Health Consultation

Review of Historical Soil Sampling Results

EL PASO COUNTY METAL SURVEY SITE

EL PASO, EL PASO COUNTY, TEXAS

JULY 20, 2001

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.

You May Contact ATSDR TOLL FREE at
1-888-42ATSDR
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

Review of Historical Soil Sampling Results

EL PASO COUNTY METAL SURVEY SITE

EL PASO, EL PASO COUNTY, TEXAS

Prepared by:

Texas Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

BACKGROUND AND STATEMENT OF ISSUES

The Texas Department of Health (TDH) and the Agency for Toxic Substances and Disease Registry (ATSDR) were asked by the U. S. Environmental Protection Agency (EPA) to determine the public health significance of arsenic and lead found in historical soil samples collected in El Paso by the Texas Air Control Board (predecessor of the Texas Natural Resource Conservation Commission) in 1989 and by graduate students from the University of Texas at El Paso in 1993 and 1994. Specifically, EPA asked TDH and ATSDR to determine whether confirmation of these data is warranted.

History

Historically, there have been several potential point sources for metals contamination in El Paso. These sources include the ASARCO Smelter on the west side of the city, the Federal Smelter in central El Paso, and the Phelps Dodge Copper refinery on the east side of the city. Much of the history pertaining to the study of industrial pollution in the El Paso has focused on the ASARCO Smelter which occupies 123 acres of a 585 acre property along the Rio Grande, near the U.S - Mexico border (Figure 1). Originally known as El Paso Smelting Works, the plant was built in 1887 and was the first smelter in Texas. In 1899 it became part of the American Smelting and Refining Company (ASARCO). Lead smelting was the primary activity at ASARCO until approximately 1910 or 1920 when copper smelting was initiated. The facility became one of the world's largest copper smelters. The smelter had a secondary zinc fuming operation from the late 1940s until 1982. A smaller cadmium roasting unit also was operated on an intermittent basis beginning in the 1950s. In 1967, a 828 foot stack was installed as the centerpiece of its operations. Lead smelting was discontinued in 1985 and the Plant was placed on care and maintenance status in 1999 [1].

In December 1971, the El Paso City-County Health Department discovered that the ASARCO facility in El Paso was discharging large quantities of lead and other metals into the air. Reportedly, between 1969 and 1971, the smelter had released 1,116 tons of lead, 560 tons of zinc, 12 tons of cadmium, and 1.2 tons of arsenic into the atmosphere. Twenty-four hour air samples collected in 1971, 1972, and 1973 by the local health department indicated that the mean concentrations of metals in the air were highest immediately downwind of the smelter and decreased logarithmically with distance from the smelter. In 1971, the annual mean lead level immediately downwind of the smelter was 92 micrograms per cubic meter ($\mu g/m^3$). Soil samples taken by the health department between June and December of 1972 showed the highest concentrations of lead and other metals to be in surface soil from within 0.2 miles of the smelter [2].

In August 1972, in part to determine whether high blood lead levels in children were associated with smelter emissions or could be explained by other lead sources in the community, the health department and the Centers for Disease Control and Prevention (CDC) measured the blood lead levels of 758 people 1–19 years of age. They found that the percentage of the people with blood lead levels greater than 40 micrograms per deciliter (µg/dL) decreased with distance from the smelter. The inverse gradient between lead in air and distance from the ASARCO smelter and the parallel blood lead gradient supported an association between the smelter emissions and the blood lead levels in the children.

They also found that people with blood lead levels ≥40 µg/dL had been exposed to soil and dust with significantly higher ($p<0.001$) mean lead concentrations (3,264 parts per million [ppm] for soil; 3,522 ppm for dust) than people with lead levels below 40 µg/dL (means: 1,032 ppm for soil; 1,279 ppm for dust). These findings supported the argument that soil and dust could be important vehicles of exposure for children [2].

Up until the early 1970s, lead attributable to emission and dispersion into the general ambient environment was not thought to have any known harmful effects [3]. The investigations conducted around the ASARCO El Paso facility played an important role in identifying the potential public health significance of lead released into the environment.

Historical Environmental Sampling Data Reviewed in this Consultation

In 1989, the Texas Air Control Board collected surface soil (top ½ inch) samples in El Paso, Texas [4]. In choosing the sampling locations an emphasis was placed on collecting samples in the vicinity of schools and recreational parks (Figure 1; Table 1). The highest concentration, 1,100 milligrams of arsenic per kilogram of soil (1,100 mg/kg), detected in the soil was found in the sample taken at the International Boundary and Water Commission, an area identified as being close to the ASARCO facility and directly across from a brick manufacturing company in Mexico. At that time the levels of contaminants were judged not to pose a threat to human health because the areas with the highest concentrations were not considered to be in places frequented by the general public.

Between 1993 and 1994, the University of Texas at El Paso released four master of science theses (Barnes, Ndame, Srinivas, and Devenahalli) documenting metals concentrations in El Paso soils [5–8]. These students collected surface soil samples (0–2.5 centimeters [cm]) from various areas around El Paso (Figure 1). There was a strong correlation (0.94) between the concentrations of lead and arsenic found in the soil (Figure 2). The highest concentrations of lead (5,194 mg/kg) and arsenic (589 mg/kg) were found in the area identified by Barnes as the ASARCO Area (Table 2a and 2b). The distribution of lead and arsenic in soil from the areas that included the ASARCO facility differed from the distribution of these contaminants in soil collected from areas that did not include the facility with a greater percentage of the samples skewed towards higher concentrations (Figure 3 and 4).

Previous TDH and ATSDR Involvement

In 1995, TDH investigated a concern that there was an excessive occurrence of multiple sclerosis (MS) among people who spent their childhoods in the Kern Place-Mission Hills area of El Paso [9]. Residents also had asked whether there could be a connection between the MS and exposure to contaminants from a nearby smelter. On the basis of initial referrals, TDH identified 15 likely cases of MS among persons who resided in this neighborhood as children. All of the people were born between 1943 and 1953 and spent at least four years of their childhood (before age 16 years) in the Kern Place-Mission Hills neighborhood. During the 1950s and 1960s, the neighborhood was comprised of upper-income, single-family housing and was considered to be among the most affluent areas of El Paso. The population was predominantly, if not exclusively, white and non-Hispanic. Of the 15 persons identified as likely cases of MS (medical verification was not performed for this evaluation), 14 went to Mesita School (the local public elementary school for grades 1–7) and one went to a private school. Mesita School, located on the east side of Kern Place, is approximately 1 mile east-northeast of the smelter.

TDH determined that the number of apparent MS cases in the age group of concern appeared to be unusual and, although the etiology of MS is unknown, epidemiologic studies provide evidence that environmental exposures, whether infectious or non-infectious, before puberty might have an important role in the risk for developing the disease later in life. Although TDH did find some studies identifying metals as having a possible etiologic role in the development of the disease, determining if contaminants from the smelter were associated with the apparent unusual number of MS cases in the area was not possible. TDH recommended further investigation of the apparent cluster and subsequently received funds from ATSDR to better verify the cluster. A final report on the investigation is being prepared.

In response to a recent concern over the possibility that soil in the area still might contain excess lead, TDH reviewed data (for 1997–1999) from the Texas Childhood Lead Surveillance Program for El Paso County. They found that 117 (4.5%) of 2,628 children tested in the combined ZIP codes 79901, 79902, 79912, 79922, and 79968 had elevated blood lead levels ($>10\mu g/dL$); 16 (9.6%) of the 167 children tested in ZIP code 79922 had elevated blood lead levels; and 385 (1.7%) of the 22,397 children tested in the rest of El Paso County had elevated blood lead levels. For the same 3–year period, 2.4% of the children tested in Texas had elevated blood lead levels [10].

DISCUSSION

The environmental sampling data that we used in this discussion include data from the 1989 Texas Air Control Board report and data from the four masters' theses written by students from the University of Texas at El Paso. In preparing this report on the public health significance of these data, we relied on the information provided in the referenced documents and assumed adequate quality assurance/quality control (QA/QC) procedures were followed with regard to data collection, chain-of-custody, laboratory procedures, and data reporting. The analysis and conclusions in this report are valid only if the referenced information is valid and complete.

To facilitate our interpretation of these data we made a reasonable attempt at delineating samples either as having been collected from the area identified in the Barnes thesis as the ASARCO area or from other areas of El Paso. For ease of presentation and historical consistency we have identified these areas as the "ASARCO area" and "Other El Paso". For lead, the data used to describe the ASARCO area includes data from the Barnes thesis (ASARCO area) and the Ndame thesis. For arsenic, the data used to describe the ASARCO area includes data from the Barnes thesis (ASARCO area) and portions of the TACB data that we were able to identify as having been collected from this area. Data collected from all other areas were included in the Other El Paso area (Figure 5). While the designation of these areas is not perfect, it is consistent with historical reports of metals contamination in the El Paso area. The concentrations of lead and arsenic in soil from the ASARCO area were significantly higher ($p<0.05$) than the concentrations of these contaminants in soil from other areas of El Paso (Figures 6 and 7; Table 3).

In assessing the potential public health significance of these sample results we recognize that the data used in this assessment were not collected with the goal of assessing exposure. Our knowledge of exactly where the samples were collected and the potential for human contact is poor. As such, the exposure estimates used in this consult are theoretical and in many cases worst case scenarios used only to determine if confirmation sampling is warranted. The exposure estimates used in this assessment should not be taken to apply to any individual or group of individuals.

We also recognize that the unique vulnerabilities of children demand special attention. Windows of vulnerability (critical periods) exist during development, particularly during early gestation, but also throughout pregnancy, infancy, childhood and adolescence ---- periods when toxicants may permanently impair or alter structure and function [11]. Unique childhood vulnerabilities may be present because, at birth, many organs and body systems (including the lungs and the immune, endocrine, reproductive, and nervous systems) have not achieved structural or functional maturity. These organ systems continue to develop throughout childhood and adolescence. Children may exhibit differences in absorption, metabolism, storage, and excretion of toxicants, resulting in higher biologically-effective doses to target tissues. Depending on the affected media, they also may be more exposed than adults because of behavior patterns specific to children. In an effort to account for children's unique vulnerabilities, and in accordance with ATSDR's Child Health Initiative [12] and EPA's National Agenda to Protect Children's Health from Environmental Threats [13], we used the potential exposure of children to the contaminants found in the soil as a guide in assessing the need for confirmation sampling.

Lead

To assess the potential health risks associated with the lead in the soil we used the CDC's definition of excessive lead absorption in children and the estimated relationship between blood lead in children and soil lead concentrations (EPA's integrated uptake biokinetic model) to derive a health-based assessment comparison (HAC) value for this contaminant. HAC values are guidelines that specify levels of chemicals in specific environmental media (soil, air, water) that are considered safe for human contact. Exceeding a health-based HAC value does not imply that a contaminant will cause harm but suggests that potential exposure to the contaminant warrants further consideration.

Based on observations of enzymatic abnormalities in the red blood cells at blood lead levels below 25 µg/dL and observations of neurologic and cognitive dysfunction in children with blood lead levels from 10–15 µg/dL, the CDC has determined that a blood lead level ≥10 µg/dL in children indicates excessive lead absorption and constitutes the grounds for intervention [14]. The relationship between soil lead levels and blood lead levels is affected by factors such as the age of the population exposed to the contaminated soil, the physical availability of the contaminated soil, the bioavailability of the lead in the soil, and differences in individual behavioral patterns [15–17]. While there is no clear relationship applicable to all sites, a number of models have been developed to estimate the potential impact that soil lead could have on the blood lead levels in different populations [17–19]. In general, soil lead will have the greatest impact on the blood lead levels of preschool-age children. These children are more likely to play in dirt and to place their hands and other contaminated objects in their mouths, they are better at absorbing lead through the gastrointestinal tract than adults, and they are more likely to exhibit the types of nutritional deficiencies that facilitate the absorption of lead. For children, the predicted 95th percentile blood lead level associated with a soil lead concentration of 500 mg/kg is approximately 10 µg/dL. This means that except in the most extreme cases (i.e., frequent contact by children exhibiting pica behavior, or desire for unnatural foods such as dirt or ashes) children regularly exposed to soil lead levels of 500 mg/kg should have no more than a 5% probability of having blood lead levels greater than 10 µg/dL.

Fitting a lognormal distribution to the available data we estimate that approximately 33 % of the soil samples from the ASARCO area could exceed 500 mg/kg (Table 3). Based on the goal of limiting the probability of exceeding a blood lead level of 10 µg/dL to no more than 5%, depending on individual exposure situations, the concentrations of lead found in some of the soil from the ASARCO area could be considered unacceptable.

Further Analysis of the Blood Lead Level Results

In the recent analysis of childhood blood lead levels for El Paso County, TDH examined two factors that could have influenced the results in the comparisons of the five ZIP codes to the rest of El Paso County [10]. Those factors were socioeconomic status (SES) and Medicaid enrollment. Lower SES is a known risk factor associated with higher rates of elevated blood lead levels in a population. Neither SES or Medicaid enrollment could explain the findings.

According to the CDC, lead-based paint remains the most common high-dose source of lead exposure for preschool age children [14]. Numerous studies have established that the risk of lead poisoning is related to the presence of lead-based paint in the home [14]. Lead-based paint containing up to 50% lead was widely used through the 1940s and although the use of interior lead-based paint declined thereafter, exterior lead-based paint and lesser amounts of interior lead-based paint continued to be available until the mid-1970s.

In an effort to examine whether lead-based paint could in part explain the differences in the blood lead data between the ZIP codes, for each ZIP code, we regressed the percentage of children with blood lead levels greater than 10 µg/dL with the median year that the houses in the ZIP code were built (Figure 8). The earlier the median age, the older the housing stock in the area. The implied assumption is that the probability that lead-based paint is present in the home increases with the age of the home. The percentage of children with elevated blood lead levels increased as the median age of the homes increased. The slope of the regression line was significantly different from zero (p=0.003) suggesting that the age of the housing stock could to some extent explain the blood lead results. When plotting the data, the data point for ZIP code area 79922 appeared to lie far from the regression line so we tested the significance of the deviation of this data point from the regression line and found it to be large enough to excite suspicion (p<0.05). While the overall analysis suggests that the age of the homes (and by inference lead-based paint) could to some extent explain the blood lead data for the different ZIP codes, the data also suggest that something else may be contributing to the blood lead level results for ZIP code 79922. ZIP code area 79922 is within the area identified by Barnes as the ASARCO area. In addition to lead-based paint, other common potential sources of lead that could explain these results include lead in soil and dust, lead from food stored in some types of glazed pottery or ceramic ware, lead from old water pipes made of lead, lead from newer water pipes that contain lead solder, and lead from certain folk or home remedies such as greta and azarcon.

Arsenic

To assess the potential health risks associated with the arsenic in soil we compared the soil concentrations to health-based assessment comparison (HAC) values for non-cancer and cancer endpoints. The non-cancer HAC values for arsenic in soil (20 mg/kg for children and 200 mg/kg for adults) are based on EPA's reference dose (RfD) for arsenic of 0.3 µg/kg/day [19]. RfDs are based on the assumption that an there is an identifiable exposure threshold (both for the individual and for populations) below which there are no observable adverse effects. Thus, the RfD is an estimate of a daily exposure to arsenic that is unlikely to cause adverse non-cancer health effects even if exposure were to occur for a lifetime. For arsenic, the RfD was derived by dividing the identified no observable adverse effects level (NOAEL[1]) of 0.8 μg/kg/day, obtained from human epidemiologic studies, by an uncertainty factor of three. The lowest observable adverse effects level (LOAEL[2]) associated with these epidemiologic studies was 14 μg/kg/day, where exposure to arsenic above this level resulted in hyperpigmentation of the skin, keratosis (patches of hardened skin), and possible vascular complications [20–22]. We used standard assumptions for body weight (70 kg adult and 15 kg child) and soil ingestion (100 mg per day for adults and 200 mg per day for a child) to calculate the HAC values.

The average concentration of arsenic in soil from the area identified as the ASARCO area (105 mg/kg), is five times greater than the non-cancer HAC value for children. Fitting a lognormal distribution to the data we estimate that approximately 73% of the soil samples from the ASARCO area could exceed the non-cancer HAC value for children (Table 3). Fifty percent of the soil samples from the ASARCO area were over 44 mg/kg, a concentration two times greater than the non-cancer HAC value. The average concentration of arsenic found in soil from other areas of El Paso was 20 mg/kg, a value equal to the non-cancer HAC value. Approximately 36% of the samples from other areas of El Paso exceeded the non-cancer HAC value (Table 3). Arsenic does occur naturally in the earth's crust and can usually be found in the inorganic form in the environment at background levels ranging from less than 1 mg/kg to 97 mg/kg with average concentrations of 7 to 8 mg/kg [23].

Assuming that the concentrations of arsenic in these soil samples are representative of the concentrations to which people may be exposed, children regularly exposed to soil from the ASARCO area could be exposed to arsenic at levels above the NOAEL. It is less likely that they would be exposed to levels above the LOAEL. Since by definition neither the NOAEL or the LOAEL represent a sharp dividing line between "safe" and "unsafe" exposures, we assume that the public health significance of the arsenic increases as the ratio of the NOAEL to the estimated exposure dose decreases. We refer to this ratio as the margin of exposure (MOE) and consider MOEs less than 10 to be unacceptable. Under some potential exposure scenarios MOEs for both children and adults could be less than 10. On the basis of these data, under some conditions the concentrations of arsenic in the soil from the area identified as the ASARCO area could be considered to be unacceptable (Table 4a, 4b).

The average concentration of arsenic found in soil from other areas of El Paso is five times lower than the average concentration found in the ASARCO area but higher than the average concentration generally found in soil from the western United States [23]. Under a limited subset of potential exposure scenarios, the MOE for children could be less than 10. Thus, the arsenic in the soil from some of these areas also could be considered unacceptable (Table 5a).

---

[1]The highest dose at which adverse effects were not observed.

[2]The lowest dose at which adverse effects were observed.

EPA classifies arsenic as a known human carcinogen on the basis of sufficient evidence from human data. An increase in lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer (non-malignant) were observed in populations consuming water high in inorganic arsenic [21]. The carcinogenic HAC value for arsenic of 0.5 mg/kg is based on EPA's cancer slope factor (CSF) for skin cancer and an estimated excess lifetime cancer risk of one cancer in 1 million (1×10^{-6}) people exposed for 70 years.

Arsenic was detected in virtually all the soil samples at concentrations above its carcinogenic HAC value; however, an important note is that background levels of arsenic also exceed this HAC value. To estimate a broad range of conservative (with respect to protecting public health) exposure scenarios we assumed that an individual would ingest 50 or 100 milligrams of soil (containing the average concentration of arsenic), 50 weeks per year, one to seven days per week. Depending on the exposure scenario, we would qualitatively interpret the potential excess lifetime cancer risk associated with soil from the ASARCO area to range from an insignificant increased lifetime risk to a low increased lifetime risk (Table 6a). We would interpret the potential excess lifetime cancer risk associated with soil from other areas of El Paso to range from an insignificant lifetime risk to no apparent increased lifetime risk (Table 6b).

Uncertainties

General Uncertainties

Because of the nature of the data used in this report we were not able to estimate exposure with any degree of certainty. Our lack of knowledge pertaining to where the samples were taken prevents us from adequately estimating whether the samples were taken from areas where people would come into contact with the soil on a regular basis.

While our analysis of the blood lead data suggest that the age of housing may to some extent explain the differences between the ZIP codes and that something else may be contributing to the blood lead levels in children from ZIP code area 79922, these data are not random and were not collected with the purpose of performing such an analysis.

Specific Uncertainties

Considerable controversy also is associated with any estimate of risk, non-cancer or cancer, associated with exposure to arsenic. Both the RfD and the CSF are based on human ecological studies that have recognized uncertainties with respect to the assignation of exposure. Such studies find it difficult to avoid errors in assigning people to specific exposure groups. The studies upon which the RfD and the CSF are based also involved exposure to arsenic in drinking water. The ability of the body to absorb arsenic in water is likely to be higher than the ability of the body to absorb arsenic in soil. In our analysis we assumed that the arsenic in the soil was 100% bioavailable. Assuming that the applied dose (the amount available for absorption) is the same as the internal dose (the amount of that has been absorbed), is very conservative with respect to protecting public health and to some unknown degree overestimates the risk. We did not consider the kinetics of arsenic in the body in our risk estimates. The RfD and the CSF are based on daily exposures over a lifetime. Since the half-life of arsenic in the body (the time it takes one-half of the arsenic to be excreted) is short (40-60 hours), the risk estimates for exposures that occur less frequently than everyday also may result in an overestimate of the risks.

With specific respect to the cancer risk estimates, the mechanisms through which arsenic causes cancer are not known; however, arsenic is not thought to act directly with DNA. Since the studies used to derive the CSF are based on exposure doses much higher than those likely to be encountered at this site, it is questionable whether it is appropriate to assume linearity for the dose-response assessment for arsenic at low doses. The actual dose-response curve at low doses may be sublinear which would mean that the above risk estimates overestimate the actual risks.

CONCLUSIONS

1. Under some theoretical exposure situations, the lead and arsenic found in the soil from some areas of El Paso could be considered unacceptable. However, in light of the uncertainties associated with site-specific exposures we would have to categorize the contaminants found in the soil to pose an indeterminate public health hazard.

2. Although our analysis suggests that the blood lead level results for the different zip codes could to some extent be explained by the age of the housing, it would not be inconsistent with the data to suspect that other causal factors could be at work in ZIP code area 79922. Such factors could include lead in soil and dust, lead from food stored in some types of glazed pottery or ceramic ware, lead in old water pipes made from lead, lead from water pipes that contain lead solder, and lead from certain folk or home remedies such as greta and azarcon.

PUBLIC HEALTH ACTION PLAN

Actions Recommended

1. Confirmation of the results from the referenced documents is warranted. Samples should be obtained from areas identified as having elevated levels of arsenic and lead and from areas known to be frequented by people, particularly children since they are at greater risk from exposure to contaminants in soil.

2. TDH and ATSDR should be provided with the sample results so that they may determine whether the concentrations found in the soil pose a threat to public health.

Actions Planned

1. EPA will be conducting confirmation sampling in publicly accessible areas within an area identified as the El Paso County /Dona Ana County study area. Sampling is to be conducted in July 2001.

2. EPA will provide TDH and ATSDR with the sample results so that they may prepare a health consultation to determine whether the concentrations found in the soil present a continuing threat to public health.

REFERENCES

1. ASARCO, El Paso plant- history and facts. www.asarcou.com/El.Paso/elpfacts.htm, 6/4/2001.

2. Human Lead Absorption - Texas. Morbidity and Mortality Weekly Review. March 3, 1999/48(LMRK);95-101.

3. National Academy of Sciences. Lead: airborne lead in perspective. Washington, DC.: Committee on Biological Effects of Atmospheric Pollutants; 1972.

4. Texas Air Control Board. Sampling and analysis of soil in the vicinity of ASARCO in El Paso, Texas. —final report; August 1989.

5. Barnes EB. An evaluation of metals concentrations in surficial soils, El Paso County, Texas. Thesis presented to the faculty of the graduate school of The University of Texas at El Paso in partial fulfillment of the requirements for the degree of master of science. Department of Geological Sciences. May 1993.

6. Ndame EC. Heavy metals in soils in the vicinity of the University of Texas at El Paso Campus (El Paso County, Texas). Thesis presented to the faculty of the graduate school of The University of Texas at El Paso in partial fulfillment of the requirements for the degree of master of science. Department of Geological Sciences. December 1993.

7. Srinivas S. Heavy metal contamination of soils in public parks, El Paso, Texas. Thesis presented to the faculty of the graduate school of The University of Texas at El Paso in partial fulfillment of the requirements for the degree of master of science. Department of Civil Engineering. May 1994.

8. Devanahalli DK. Survey of heavy metal concentrations of soils in downtown El Paso, Texas. Thesis presented to the faculty of the graduate school of The University of Texas

at El Paso in partial fulfillment of the requirements for the degree of master of science. Department of Civil Engineering. May 1994.

9. Agency for Toxic Substances and Disease Registry. Health Consultation Multiple Sclerosis Cluster, El Paso, El Paso County, Texas Department of Health. January 2, 1996.

10. Texas Department of Health (TDH). Letter to Blanco Serrano (TDH Region 10) from Jeff Shire (TDH Central Office, Bureau of Epidemiology) concerning analysis of childhood blood lead levels for El Paso County. March 14, 2001.

11. US Environmental Protection Agency. 2000. Strategy for research on environmental risks to children. Washington, DC: US Environmental Protection Agency, Office of Research and Development. EPA/600/R-00/068, Section 1.2.

12. Agency for Toxic Substances and Disease Registry (ATSDR). Child health initiative. Atlanta: US Department of Health and Human Services; 1995.

13. US Environmental Protection Agency. The children's environmental health yearbook; 1998.

14. Centers for Disease Control. Preventing lead poisoning in young children. US Department of Health and Human Services; October 1991.

15. Agency for Toxic Substances and Disease Registry. Toxicological profile for lead. Atlanta: US Department of Health and Human Services; April 1993.

16. Agency for Toxic Substances and Disease Registry. The nature and extent of lead poisoning in children in the United States: a report to Congress. Atlanta: US Department of Health and Human Services; 1988.

17. Agency for Toxic Substances and Disease Registry (ATSDR). Analysis paper: Impact of lead-contaminated soil on public health. US Department of Health and Human Services; May 1992.

18. Society for Environmental Geochemistry and Health. 1993. Lead in soil, recommended guidelines. Science Reviews.

19. US Environmental Protection Agency (USEPA). Memorandum from Mark Maddaloni, chair technical review workgroup adult lead subgroup to Pat Van Leeuwen, region 5 superfund program use of the technical review workgroup Interim Adult Lead Methodology in Risk Assessment, April 1999.

20. U.S. Environmental Protection Agency. Integrated risk information system. Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office. Cincinnati, OH: US Environmental Protection Agency; 1999.

21. Agency for Toxic Substances and Disease Registry. Toxicological profile for arsenic. Atlanta: US Department of Health and Human Services; April 1993.

22. Tseng WP, Chu H, How S, Fong J, Lin C, Yeh S. 1968. Prevalence of skin cancer in an endemic area of chronic arsenism in Taiwan. J. Natl. Cancer Inst 40:453–463.

23. Agency for Toxic Substances and Disease Registry. Health assessment guidance manual Chapter 5, Table 5.1. ATSDR1.atsdr.cdc.gov:8080/HAC/HAGM/t51.html.

Table 1. 1989 Texas Air Control Board Surface Soil Sample Results – El Paso, Texas	
Sample location	**Arsenic concentration (mg/kg)**
Dunn Park	10
Tom Lea Park	7
Mission Hills Park	11
Westside Park	5
Madeline Park	16
Ascarte Park	<3
Washington Park	<3
Loretto Park	<3
Memorial Park	6
Grandview Park	5
Newmann Park	6
Houston Square Park	7
Armijo Park	6
Kerr Park	59
Doniphan Park	6
Vilas Elementary School	10
Mesita Elementary School	24
University of Texas at El Paso	12
University of Texas at El Paso	15
Crazycat Mountain	16
Rio Bravo Drive	15
Interstate Hwy. 10	250
International Boundary and Water Commission	1,100
W. Robertson Water Treatment Plant	26

Table 2a. Soil Lead Levels in Surface Soil Collected from Various Areas of El Paso

Parameter	Barnes ASARCO area	Barnes other El Paso areas	Ndame ASARCO area	Srinivas other El Paso areas	Devanahalli other El Paso areas
Average	963	93	385	55	103
Min-max	54 - 5,194	27 - 390	34 - 1,500	30 - 135	17 - 560
50th Percentile	541	68	163	50	65

Table 2b. Soil Arsenic Levels in Surface Soil Collected from Various Areas of El Paso

Parameter	Barnes ASARCO area	Barnes other El Paso areas	TACB mixed areas	Devanahalli other El Paso areas
Average	115	23	65	18
Min-max	19 - 589	10 - 66	3 - 1,100	13 - 92
50th Percentile	72	19	12	14

Table 3. Lead and Arsenic in El Paso Soil. ASARCO area vs. other El Paso areas

Parameter	Lead		Arsenic	
	ASARCO area	other El Paso	ASARCO area	other El Paso
Arithmetic average (mg/kg)	606	84	105	20
Geometric mean (mg/kg)	276	62	44	16
Percent > 400 mg/kg (lead) Percent >20 mg/kg (Arsenic)	39	< 1	73	36
Percent > 500 mg/kg (lead) Percent >30 mg/kg (arsenic)	33	< 1	62	18

Table 4a. ASARCO Area Margin of Exposure [1] Analysis for exposure of Children to Arsenic [2]

Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	16.0	8.0	5.3	4	3.2	2.7	2.3
75	10.7	5.3	3.6	2.7	2.1	1.8	1.5
100	8.0	4	2.7	2	1.6	1.3	1.1
125	6.4	3.2	2.1	1.6	1.3	1.1	0.9
150	5.3	2.7	1.8	1.3	1.1	0.9	0.8
175	4.6	2.3	1.5	1.1	0.9	0.8	0.7
200	4	2	1.3	1.0	0.8	0.7	0.6

Table 4b. ASARCO Area Margin of Exposure [1] Analysis for exposure of Adults to Arsenic [2]

Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	74.7	37.3	24.9	18.7	14.9	12.4	10.7
75	49.8	24.9	16.6	12.4	10.0	8.3	7.1
100	37.3	18.7	12.4	9.3	7.5	6.2	5.3
125	29.9	14.9	10.0	7.5	6.0	5.0	4.3
150	24.9	12.4	8.3	6.2	5.0	4.2	3.6
175	21.3	10.7	7.1	5.3	4.3	3.6	3.1
200	16.7	9.3	6.2	4.7	3.7	3.1	2.7

[1] No observable adverse effects level (NOAEL) divided by the estimated exposure dose. Shaded areas represent those conditions under which the MOE is less than 10. Body weights assumed to be 15 kilograms (kg) for children and 70 kg for adults.

[2] This analysis likely overestimates the actual risks as it assumes that the arsenic in the soil is 100% bioavailable and does not take into account the biokinetics of arsenic in the body.

Table 5a. Other El Paso Areas Margin of Exposure[1] Analysis for exposure of Children to Arsenic[2]							
Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	84.0	42.0	28.0	21.0	16.8	14.0	12.0
75	56.0	28.0	18.7	14.0	11.2	9.3	8.0
100	42.0	21.0	14.0	10.5	8.4	7.0	6.0
125	33.6	16.8	11.2	8.4	6.7	5.6	4.8
150	28.0	14.0	9.3	7.0	5.6	4.7	4.0
175	24.0	12.0	8.0	6.0	4.6	4.0	3.4
200	21.0	10.5	7.0	5.3	4.2	3.5	3.0

Table 5b. Other El Paso Areas Margin of Exposure[1] Analysis for exposure of Adults to Arsenic[2]							
Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	392	196	131	98	78	65	56
75	261	131	87	65	52	44	37
100	196	98	65	49	39	33	28
125	157	78	52	39	31	26	22
150	131	65	44	33	26	22	19
175	112	56	37	28	22	19	16
200	98	49	33	25	20	16	14

[1] No observable adverse effects level (NOAEL) divided by the estimated exposure dose. Shaded areas represent those conditions under which the MOE is less than 10. Body weights assumed to be 15 kilograms (kg) for children and 70 kg for adults.

[2] This analysis likely overestimates the actual risks as it assumes that the arsenic in the soil is 100% bioavailable and does not take into account the biokinetics of arsenic in the body.

Table 6a. ASARCO Area Estimated Excess Lifetime Cancer Risk from Exposure to Arsenic in Soil[1]							
Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	6.6×10^{-6}	1.3×10^{-5}	2.0×10^{-5}	2.6×10^{-5}	3.3×10^{-5}	4.0×10^{-5}	4.6×10^{-5}
100	1.3×10^{-5}	2.6×10^{-5}	4.0×10^{-5}	5.3×10^{-5}	6.6×10^{-5}	7.9×10^{-5}	9.3×10^{-5}

Table 6b. Other El Paso Areas Estimated Excess Lifetime Cancer Risk from Exposure to Arsenic in Soil[1]							
Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	1.3×10^{-6}	2.5×10^{-6}	3.8×10^{-6}	5.0×10^{-6}	6.3×10^{-6}	7.6×10^{-6}	8.8×10^{-6}
100	2.5×10^{-6}	5.0×10^{-6}	7.6×10^{-6}	1.0×10^{-5}	1.3×10^{-5}	1.5×10^{-5}	1.8×10^{-5}

[1] This analysis likely overestimates the actual risks as it assumes that the arsenic in the soil is 100% bioavailable and does not take into account the biokinetics of arsenic in the body.

PREPARERS OF THE REPORT

John F. Villanacci, Ph.D.
Co-Director
Environmental Epidemiology and Toxicology Division

ATSDR REGIONAL REPRESENTATIVE

Jennifer Lyke
Regional Representative
ATSDR - Region 6

George Pettigrew, PE
Senior Regional representative
ATSDR - Region 6

ATSDR TECHNICAL PROJECT OFFICER

Alan W. Yarbrough
Environmental Health Scientist
Division of Health Assessment and Consultation
Superfund Site Assessment Branch
State Programs Section

CERTIFICATION

This health consultation was prepared by the Texas Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated.

Technical Project Officer, SPS, SSAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with its findings.

Chief, State Programs Section, SSAB, DHAC, ATSDR

Figure 1. Approximate location of the ASARCO Facility and Sampling Areas

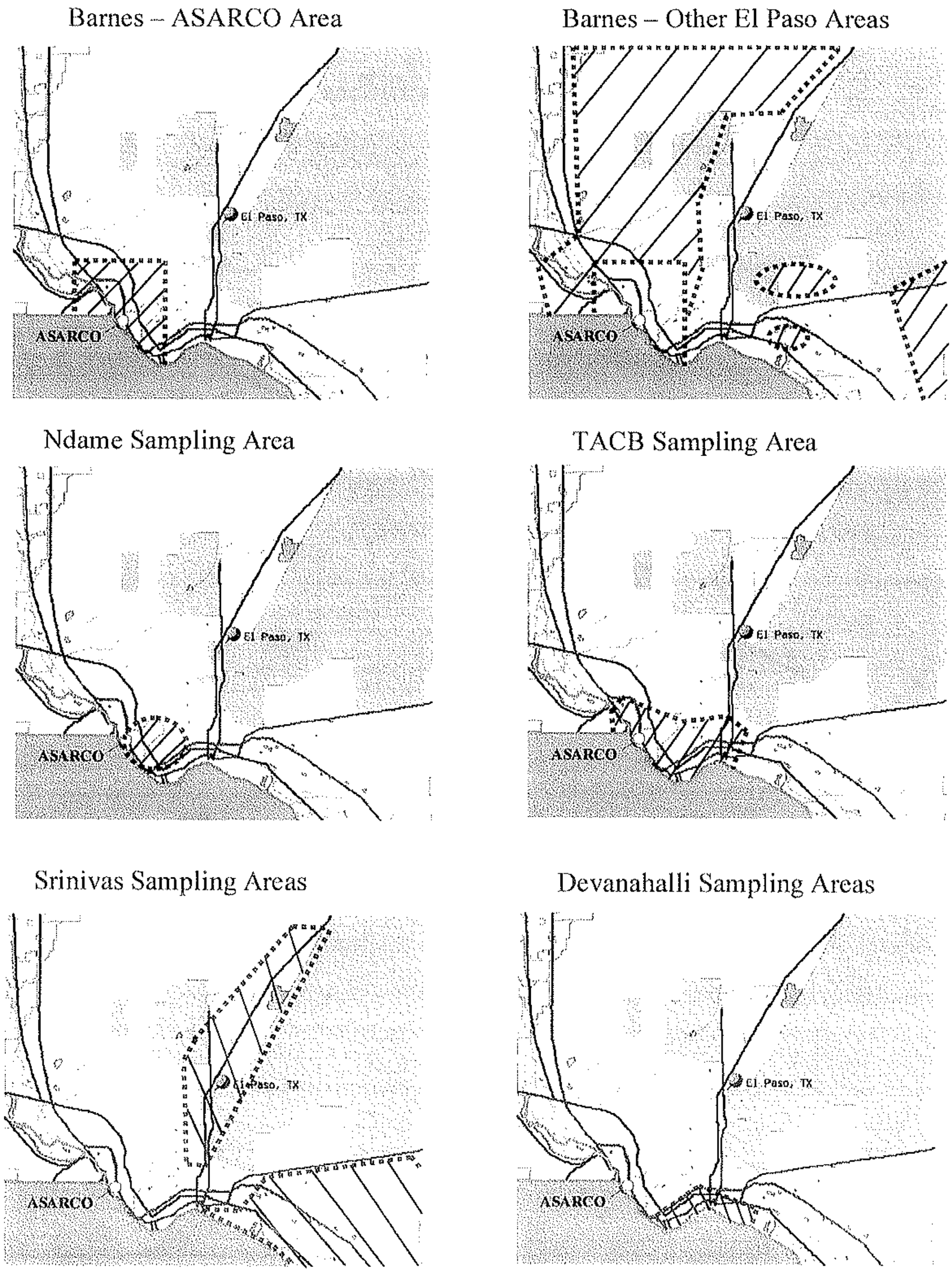


Figure 2
Barnes Thesis
Arsenic vs Lead Surface Soil Concentrations El Paso, Texas

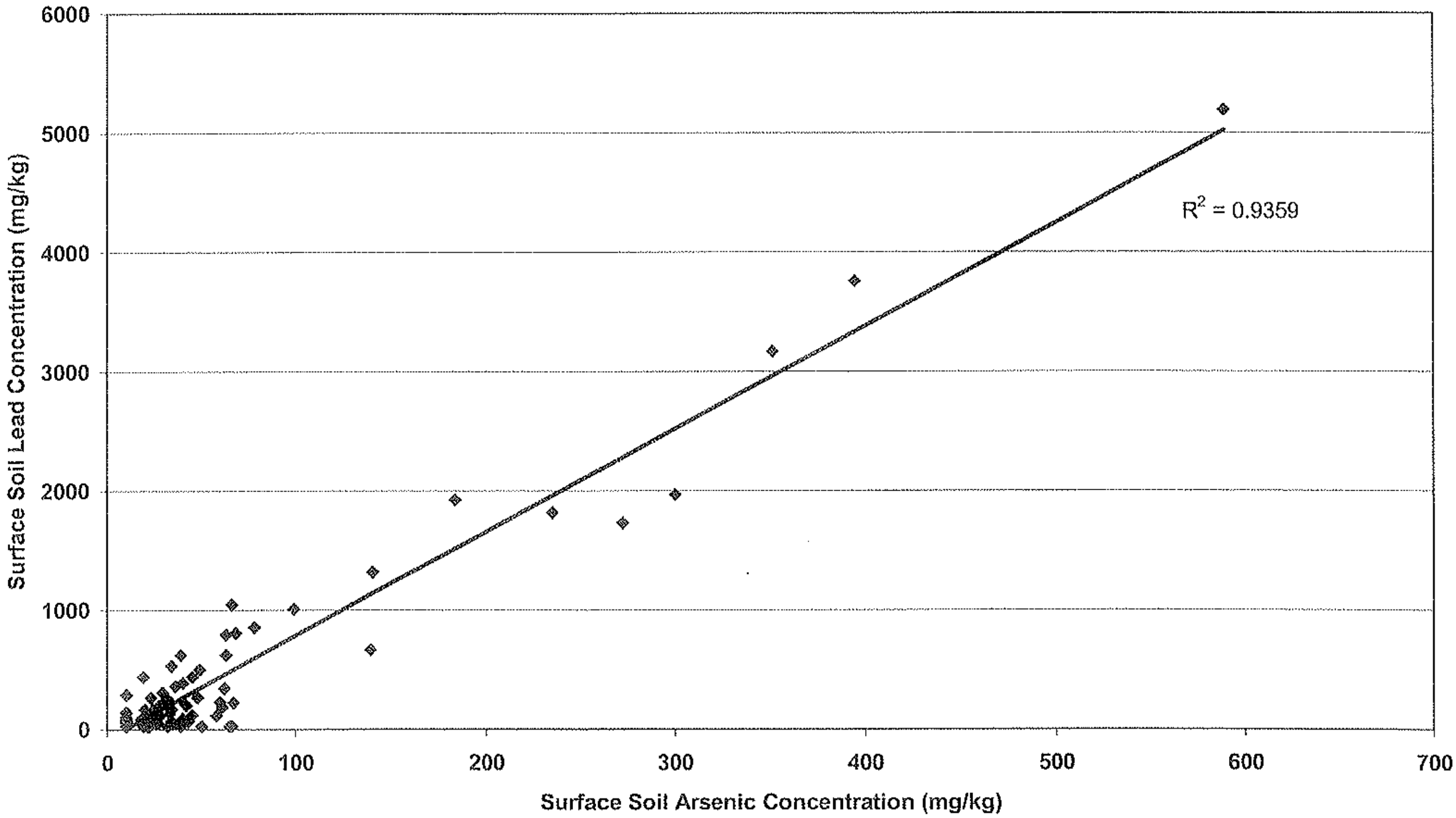
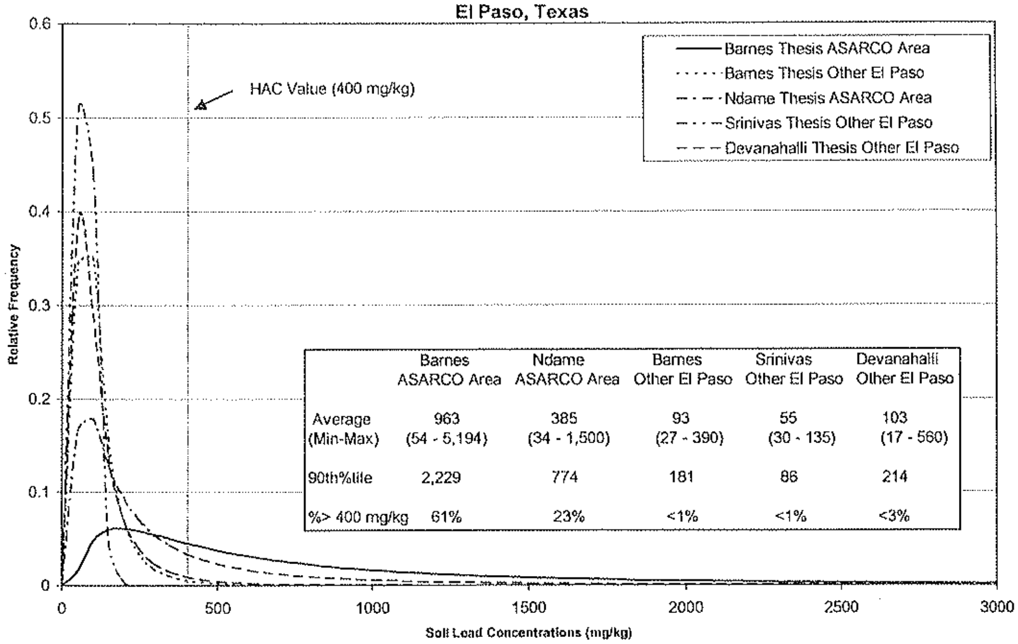
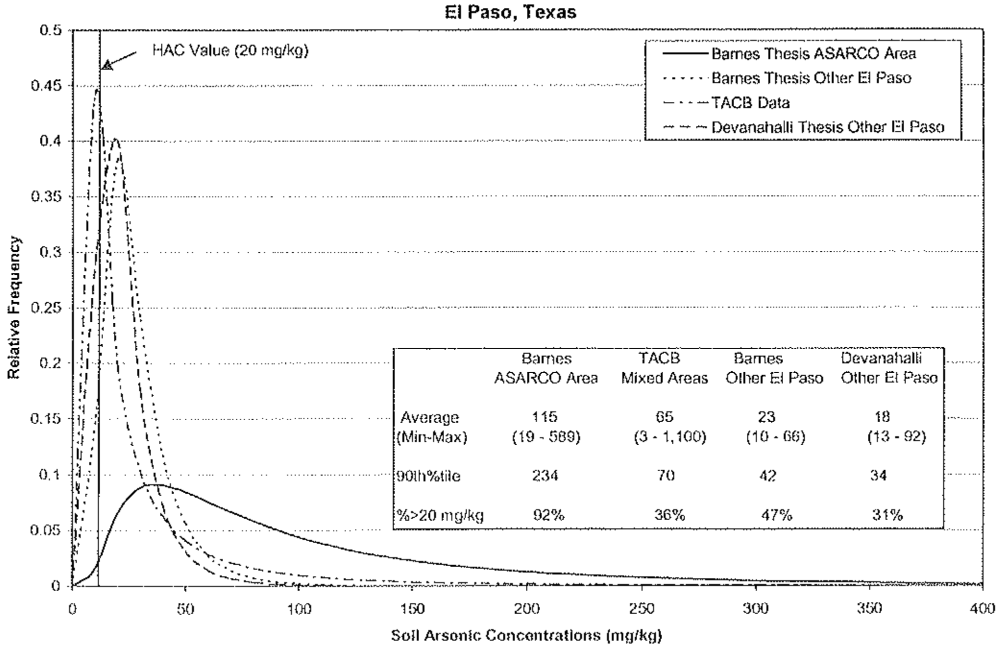


Figure 3.
Available Surface Soil Lead Data
El Paso, Texas



	Barnes ASARCO Area	Ndame ASARCO Area	Barnes Other El Paso	Srinivas Other El Paso	Devanahalli Other El Paso
Average (Min-Max)	963 (54 - 5,194)	385 (34 - 1,500)	93 (27 - 390)	55 (30 - 135)	103 (17 - 560)
90th%tile	2,229	774	181	86	214
%> 400 mg/kg	61%	23%	<1%	<1%	<3%

Figure 4
Available Surface Soil Arsenic Data
El Paso, Texas



	Barnes ASARCO Area	TACB Mixed Areas	Barnes Other El Paso	Devanahalli Other El Paso
Average (Min-Max)	115 (19 - 589)	65 (3 - 1,100)	23 (10 - 66)	18 (13 - 92)
90th%tile	234	70	42	34
%>20 mg/kg	92%	36%	47%	31%

Figure 5. Approximate delineation of sampling areas; ASARCO Area vs. Other El Paso.

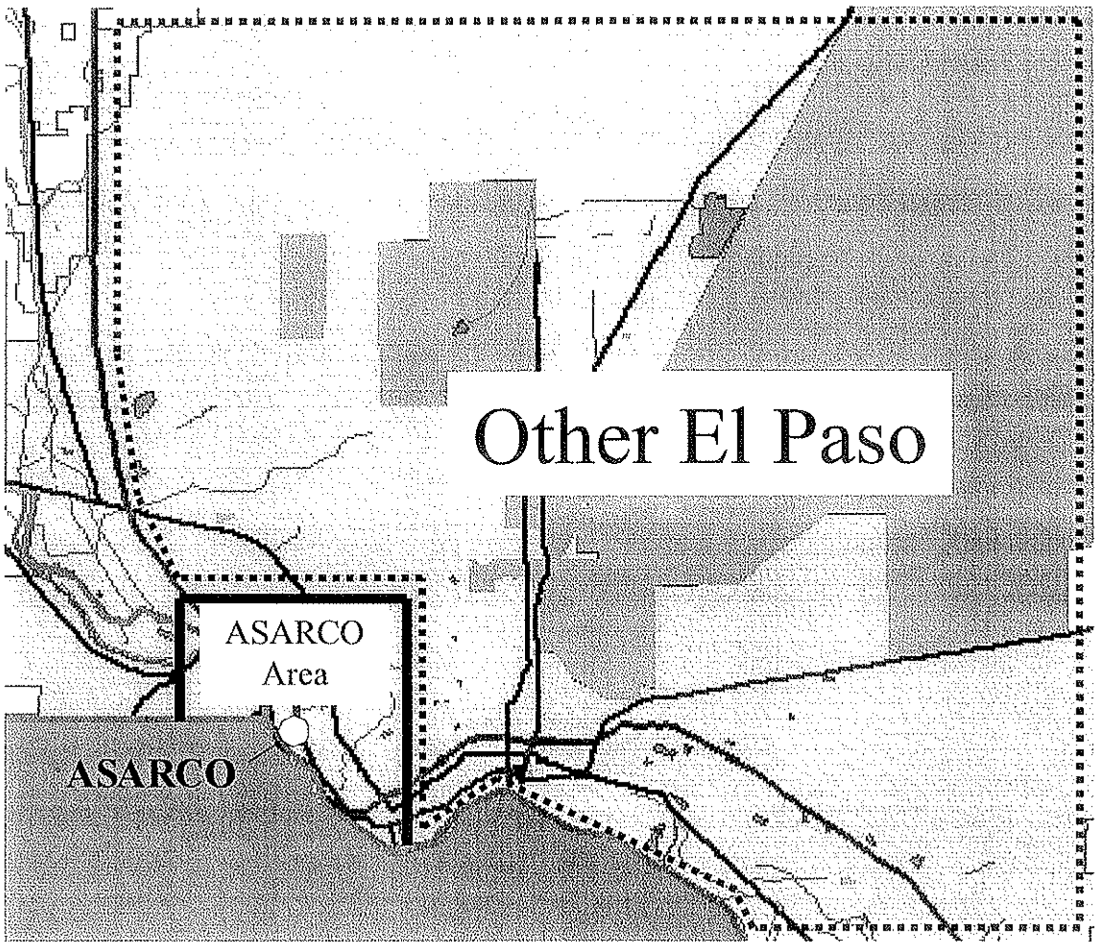


Figure 6.
Surface Soil Lead Data ASARCO Area vs. Other El Paso
El Paso, Texas

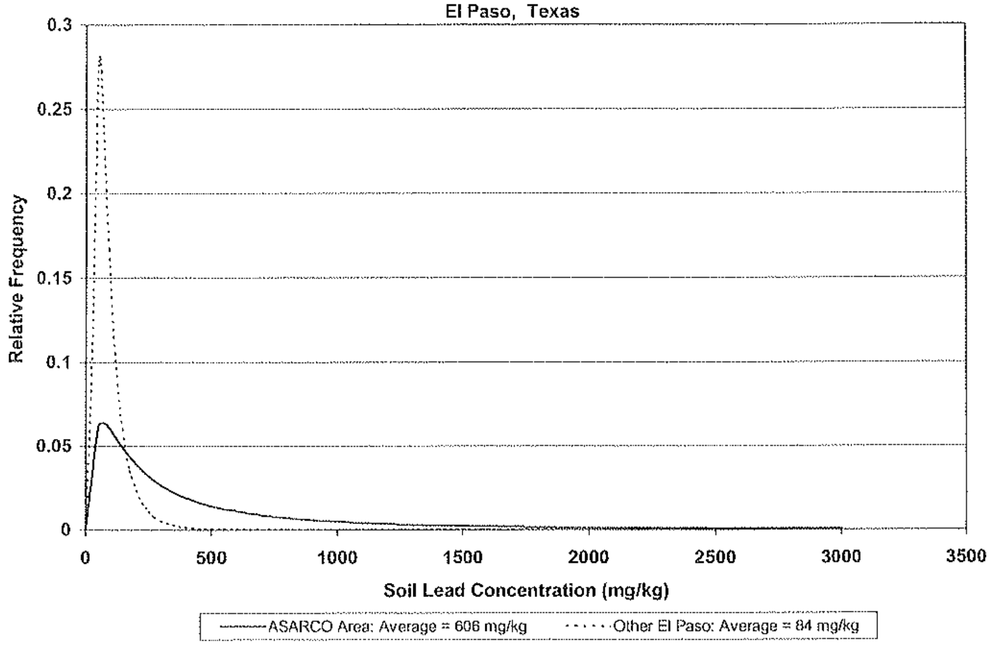


Figure 7.
Surface Soil Arsenic Data ASARCO Area vs. Other El Paso
El Paso, Texas

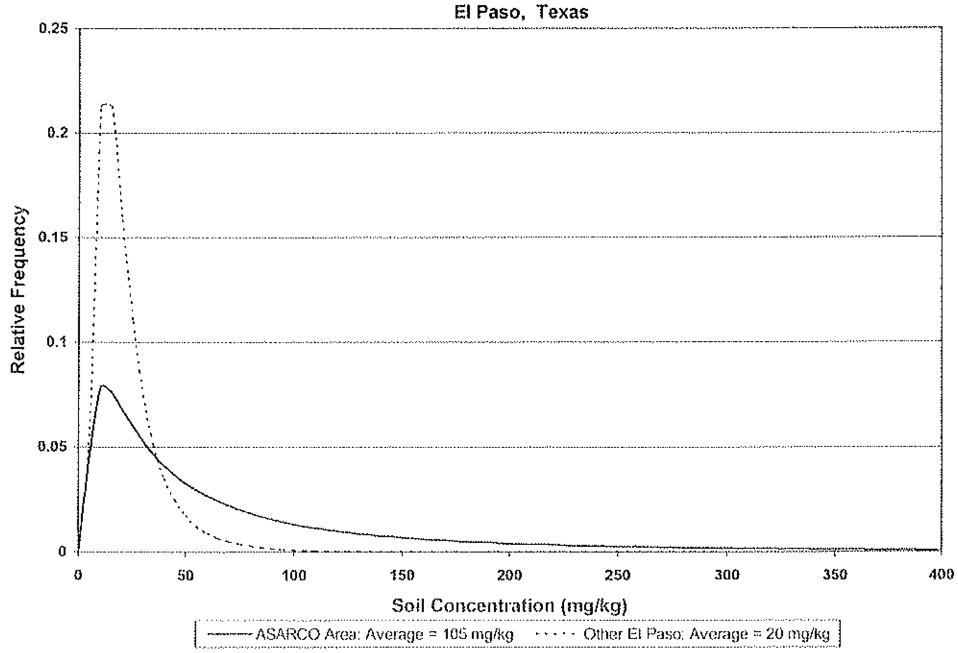


Figure 8
Regression of Percent of Children With Blood Levels Greater Than 10 µg/dL on the Median Year that Houses were Built