartment unit 301-17	None
IAPPC	12/5/2001	Inside occupied apartment unit 301-5	None
IAPPD	12/5/2001	Inside vacant apartment unit 301-30	Maintenance activities: new carpet, painting; cigarette smoke
IAPPDD	12/5/2001	Duplicate Inside vacant apartment unit 301-30	Maintenance activities: new carpet, painting; cigarette smoke
IAPPA	12/6/2001	Inside occupied apartment unit 700-9	None
IAPPB	12/6/2001	Inside occupied apartment unit 301-17	None
IAPPC	12/6/2001	Inside occupied apartment unit 301-5	None
IAPPD	12/6/2001	Inside vacant apartment unit 301-30	Maintenance activities: new carpet, painting; cigarette smoke

Table 4. Summary of groundwater results for sampling location NPW214WAS*

(µg/L)

Chemical	CAS #	Maximum	Minimum	Average	Detection	CV	CV Type
1-methylnaphthalene	90-12-0	19	19	19	Y	700	CEMEG-child
2-methylnaphthalene	91-57-6	16	11	13.5	Y	120	RBC
acenaphthene	83-32-9	25	19	22	Y	600	CRMEG-child
acenaphthylene	208-96-8	19	19	19	Y	NA	NA
anthracene	120-12-7	0.62	0.62	0.62	Y	3000	CRMEG-child
arsenic	7440-38-2	2.1	0.01	1.06	N	10	MCL
barium	7440-39-3	0.064	0.064	0.06	Y	700	CRMEG-child
benzene	**71-43-2**	**270**	**200**	**235**	**Y**	**0.6**	**CREG**
benzo(a)anthracene	56-55-3	0.2	0.2	0.2	N	920	RBC
benzo(a)pyrene	50-32-8	0.2	0.2	0.2	N	0.2	MCL
benzo(b)fluoranthene	205-99-2	0.2	0.2	0.2	N	920	RBC
benzo(g,h,i)perylene	191-24-2	0.5	0.5	0.5	N	NA	NA
benzo(k)fluoranthene	207-08-9	0.2	0.2	0.2	N	92	RBC
cadmium	7440-43-9	0.005	0.005	0.01	N	2	CEMEG-child
chromium	7440-47-3	5	0.01	2.51	N	100	MCL
chrysene	218-01-9	0.2	0.2	0.2	N	9.2	RBC
dibenzo(a,h)anthracene	53-70-3	0.2	0.2	0.2	N	0.0092	RBC
ethylbenzene	100-41-4	70	50	60	Y	1000	CRMEG-child
fluoranthene	206-44-0	0.25	0.25	0.25	Y	400	CRMEG-child
fluorene	86-73-7	1.7	1.7	1.7	Y	400	CRMEG-child
indeno(1,2,3-cd)pyrene	193-39-5	0.12	0.12	0.12	Y	0.092	RBC
lead	7439-92-1	2.2	2.2	2.2	N	15	AL
lead	7439-92-1	0.11	0.11	0.11	Y	15	AL
mercury	7439-97-6	0.0002	0.0002	0	N	2	MCL-inorganic
methylene chloride	75-09-2	6	6	6	Y	600	CEMEG-child
naphthalene	91-20-3	130	100	115	Y	200	CEMEG-child
phenanthrene	85-01-8	1.4	1.4	1.4	Y	NA	NA
pyrene	129-00-0	0.5	0.5	0.5	N	300	CRMEG-child
selenium	7782-49-2	0.01	0.01	0.01	N	50	CEMEG-child
silver	7440-22-4	0.01	0.01	0.01	N	50	CRMEG-child
toluene	108-88-3	5	5	5	N	2000	CRMEG-child
toluene	108-88-3	11	11	11	Y	2000	CRMEG-child
total cyanide	57-12-5	10	10	10	N	200	CRMEG-child
trph	NA	3.3	3.3	3.3	N	NA	NA

* Data used in this table came from a database provided by RETEC on 10/24/2002 of the results of analysis of samples taken from 08/2001 to 07/2002. Results indicating no detected chemicals were not used in the statistics. Bold text denotes chemicals with average concentrations exceeding their respective comparison values. All concentrations are in micrograms per liter (µg/L).

AL: action level
CEMEG: chronic environmental media evaluation guide
CREG: cancer risk evaluation guide for 1×10^{-6} excess cancer risk
CRMEG: chronic reference dose media evaluation guide
MCL: maximum contaminant level
N: no, not detected. Associated values are detection limits or surrogate spikes.
NA: not available
RBC: risk-based concentration
TRPH: total petroleum hydrocarbons
Y: yes, detected

Table 5 Summary of surface soil sample data for arsenic at 208 Washington Street*

Sample location	Sample date	Sample depth (feet)	Result (mg/kg)	Detection flag
CSD01	**8/21/2001**	**0-0.5**	**110**	**y**
CSD02	**8/21/2001**	**0-0.5**	**59.0**	**y**
CSD03	**8/21/2001**	**0-0.5**	**88.0**	**y**
GPD01	8/21/2001	0-0.5	11.0	y
GPD02	8/21/2001	0-0.5	14.0	y
GPD03	**8/21/2001**	**0-0.5**	**25.0**	**y**
GPD04	**8/21/2001**	**0-0.5**	**28.0**	**y**
GPD05	**8/21/2001**	**0-0.5**	**100**	**y**
GPD06	**8/21/2001**	**0-0.5**	**39.0**	**y**
GPD07	**8/21/2001**	**0-0.5**	**110**	**y**
GPD08	8/21/2001	0-0.5	6.60	y
SS14	7/1/1998	0-0.5	9.6	y
SS14	7/27/1998	0-0.5	9.6	y
SS15	7/1/1998	0-0.5	9.5	y
SS15	7/27/1998	0-0.5	9.5	y
G1ERM	11/1/2000	0-0.5	14.7	y
G1ERM	**11/1/2000**	**0-1**	**38.3**	**y**
G2ERM	11/1/2000	0-0.5	16.4	y
G2ERM	**11/1/2000**	**0-1**	**23.7**	**y**
G3ERM	**11/1/2000**	**0-0.5**	**48.4**	**y**
G3ERM	**11/1/2000**	**0-1**	**74.9**	**y**
G4ERM	11/1/2000	0-0.5	8.4	y
G4ERM	11/1/2000	0-1	7.3	y
G5ERM	**11/1/2000**	**0-0.5**	**38.2**	**y**
208DR	5/21/2002	NA	5.4	N
208FE	5/21/2002	NA	5.7	N
208PT	5/21/2002	NA	2.61	y(J)
208DR	5/21/2002	NA	5.2	N
CS BACKFILL	7/10/2002	NA	5.05	N
CS BACKFILL	7/10/2002	NA	5.04	N

* Data used in this table came from a database provided by RETEC on 10/24/2002 of the results of analysis of samples taken from 08/2001 to 07/2002. Results indicating no detected chemicals were not used in the statistics. Bold text denotes chemicals with average concentrations exceeding their respective comparison values. All concentrations are in milligrams per kilogram (mg/kg).

N: no, not detected. Associated values are detection limits or surrogate spikes.
NA: not available
J: analyte present. Reported value was estimated.
Y: yes, detected

Table 6. Summary of surface soil sample data for lead and mercury at 226 Washington Street*

Sample location	Sample date	Lead (mg/kg)	Detect flag	Mercury (mg/kg)	Detect flag
CSQ01	**8/30/2001**	**430**	Y, (J)	29.0	Y
CSQ02	8/30/2001	370	Y, (J)	35.0	Y
GPQ01	12/7/2001	229	Y	6.30	Y
GPQ02	12/7/2001	313	Y	13.0	Y
GPQ03	12/7/2001	168	Y	1.50	Y
GPQ04	12/7/2001	65.2	Y	0.470	Y
GPQ05	12/7/2001	12.2	Y	0.290	Y
01	6/1/2000	NA	NA	0.87	Y
02	6/1/2000	46	Y	1.7	Y
03	**6/1/2000**	**440**	Y	51	Y
04	**6/1/2000**	**580**	Y	**360**	**Y**
05	6/1/2000	160	Y	4.6	Y
06	6/1/2000	NA	NA	7.1	Y
07	6/1/2000	230	Y	2.2	Y
08	**6/1/2000**	**1500**	Y	100	Y
09	6/1/2000	350	Y	63	Y
10	6/1/2000	300	Y	75	Y
11	6/1/2000	NA	NA	6	Y
12	6/1/2000	330	Y	12	Y
13	6/1/2000	270	Y	17	Y
14	**6/1/2000**	**600**	Y	27	Y
15	6/1/2000	280	Y	42	Y
16	6/1/2000	NA	NA	38	Y
17	6/1/2000	NA	NA	46	Y
18	6/1/2000	320	Y	100	Y
19	**6/1/2000**	**430**	Y	8.6	Y
20	**6/1/2000**	**510**	Y	19	Y
21	6/1/2000	NA	NA	2.4	Y
23	6/1/2000	NA	NA	1.09	Y
24	6/1/2000	NA	NA	0.77	Y
25	6/1/2000	NA	NA	12.8	Y
26	6/1/2000	NA	NA	21.28	Y
27	6/1/2000	NA	NA	**321**	**Y**
SS23	**7/27/1998**	**958**	Y	70	Y
SS24	7/27/1998	359	Y	2.9	Y
226DR	5/20/2002	5.4	ND	0.28	ND
226DR	5/20/2002	6.04	ND	0.29	ND
CS BACKFILL	7/10/2002	5.05	ND	0.26	ND
CS BACKFILL	7/10/2002	5.04	ND	0.26	ND

* Data used in this table came from a database provided by RETEC on 10/24/2002 of the results of analysis of samples taken from 08/2001 to 07/2002. Results indicating no detected chemicals were not used in the statistics. Bold text denotes chemicals with average concentrations exceeding their respective comparison values. All concentrations are in milligrams per kilogram (mg/kg).
N: no, not detected. Associated values are detection limits or surrogate spikes.
NA: not available
J: analyte present. Reported value was estimated.
Y: yes, detected

Table 7. Surface soil data summary for Patio Plaza apartments before soil removal (mg/kg)*

Chemical	98 & 99 Data Average	93 Data Average	CV (source)
2-methylnaphthalene	0.34	1.58	41,000 (RBC)
acenaphthene	ND	0.94	40,000 (RMEG)
acenaphthylene	ND	0.52	4,700 (RBC)
aluminum	7,454.55	NT	1,000,000 (IEMEG)
amenable cyanide	NT	78.85	1,000,0 (RMEG)
anthracene	0.10	2.35	20,000 (RMEG)
antimony	2.5	NT	300 (RMEG)
arsenic	**6.40**	**13.61**	**0.5 (CREG)**
barium	53.45	ND	50,000 (RMEG)
benzene	NT	0.16	10 (CREG)
benzo(a)anthracene	**0.62**	**5.69**	**0.87 (RBC)**
benzo(a)pyrene	**1.37**	**4.08**	**0.1 (CREG)**
benzo(b)fluoranthene	**1.47**	**6.56**	**0.87 (RBC)**
benzo(g,h,i)perylene	1.91	2.98	NA
benzo(k)fluoranthene	0.52	2.13	8.7 (RBC)
beryllium	0.20	NT	700 (CEMEG)
bis (2-ethylhexyl) phthalate	NT	0.35	46 (RBC)
carbazole	NT	1.02	32 (RBC)
cadmium	0.68	NT	100 (CEMEG)
calcium	4663.64	NT	NA
chromium	11.92	15.10	2,000 (RMEG)for VI
chrysene	0.72	3.27	87 (RBC)
cobalt	1.42	NT	1,600 (RBC)
copper	32.3	NT	3100 (RBC)
dibenzo(a,h)anthracene	0.88	1.09	70,000 (RMEG)
dibenzofuran	NT	1.99	310 (RBC)
di-n-octylphthalate	NT	1.60	1,600 (RBC)
ethylbenzene	NT	19.43	70,000 (RMEG)
fluoranthene	1.29	8.37	30,000 (RMEG)
fluorene	54	1.80	30,000 (RMEG)
indeno(1,2,3-cd)pyrene	**1.23**	**NT**	**0.87 (RBC)**
iron	4,936.36	NT	23,000 (RBC)
lead	99.27	144.13	400 (SSL)region 6
magnesium	612.73	NT	NA
manganese	45.82	NT	40,000 (RMEG)
mercury	1.32	ND	23 (SSL)regin6
methylene chloride	NT	0.071	90 (CREG)
naphthalene	0.49	1.13	10,000 (RMEG)
nickel	6.07	NT	10,000 (RMEG)
phenanthrene	0.59	5.52	400,000 (RMEG)
potassium	348.18	NT	NA
pyrene	1.68	8.64	2,000 (RMEG)
silver	0.17	ND	400 (RMEG)
sodium	108	NT	NA
styrene	NT	0.45	10,000 (RMEG)
tetrachloroethene	NT	0.006	12 (RBC)

Chemical	98 & 99 Data Average	93 Data Average	CV (source)
toluene	NT	0.14	100,000 (RMEG)
total cyanide	NT	69.03	10,000 (RMEG)
trph	NT	187.26	NA
vanadium	17.27	NT	2,0009 (IEMEG)
xylenes, total	NT	3.40	1,000,000 (RMEG)
zinc	138.45	NT	200,000 (CEMEG)

* Data used in this table came from a database provided by RETEC on 10/24/2002 of the results of analysis of samples taken from 08/2001 to 07/2002. Results indicating no detected chemicals were not used in the statistics. Bold text denotes chemicals with average concentrations exceeding their respective comparison values. All concentrations are in milligrams per kilogram (mg/kg).

CEMEG: chronic environmental media evaluation guide
CREG: cancer risk evaluation guide for 1×10^{-6} excess cancer risk
EMEG: environmental media evaluation guide
IEMEG: intermediate environmental media evaluation guide
N: no, not detected. Associated values are detection limits or surrogate spikes.
NA: not available
ND: not detected
NT: not tested
RBC: risk-based concentration
RMEG: reference dose media evaluation guide
SSL: soil screen level
TRPH: total petroleum hydrocarbons
Y: yes, detected

Table 8. Surface soil data summary for the Patio Plaza apartments - 2001(mg/kg)*

Chemical	Maximum	Minimum	Average	CV (source)
2-fluorobiphenyl	1.680	0.99	0.99	NA
a,a,a-trifluorotoluene	0.03	0.02	0.03	NA
acenaphthene	49	0.19	6.54	40,000 (RMEG)
acenaphthylene	56	0.22	8.55	4,700 (RBC)
anthracene	490	0.19	6.8	20,000 (RMEG)
arsenic	**16**	**5.7**	**8.59**	**0.5 (CREG)**
benzene	0.03	0.005	0.008	10 (CREG)
benzo(a)anthracene	**40**	**0.25**	**9.16**	**0.87 (RBC)**
benzo(a)pyrene	**67**	**0.39**	**11.61**	**0.1 (CREG)**
benzo(b)fluoranthene	**61**	**0.35**	**10.13**	**0.87 (RBC)**
benzo(g,h,i)perylene	53	0.43	8.84	NA
benzo(k)fluoranthene	40	0.21	7.60	8.7 (RBC)
chrysene	40	0.25	9.06	NA
cyanide	10	0.57	2.02	10,000 (RMEG)
dibenzo(a,h)anthracene	19	0.19	4.38	70,000 (RMEG)
ethylbenzene	0.03	0.005	0.008	70,000 (RMEG)
fluoranthene	88	0.34	15.01	30,000 (RMEG)
fluorene	62	0.19	7.57	30,000 (RMEG)
indeno(1,2,3-cd)pyrene	**42**	**0.30**	**7.44**	**0.87 (RBC)**
lead	**1,300**	**20**	**216.07**	**400 (SSL)region 6**
mercury	22	0.3	4.29	23 (SSL) region 6
naphthalene	68	0.21	8.16	10,000 (RMEG)
nickel	28	5.7	10	10,000 (RMEG)
nitrobenzene-d5	1.20	0.75	7.87	NA
phenanthrene	190	0.21	18.74	400,000 (RMEG)
p-terphenyl-d14	1.88	1.10	1.15	NA
pyrene	110	0.37	20.99	2,000 (RMEG)
toluene	0.03	0.006	0.008	100,000 (RMEG)
xylenes, total	0.03	0.006	0.009	1,000,000 (RMEG)

* Data used in this table came from a database provided by RETEC on 10/24/2002 of the results of analysis of samples taken from 08/2001 to 07/2002. Results indicating no detected chemicals were not used in the statistics. Bold text denotes chemicals with average concentrations exceeding their respective comparison values. All concentrations are in milligrams per kilogram (mg/kg).

CREG: cancer risk evaluation guide for 1×10^{-6} excess cancer risk
NA: not available
ND: not detected
RBC: risk-based concentration
RMEG: reference dose media evaluation guide
SSL: soil screen level

Appendix A - ATSDR Comparison Values and Definitions

ATSDR comparison values (CVs) are media-specific concentrations considered safe under default exposure scenario. They are used as screening values for the identification of contaminants (site-specific substances) that require further evaluation to determine the potential for adverse health effects.

Generally, a chemical is selected for further evaluation because its maximum concentration in air, water, or soil at the site exceeds one of ATSDR's comparison values. However, it cannot be emphasized strongly enough that comparison values are **not** thresholds of toxicity. While concentrations at or below the relevant comparison value may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would be expected to produce adverse health effects. Indeed, the whole purpose behind highly conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health problems **before** they become actual health hazards. The probability that adverse health outcomes will actually occur as a result of exposure to environmental contaminants depends on site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure, and **not** on environmental concentrations alone.

Screening values based on noncancer effects are obtained by dividing NOAELs(no-observed-adverse-effect levels) or LOAELs (lowest-observed-adverse-effect levels) determined in animal or (less often) human studies by cumulative safety margins (variously called safety factors, uncertainty factors, and modifying factors) that typically range from 10 to 1,000 or more. By contrast, cancer-based screening values are usually derived by linear extrapolation from animal data obtained at high doses, because human cancer incidence data for very low levels of exposure simply do not exist, and probably never will.

Listed and described below are the comparison values that ATSDR has used to select chemicals for further evaluation for this health consultation, along with the abbreviations for the most common units of measure.

EMEG	environmental media evaluation guide
RMEG	reference dose media evaluation guide
MRL	minimal risk level
MCL	maximum contaminant level
ppm	parts per million, for example, mg/L or mg/kg
ppb	parts per billion, for example, µg/L or µg/kg
kg	kilogram (1,000 grams)
mg	milligram (0.001 grams)
µg	microgram (0.000001 grams)
L	liter
m^3	cubic meter (used in reference to a volume of air equal to 1,000 liters)

Acute exposure is defined as exposure to a chemical for a duration of 14 days or less.

Cancer risk evaluation guides (CREGs) are estimated contaminant concentrations in water, soil, or air that would be expected to cause no more than one excess cancer in a million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors.

Chronic exposure is defined as exposure to a chemical for 365 days or more.

Environmental media evaluation guides (EMEGs) are concentrations of a contaminant in water, soil, or air that are unlikely to be associated with any appreciable risk of deleterious non-cancer effects over a specified duration of exposure. EMEGs are derived from ATSDR minimal risk levels by factoring in default body weights and ingestion rates. Separate EMEGs are computed for acute (≤14 days), intermediate (15–364 days), and chronic (≥365 days) exposures.

Intermediate exposure is defined as exposure to a chemical for a duration of 15–364 days.

Lowest-observed-adverse-effect levels are the lowest exposure level of a chemical in a study, or group of studies, that produces statistically or biologically significant increase in frequency or severity of adverse health effects between the exposed population and its appropriate control.

Maximum contaminant levels (MCLs) represent contaminant concentrations in drinking water that EPA deems protective of public health (considering the availability and economics of water treatment technology) over a lifetime (70 years) at an exposure rate of 2 liters of water per day.

Minimal risk levels (MRLs) are estimates of daily human exposure to a hazardous substance that is likely to be without an appreciable risk of adverse noncancer health effects over a specified route and duration of exposure.

National Primary Drinking Water Regulations (NPDWR or primary standards) are legally-enforceable standards that apply to public water systems. Primary standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and known or anticipated to occur in water. They take the form of MCLs or Treatment Techniques.

National Secondary Drinking Water Regulations (NSDWR or secondary standards) are nonenforceable guidelines regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

No-observed-adverse-effect level is the dose of a chemical at which there were no statistically or biologically significant increases in frequency or severity of adverse health effects seen between the exposed population and its appropriate control. Effects may be produced at this dose, but they are not considered to be adverse.

Uncertainty factor (UF) is a factor used in operationally deriving the MRL or reference dose or reference concentration from exposure data.

The following comparison values were used for this health consultation: Environmental media evaluation guidelines (EMEGs); reference dose media evaluation guides (RMEGs); cancer risk evaluation guides (CREGS); minimal risk levels (MRLS); and U.S. Environmental Protection Agency Region 3 Risk-Based Concentrations (RBCs).

Appendix B - Dose Calculations

Air pathway for indoor and outdoor samples, November 2000 and January 2001

The following formula was used to estimate inhalation exposure doses for benzene and methylene chloride:

ID = (C x IR x EF)/BW

Where,
ID = inhalation exposure dose (mg/kg/day)
C = contaminant concentration (mg/ $m^{3)}$
IR = inhalation rate (20 m^3/day for adults)
EF = exposure factor (unitless, conservatively assumed to be 1.0)
BW = body weight (70 kg for adults)

Benzene and methylene chloride were detected at average levels of 0.89 and 10.97 μg/ m^3, respectively. Therefore,

ID for benzene = (0.00089 mg/ m^3x20 m^3 /day x 1)/70 kg = 0.00025 mg/kg/day
ID for methylene chloride = (0.01097 mg/ m^3 x 20 m^3 /day x 1)/70 kg = 0.003 mg/kg/day

ATSDR established acute and intermediate EMEG/MRLs for benzene as 160 and 13 μg/ m^3, respectively [4]. The ATSDR acute EMEG/MRL for methylene chloride is 2,084μg/ m^3, and the intermediate and chronic EMEG/MRL is 1042 μg/m^3. The levels of benzene and methyl chloride in the Patio Plaza and Gates apartments were not present at levels likely to cause adverse health effects (noncarcinogenic) during short-term, intermediate term, and long-term exposures.

To evaluate the cancer risk, ATSDR used the EPA region 3 cancer slope factors (CSF) for inhalation exposures. CSFs are based on conservative assumptions such as fixed level of risk (i.e., a 1-in-1 million cancer risk) and a life time exposure (i.e., 365 days per year for 70 years). Together, with the very conservative assumptions used for the above dose calculation, ATSDR overestimates rather than underestimate risk by factors ranging from 10 to 1000.

Cancer risk is calculated as follows:

Cancer risk = average daily intake x CSF x exposure factor (conservatively assumed to be 1.0)

Cancer risk evaluation results are presented in the following table.

CHEMICAL	Dose	CSF	CV	CV Type	Risk
BENZENE	0.00025	2.9E-02	0.1	CREG	7.3E-6
METHYLENE CHLORIDE	0.003	1.65E-03	3	CREG	4.8E-6

Dose: average inhalation dose in mg/kg/day
CSF: EPA region 3 cancer slope factors in mg/ kg/day^{-1}
CV: comparison values

CREG: cancer risk evaluation guide (ATSDR)

Based on the average levels of benzene and methylene chloride detected, residents who have a continuous lifetime exposure to those two chemicals via inhalation have no increased risk of developing cancer.

Cancer Risk Evaluations for Air sampling data during the site investigation

Concentrations of five VOCs (1,3-butadiane, benzene, chloroform, methylene chloride, and tetrahydrofuran) exceeded their respective CREGs. The same formula was used to estimate inhalation exposure dose for these chemicals (average concentrations for Patio Plaza area locations were used):

ID for 1,3-butadiene = (0.011 mg/m^3 x 20 m^3/day x 1)/70 kg = 0.003 mg/kg/day
ID for benzene = (0.0055 mg/m^3 x20m^3/day x 1)/70 kg = 0.0016 mg/kg/day
ID for chloroform = (0.0059 mg/m^3 x 20m^3/day x 1)/70 kg = 0.0017 mg/kg/day
ID for methylene chloride = (0.5 mg/m^3 x 20m^3/day x 1)/70 kg = 0.14 mg/kg/day
ID for tetrahydrofuran = (0.27 mg/m^3 x 20m^3/day x 1)/70 kg = 0.077 mg/kg/day

Cancer risk evaluation results are presented in the following table.

CHEMICAL	Dose	CSF	CV	CV Type	Risk
1,3-BUTADIENE	0.0031	1.8E+00	0.004	CREG	5.6E-3
BENZENE	0.0016	2.9E-02	0.1	CREG	4.6E-5
CHLOROFORM	0.0017	8.1E-02	0.04	CREG	1.4E-4
METHYLENE CHLORIDE	0.14	1.65E-03	3	CREG	2.3E-4
TETRAHYDROFURAN	0.077	6.8E-03	0.92	RBC	5.2E-4

Dose: average inhalation dose in mg/kg/day
CSF: EPA region 3 cancer slope factors in mg/ kg/day^{-1}
CV: comparison values
CREG: cancer risk evaluation guide (ATSDR)
RBC: EPA Region 3 risk based concentration

Dermal absorption pathway for benzene exposure

The following assumptions were made to estimate the dermal exposure dose for benzene:

(1) A resident would spend 2 hours per event, 40 events per year, for outdoor gardening (approximately 0.22 hour per day),
(2) Flow rate for irrigation is 8 liters per minute (L/min), and
(3) Average exposed body surface area is 3,300 square centimeter (cm^2)

The following mathematical formula was used to estimate daily dermal absorption intake:

DDw = C x P x SA x ET

Where:

DDw = dermal absorption intake from dermal contact with water during gardening activities (mg)
C = benzene concentration in irrigation water in mg/L. The concentration in irrigation water is conservatively assumed as the fraction remaining after 50% of the benzene has volatilized (i.e., 50% of the drinking water concentration.)
P = permeability constant (conservatively assumed to be 0.001 liter /cm^2 per hour)
SA = exposed body surface area (cm^2)
ET = exposure time (hour)

If the concentration of benzene in the drinking water is 0.235 mg/L, the estimated exposure during gardening is as follows:

dermal intake
= (0.235 mg/L) x 50% x (0.001 liter /cm^2 x hr) x (3,300 cm^2) x (0.22 hr)
= 0.0085 mg

A 70 kg-adult from water contact during gardening activities dermal intake of 0.0085 mg benzene would be exposed to 0.12 μg/kg/day. A 10 kg-child from water contact during gardening activities dermal intake of 0.0085 mg benzene would receive a 0.85 μg/kg/day dose (This is an overestimate for children because the average exposed body surface area for children is much less than that used for adults in this dose calculation).

There are very limited data on the dermal exposure health effects for benzene. On the based of the mechanisms of toxicity, ATSDR assumes that dermal absorption is more toxicologically equivalent to inhalation than ingestion. Therefore, inhalation MRLs are used as respective CVs for the following noncancer effects evaluation. For noncancer effects, the ATSDR acute and intermediate MRLs for benzene are 0.05 and 0.004 ppm respectively. An estimated air

concentration was calculated by using dermal intake:

Estimated air concentration = dermal intake / hourly inhalation rate x exposure duration = 0.00055 mg/m3 = 0.00017 ppm

The estimated concentration for residents in the location is much less than the MRLs. Therefore, no adverse health effects (noncarcinogenic) would result from infrequent dermal contact during gardening.

Soil ingestion pathway for mercury exposures

The following mathematical formula was used to estimate the soil ingestion exposure dose of mercury:

IDs = C x IR x EF x10^{-6}/BW

where:
IDs = soil ingestion exposure dose (mg/kg/day)
C = contaminant concentration in soil (mg/kg)
IR = soil ingestion rate (100 mg/day for adults)
EF = exposure factor (unitless—conservatively assumed to be 1.0)
BW= body weight (70 kg)

A 70 kg-adult ingesting 100 mg of soil per day containing 360 mg/kg (maximum concentration) or 42.8mg/kg (average concentration) of mercury would be exposed to 0.005 mg/kg/day or 0.00006 mg/kg/day. A 10-kg child ingesting 200 mg of soil containing 360 mg/kg (maximum concentration) or 42.8mg/kg (average concentration) of mercury would receive doses of 0.076 mg/kg/day or 0.00856mg/kg/day.

For noncancer effects, the ATSDR acute and intermediate oral MRLs for inorganic mercury are 0.007 and 0.002 mg/kg/day respectively. These MRLs are based on no-observed-adverse-effect levels (NOAELs) for renal effects in rats, with an uncertainty (safety) factor of 100 for extrapolation from animals to humans and human variability. The estimated mercury dose for children ingesting mercury-contaminated soil exceeds the acute and intermediate MRLs. Organic and inorganic mercury is not known to be carcinogenic by the oral ingestion route [7].

Cancer risk evaluations for surface soil sampling data before removal at Patio plaza apartments

IDs for arsenic = C x IR x EF x10^{-6}/BW = 13.61 x 100 x 10^{-6}/70 = 0.000019 mg/kg/day
IDs for benzo(a)pryene = 5.69 x 100 x 10^{-6}/70 = 0.0000081 mg/kg/day
IDs for benzo(b) fluoranthene = 4.08x100 x10^{-6}/70=0.0000058 mg/kg/day
IDs for benzo(a)anthracene = 6.56 x 100 x 10^{-6}/70 = 0.0000093 mg/kg/day

IDs for indeno (1,2,3_CD)pyrene = 1.23 x 100 x 10^{-}6/70 = 0.0000093 mg/kg/day

Chemical Name	Ave.	Dose	CSF	CV	CV Type	Risk
arsenic	13.61	0.000019	1.5E+00	0.5	CREG	2.9E-05
benzo(a) pryene	5.69	0.0000081	7.3E+00	0.87	RBC	5.9E-05
benzo(b) fluoranthene	4.08	0.0000058	7.3E-01	0.1	CREG	4.3E-6
benzo(a)anthracene	6.56	0.0000094	7.3E-01	0.87	RBC	6.8E-6
indeno (1,2,3_CD)pyrene	1.23	0.0000018	7.3E-01	0.87	RBC	1.3E-6

Ave.: average concentrations in mg/kg
Dose: soil ingestion exposure dose (mg/kg/day)
CSF: EPA region 3 cancer slope factors in mg/ kg/day^{-}1
CV: comparison values
CREG: cancer risk evaluation guide (ATSDR)

Cancer risk evaluations for surface soil sampling data after soil removal at the Patio plaza apartments

IDs for arsenic = C x IR x EF x 10^{-}6/BW = 8.59 x 100 x 10^{-}6/70 = 0.000012 mg/kg/day
IDs for benzo (a) pryene = 11.61 x 100 x 10^{-}6/70 = 0.0000081 mg/kg/day
IDs for benzo(b) fluoranthene = 10.13 x 100 x 10^{-}6/70 = 0.000014 mg/kg/day
IDs for benzo(a) anthracene = 9.16x100 x 10^{-}6/70 = 0.000013 mg/kg/day
IDs for indeno (1,2,3-cd) pyrene = 7.44x100 x10^{-}6/70=0.0000093 mg/kg/day

Chemical Name	Ave.	Dose	CSF	CV	CV Type	Risk
arsenic	8.59	0.000012	1.5E+00	0.5	CREG	1.8E-05
benzo(a) pryene	11.61	0.0000081	7.3E+00	0.87	RBC	1.2E-04
benzo(b) fluoranthene	10.13	0.000014	7.3E-01	0.1	CREG	1.1E-5
benzo(a) anthracene	9.16	0.000013	7.3E-01	0.87	RBC	9.6E-6
indeno (1,2,3-cd) pyrene	7.44	0.000011	7.3E-01	0.87	RBC	7.8E-6

Appendix C - ATSDR Levels of Public Health Hazard

CATEGORY A: URGENT PUBLIC HEALTH HAZARD

This category is used for sites where short-term exposures (< 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.

This determination represents a professional judgment based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.

Criteria

Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards, such as open mine shafts, poorly stored or maintained flammable/explosive substances, or medical devices which, upon rupture, could release radioactive materials.

CATEGORY B: PUBLIC HEALTH HAZARD

This category is used for sites that pose a public health hazard due to the existence of long-term exposures (> 1 yr) to hazardous substances or conditions that could result in adverse health effects.

This determination represents a professional judgment based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.

Criteria

Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical hazards, such as open mine shafts, poorly stored or maintained flammable/ explosive substances, or medical devices which, upon rupture, could release radioactive materials.

CATEGORY C: INDETERMINATE PUBLIC HEALTH HAZARD

This category is used for sites when a professional judgment on the level of health hazard cannot be made because information critical to such a decision is lacking.

Criteria

This category is used for sites in which "*critical*" data are *insufficient* with regard to extent of exposure and/or toxicologic properties at estimated exposure levels. The health assessor must determine, using professional judgment, the importance of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support decisions with a clear narrative that explains the limits of the data and the rationale for the decision.

CATEGORY D: NO APPARENT PUBLIC HEALTH HAZARD

This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.

This determination represents a professional judgment based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete, in some cases additional data may be required to confirm or further support the decision made.

Criteria

Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.

CATEGORY E: NO PUBLIC HEALTH HAZARD

This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.

Criteria

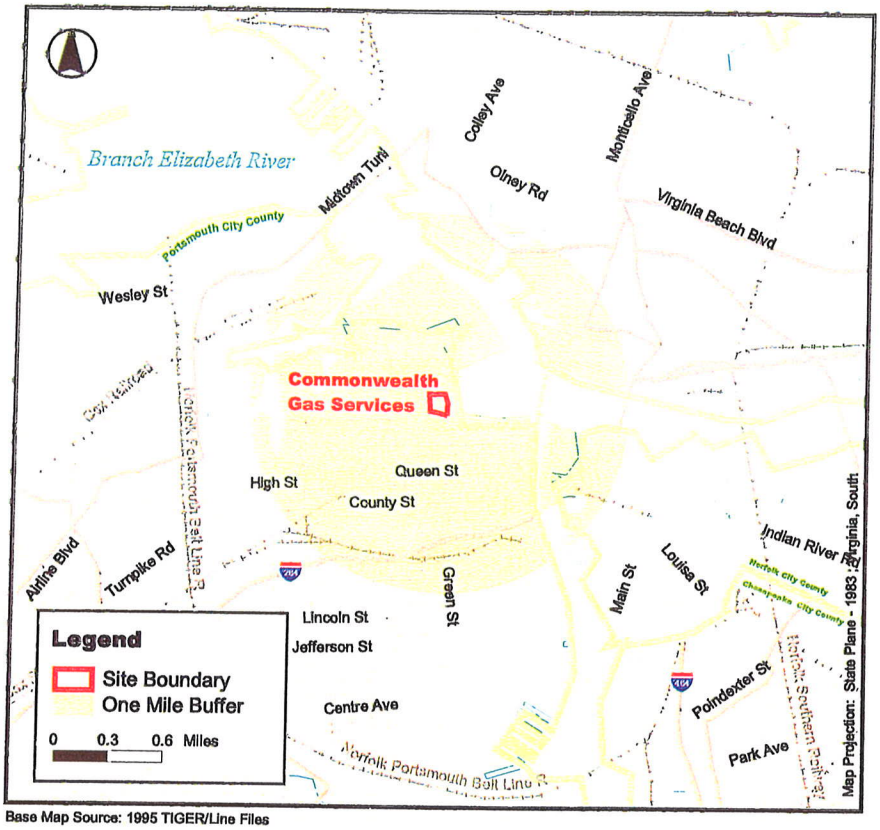
Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future.

* *Such as environmental and demographic data; health outcome data; community health concerns information; toxicological, medical, and epidemiologic data.*

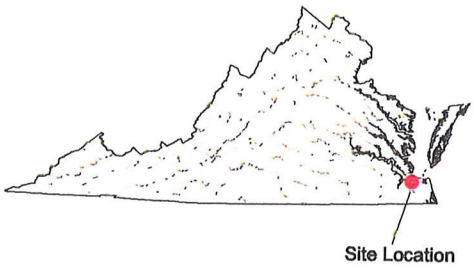
Commonwealth Gas Services

Portsmouth, Virginia

EPA Facility ID VA0001142215



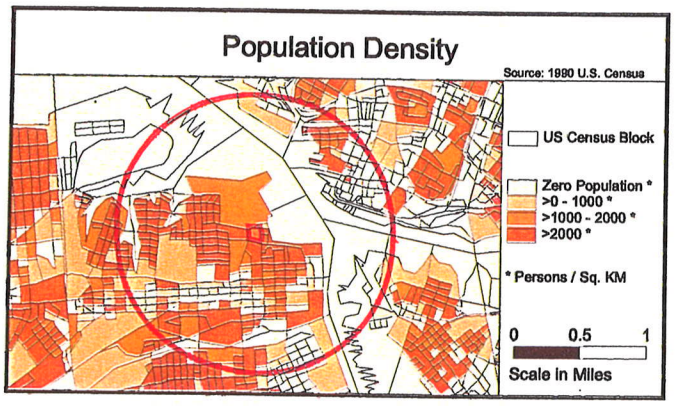
Base Map Source: 1995 TIGER/Line Files

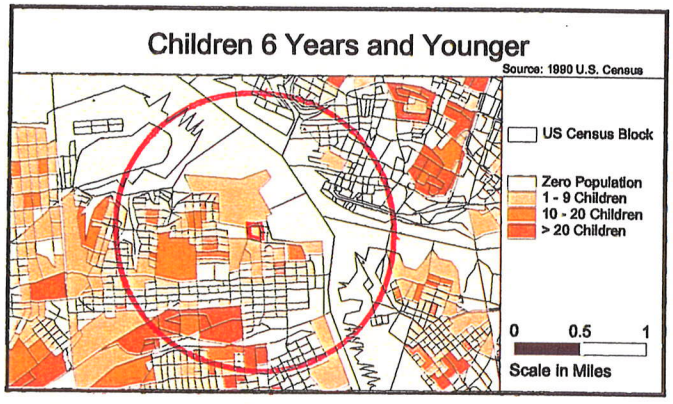


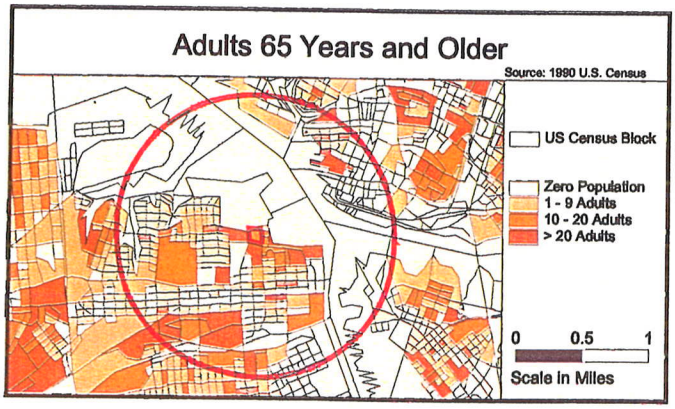
Portsmouth City, Virginia

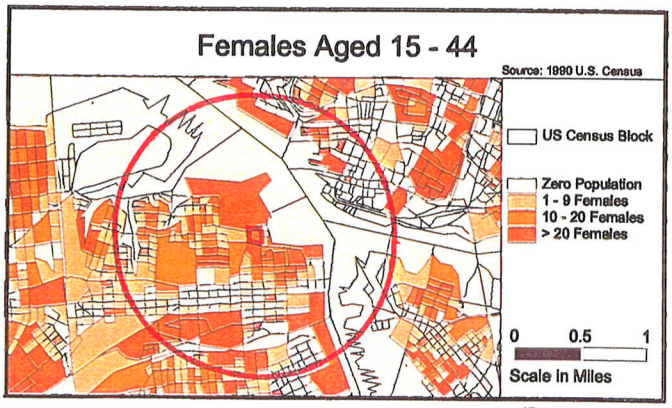
Demographic Statistics Within One Mile of Site*	
Total Population	11780
White	4898
Black	6697
American Indian, Eskimo, Aleut	21
Asian or Pacific Islander	115
Other Race	51
Hispanic Origin	184
Children Aged 6 and Younger	1093
Adults Aged 65 and Older	1833
Females Aged 15 - 44	2620
Total Housing Units	5289

Demographics Statistics Source: 1990 US Census
*Calculated using an area-proportion spatial analysis technique









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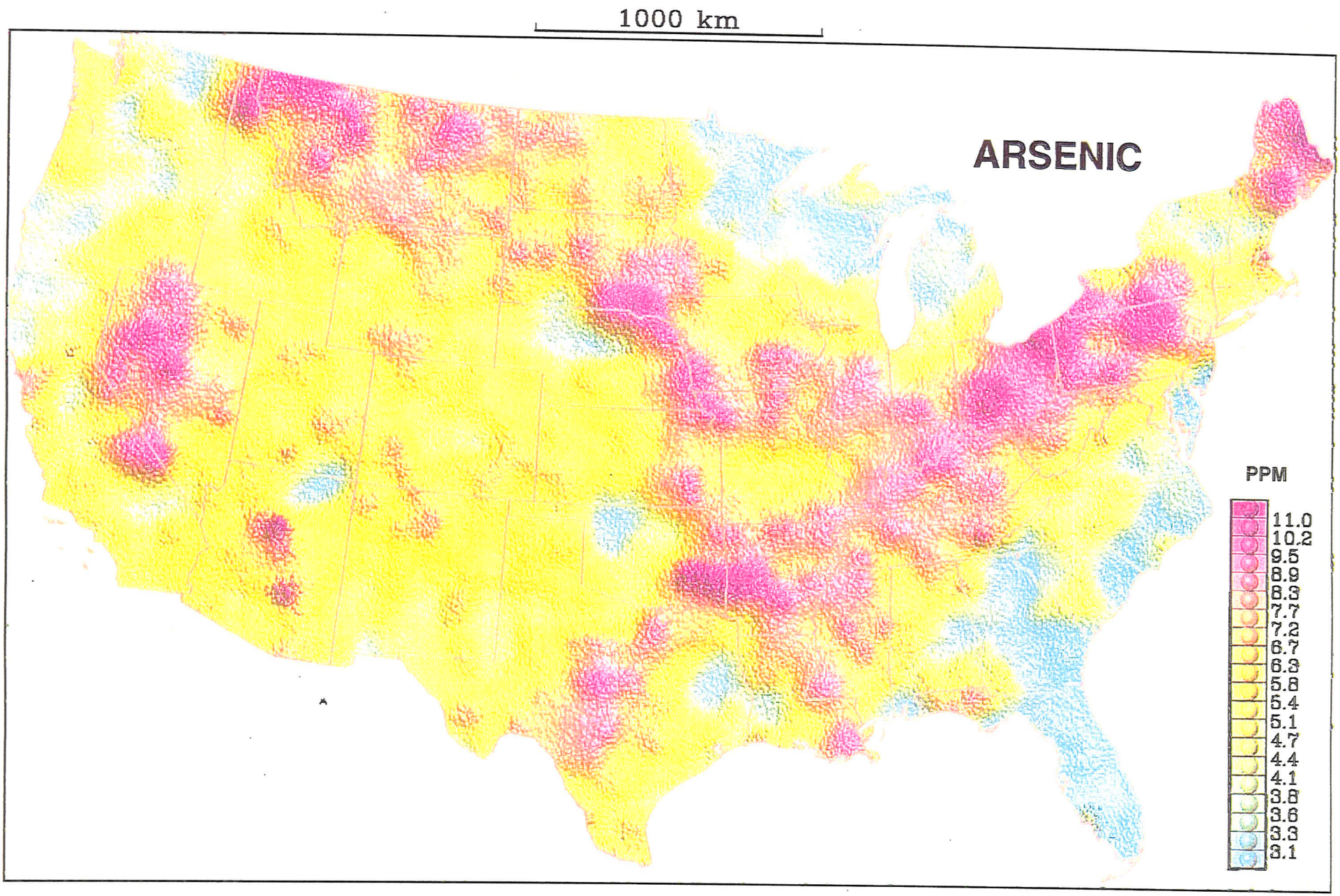
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PPM
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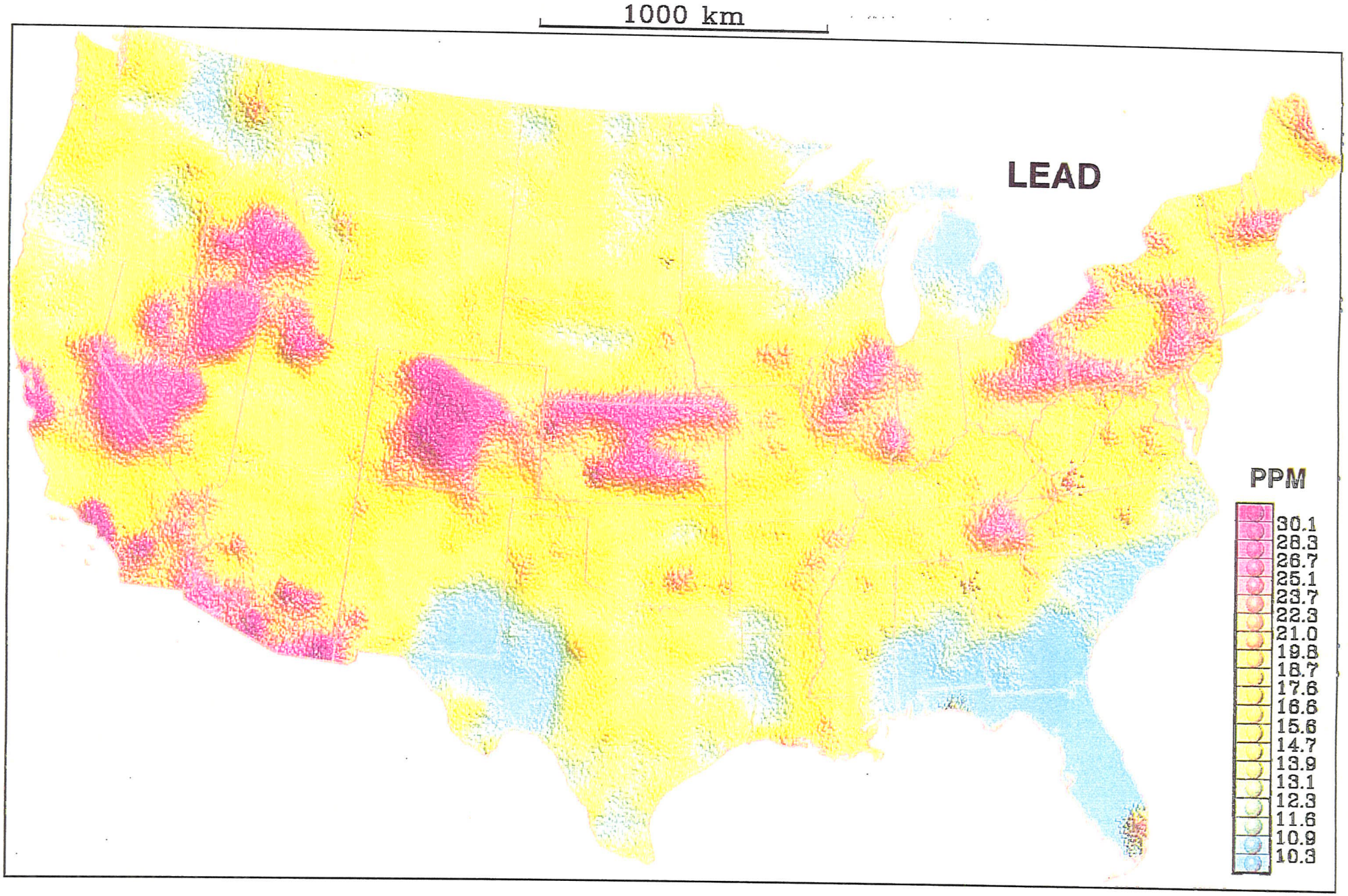
1000 km
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