PETITIONED PUBLIC HEALTH ASSESSMENT

PHELPS DODGE CORP DOUGLAS REDUCTION WORKS
DOUGLAS, COCHISE COUNTY, ARIZONA
CERCLIS NO. AZDOO8397143

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Prepared by

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SUMMARY

The Phelps-Dodge site, a former copper-smelting operation just outside Douglas, Cochise County, Arizona, posed a public health hazard to children who live in Douglas and possibly Agua Prieta, Sonora, Mexico. This site contributed to lead-contaminated surface soils in residential areas in Douglas. Exposure to the lead-contaminated soils may have contributed and/or caused elevated blood lead levels in children living in both Douglas, AZ and Agua Prieta, Sonora, Mexico. Elevated blood lead levels (above 10 µg/dL) have been associated with a decreased Intelligence Quotient (IQ) and other neurobehavioral health outcomes. In addition, past chronic exposures to smelter emissions may have aggravated respiratory problems in sensitive people, such as children and adults with respiratory ailments.

In 1985, lead contamination in off-site soil (in Douglas) averaged more than 250 mg/kg; and about 350 mg/kg in Pirtleville (the neighborhood in Douglas closest to the site). Results of blood lead testing in children in 1975 and 1985 showed that the childrens' levels exceeded 10 µg/dL on the average. At the time, the levels found did not exceed levels of concern. Since then, the Centers for Disease Control and Prevention (CDC) has lowered its level of concern to 10 µg/dL, since new research indicates that even low levels of lead in the blood may negatively effect health in children. Blood lead levels greater than 10 µg/dL have been associated with decreased IQs, which measure a child's ability to learn. The rates of learning disabilities in Douglas' elementary schools were determined during preparation of this public health assessment; however, more investigation is needed to determine the relationship between the rates and environmental exposure. It is possible that lead contaminated soil in Douglas and Pirtleville could have contributed to elevated blood lead levels in Douglas' and Pirtleville's children.

Past emissions from the smelter included arsenic, lead, sulfur dioxide, inhalable particulate matter, and other heavy metals. The levels detected by air monitoring were elevated above health guidelines. Past exposures to airborne arsenic emissions, if inhaled over a long period of time, may present a low increased risk of lung cancer. Chronic inhalation of inhalable particulate matter and sulfur dioxide are also associated with adverse respiratory effects. A study conducted in 1979 by the University of Utah concluded that there was no increase in mortality associated with lung cancer in Douglas; however, the study had numerous methodologic problems that limit its usefulness for evaluating lung cancer outcomes in the area. A new study of lung cancer deaths (considering various risk factors) is currently underway by the Arizona Department of Health Services.

Along with concerns about contamination of soil and air in Douglas, community members are concerned about numerous health outcomes, including birth defects, collagen diseases, cancer, diabetes, asthma, allergies, ear infections, and poor eyesight in children. The Border Ecology Project (a local activist group) has expressed concerns about heavy metal contamination on site and its potential to migrate off site via Whitewater Draw (an intermittent stream) and underground water. Those concerns are addressed in the Community Health Concerns Evaluation section of this public health assessment.

The petitioner who requested a public health assessment of the Phelps-Dodge smelter was concerned about occupational exposure to asbestos during removal operations at the site in 1990. Workers who did not have or use protective respiratory equipment during demolition were exposed to levels of asbestos that increase their risk of developing lung cancer.

Following its evaluation of site-related information, the Agency for Toxic Substances and Disease Registry (ATSDR) has taken the following steps to protect the public health:

- ATSDR implemented an education program for physicians and staff at the Cochise County Health Department in 1992.
- ATSDR is coordinating with the Arizona Department of Health Services (ADHS) in implementing a blood lead screening program for Douglas children.
- ADHS is conducting a case-control study of lung cancer mortality in smelter towns in Arizona. Researchers have included Douglas in the study.

- Through an agreement with the Pan American Health Organization (PAHO), ATSDR is currently negotiating cooperative efforts at all of the US-Mexican Border sites (including Douglas) with Mexican officials. The goal of these efforts is to coordinate public health assessments and follow-up activities with health professionals in Mexico.

- ATSDR participated in the annual Douglas CARE Fair in 1994. ATSDR distributed fact sheets (in both English and Spanish) and discussed the need for blood lead screening in young children with over 100 parents.

- ATSDR also participated in health profession education for health officials from Agua Prieta in 1994. The education program was facilitated through the Cochise County Health Department and the Binational Health Coalition.

- EPA is currently conducting an expanded Remedial Investigation, under the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS). This investigation will include off-site environmental monitoring of groundwater, soil, and surface water.

BACKGROUND

From the findings of a report summarizing a site visit to the Phelps-Dodge smelter (discussed in subsequent sections of this public health assessment), ATSDR accepted a petitioner's request to conduct a public health assessment of the former smelter site. In cooperation with the Arizona Department of Health Services (ADHS), the Agency for Toxic Substances and Disease Registry (ATSDR) has evaluated the public health significance of this site. More specifically, ATSDR has determined whether adverse health effects are possible and has recommended actions to reduce or prevent possible health effects. ATSDR, which is based in Atlanta, Georgia, is a federal agency within the U.S. Department of Health and Human Services authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) to conduct public health assessments of hazardous waste sites.

A. Site Description and History

The Phelps-Dodge Corporation Douglas Reduction Works is a 2000 acre site whose works are located about 1 mile west of Douglas. Two primary copper smelters operated at the site. The Calumet and Arizona Company Smelter was built in 1902. The Copper Queen operated in Douglas from 1904 until 1931, when the Phelps-Dodge Corporation purchased the Calumet and Arizona Company and took over their smelter. The Calumet and Arizona smelter then became the Douglas Reduction Works. The Douglas Reduction Works operated until January, 1987, (see Figure 1, Appendix 1) (45).

Copper and other metals were smelted at the facility. During the smelting process, the metal ores were heated producing molten metals and releasing sulfur dioxide and particulate matter through two 600-foot stacks (45). Prevailing wind in the area blew south toward Mexico in the evening and north-northeast during the day. The greatest air emissions occurred during the day and decreased in the evening. Air quality monitoring began in 1967; the Arizona Department of Environmental Quality (ADEQ) comprehensive air monitoring program found elevated levels of sulfates, arsenic, and lead particulate in outdoor air in Douglas (3).

The smelter had a history of exceeding allowable stack emission rates for particulate matter and sulfur dioxide gas. It was this failure to comply with the Environmental Protection Agency's (EPA) National Ambient Air Quality Standards (NAAQS) for particulates and sulfur dioxide gas that led to the smelter's closure in 1987 (45). Between 1987 and 1991, the Phelps-Dodge site underwent extensive salvage operations, including removal of all soils with recoverable copper values. The copper recovery operation ultimately resulted in the removal of 15.6 million tons of soil from the site for smelting. Remaining soils were tested for heavy metals, and found to meet Health Based Guidance Levels (HBGLs) as established by ADHS. Other recovery and salvage operations included:

- sand blasting of stack interiors for copper recovery
- removal of all asbestos
- removal of petroleum product storage tanks
- removal of PCB transformers
- excavation and removal of waste oil sump
- production well abandonment
- septic tank abandonment
- final site grading (45).

The smelter facilities were demolished in January, 1990. Nonhazardous demolition wastes were deposited in an on-site landfill; hazardous demolition wastes (i.e., asbestos and cyanide) were transported off site (5).

Controversy surrounded the removal operations, which were conducted by Spray Systems International. Employees of Spray Systems claimed they were being occupationally exposed to hazardous levels of asbestos and cyanide. At the time, ADEQ and state Occupational Safety and Health Administration (OSHA) investigations did not substantiate the claims (13). In March 1990, ATSDR received a petition from a Spray System worker requesting a public health assessment of the site.

Currently, there is no sign of the smelter facilities that were once on site; it now looks like typical desert terrain (12). A large pile of slag (solid wastes from processing copper ore) occupies about 200 acres of the site. Three landfills exist on site. Two of the landfills were historical dumping areas that are closed and covered in soil. The third, located on the former Phelps-Dodge property, was a municipal landfill that is now closed. The total landfill area is about 60 acres. Access to the site remains partially restricted. A four-foot, barbed-wire fence surrounds most of the site; the gate is at the access road entrance off U.S. Highway 80. The southern border of the site abuts the US-Mexican Border. The border area was not fenced (the fence was

stolen). However, border patrol police use surveillance cameras, motion detectors, and regular vehicle patrols to prevent trespassing (45). The northern border has an eight-foot high chain-linked fence. One access road gate was open off of U.S. Highway 80, and some evidence of trespassing was noted in this area (see discussion in Site Visit section).

Also on site were five wastewater treatment ponds and an acid tank; consequently, ADEQ began monitoring groundwater and surface water in 1980 and 1987, respectively (6). In 1986, EPA conducted a wastewater sampling program. Nine on site, unpermitted discharges of wastewater containing heavy metal contaminants were observed draining to the Whitewater Draw, a small seasonal stream flowing from the Phelps-Dodge site into Mexico. These discharge points were not permitted by EPA because of a court decision which determined that Phelps-Dodge did not discharge to "navigable waters of the United States" (45).

EPA first discovered this site in 1979, and began a Preliminary Investigation in 1983. EPA is currently conducting an expanded Remedial Investigation, under the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) (45).

In September 1991, ATSDR personnel visited the former Phelps-Dodge site and neighboring community. Because of possible past and current contamination of the surrounding community with heavy metals and the high degree of community concern about possible health effects, ATSDR decided to conduct a public health assessment of the site.

In April 1992, ATSDR completed a site review and update, which addressed lead exposure issues at the site. Recommendations made include: 1) health profession education, 2) community health education, 3) a blood lead screening program for Douglas' children, and 4) off-site surface soil monitoring for heavy metals.

B. Site Visit

During the week of September 16-20, 1991, ATSDR staff members Lynelle Neufer and Joseph Hughart visited the site, gathered site information, and discussed the public health assessment process with local health department staff and the Border Ecology Project, a regional community activist group. ATSDR personnel also reviewed files at ADEQ and ADHS. ATSDR personnel viewed the former smelter site from U.S. Highway 80; the nearby community of Pirtleville was assessed for human exposure pathways.

A second site visit was conducted the week of January 27-29, 1992, by ATSDR staff members Lynelle Neufer, Antonio Quiñones, William Nelson, and Lynn Berlad. The purposes of the second visit were to retrieve health outcome data, assess community health concerns; and revisit the site and surrounding communities.

From U.S. Highway 80, ATSDR personnel noted the following characteristics of the former smelter site:

- The gate at the entrance to the site was locked; "No Trespassing" signs were intact. It appeared that trespassers gained easy access to the site, however, because tire tracks made by bicycles and motorcycles were seen in the dirt around the gate.
- A four-foot, barbed-wire fence around the perimeter of the site was intact, but poorly maintained.
- A large slag pile with no cover was seen on site.
- The ground surface was sparsely vegetated; soils were loose and dry.
- Whitewater Draw, a stream bordering the site about 50 yards from the former smelter entrance, was dry at the time of the site visit.
- No buildings or people were seen on or near the site at the time of the visit.
- Various debris, including soft drink bottles and paper wrappers, were seen at the site entrance.

ATSDR staff also observed the following characteristics of the nearest residential community:

- Very small, modest, one-story, Spanish-style houses were connected by dirt and gravel roads.
- Generally, yards had no vegetation.
- A large schoolyard at Faras Elementary School also is bare of vegetation.
- Young children were seen playing in the yards of residences, as well as in the school yard.
- Produce in residential gardens appeared to consist mainly of corn and cabbage.

During the site visit, ATSDR staff met with local physicians, concerned community members, and representatives of the Border Ecology Project. Information gathered from those meetings is discussed in the Community Health Concerns and Health Outcome Data sections of this

public health assessment.

C. Actions Implemented During the Public Health Assessment Process

ATSDR personnel completed a site review and update for the Phelps-Dodge Smelter site in April 1992. Health profession and community health education were recommended; health education activities were referred to the Division of Health Education. The Health Activities Recommendation Panel (HARP) also recommended that a comprehensive blood lead screening program be considered.

ATSDR implemented an education program for physicians and staff at the Cochise County Health Department in Douglas in October 1992. ATSDR also met with state officials and are coordinating with them in implementing a blood lead screening program for Douglas children.

Because previous lung cancer mortality studies have been inconclusive in their evaluation of lung cancer rates of Douglas and other smelter towns (see the Public Health Implications section), ADHS received funding from ATSDR for a case-control study of lung cancer mortality in smelter towns in Arizona. Researchers will include Douglas in the study. ATSDR will assist in this study as needed.

ATSDR is currently negotiating cooperative efforts at all of the US-Mexican Border sites (including Douglas) with Mexican officials. The goal of these efforts is to coordinate public health assessments and follow-up activities with health professionals in Mexico. The last meeting was held in April, 1994. The purpose of the meeting was to open lines of communication between Mexico and the United States for addressing sites along the US- Mexican Border, such as the Phelps-Dodge site. Because Agua Prieta, Mexico also borders the Phelps-Dodge site, officials from Mexico discussed conducting parallel public health activities for Agua Prieta residents. These activities may include health education for health care providers and community members, and environmental sampling.

In August, 1994, ATSDR participated in the annual Douglas CARE Fair. ATSDR distributed fact sheets (in both English and Spanish) and discussed the need for blood lead screening in young children with over 100 parents. ATSDR also participated in health professions education for health officials from Agua Prieta at this time. The education program was facilitated through the Cochise County Health Department and the Binational Health Coalition.

D. Demographics, Land Use, and Natural Resource Use

Demographics

According to 1990 U.S. Census data, Douglas, Arizona, had a population of 12,822; 83% of the population were Hispanic, 15% were caucasian, and 2% were of other ethnic origin. Douglas is primarily a low- to middle-income community; 20% of the population lives below the poverty level. Forty-eight percent of the population are high school graduates, and 10% have completed at least 4 years of college (1980). Douglas age groups are evenly distributed; 34% are younger than 18 years, 52% are between 18 and 64, and 14% are 65 or older. The northeast Sonora Cochise County Health Council report the combined population of Douglas and Agua Prieta is about 90,000.

Pirtleville, a small Mexican-American neighborhood northeast of the former Phelps-Dodge smelter, is the residential area closest to the site (about a mile east). This newer low- to middle-income community has a population of about 1200 (8). Faras Elementary School, which has 158 students, is in Pirtleville (Appendix A) (14).

Land Use

Pirtleville's Faras Elementary School is about 1.4 miles northeast of the former smelter. Several other schools in Douglas, including Sarah Miley, Clawson, and A Avenue elementary schools, are more than 2 miles away from the former air emission stacks (7).

Several small businesses are about 2 miles east of the former air emission stacks; the only local industry is an oil storage facility, which is about a mile and a quarter east (7).

No major farming operations are near the site; however, several ranches are in the desert near Douglas. The nearest is about 4 miles north of the former smelter (7). In addition, ATSDR staff saw gardens at residences in Pirtleville. Crops included corn and cabbages. Watermelons and corn were seen on the ground at a vendor stand along the outskirts of Pirtleville, within view of the site.

The Southeast Arizona Medical Center is about 2 miles east of the former smelter. Another hospital is approximately 2.5 miles east (7).

Natural Resources Use

The Douglas basin area includes about 1,200 square miles in the southern part of Sulphur Springs Valley, in southeastern Arizona. The valley floor, which occupies about 500 square miles, is underlain by alluvium (material deposited by moving water) that consists of permeable layers of gravel and sand interbedded with relatively impermeable silt and clay. The area is drained by Whitewater Draw, a stream that starts in the northeastern part of the area, flows westward into the valley, southward through the valley, and across the international boundary into Mexico. Through most of the area, Whitewater Draw and its tributaries flow only after precipitation and snowmelt (42).

Whitewater Draw is the only significant surface water body in the area; it runs down the eastern border of the site, then crosses the border where

it becomes the Rio Agua Prieta, a perennial body of water (7). ATSDR received no reports of fishing or recreation in the area (11). The stream was dry during ATSDR site visits; fishing is unlikely because the stream appears only during rainstorms. In the past, Phelps-Dodge discharged between 0.4 and 2 million gallons per day of low-level contaminated waste waters into Whitewater Draw. The discharges were not permitted, because of a 1975 Federal Court decision that Phelps-Dodge did not discharge pollutants to navigable waters of the United States (Whitewater Draw never left the site before entering Mexico)(45).

The main source of water for Douglas is the groundwater that underlies Sulphur Springs Valley. The alluvium is at least 1,600 feet thick in the central part of the valley; it thins to a few feet along the mountain fronts. Depths to groundwater are the shallowest near Whitewater Draw, and vary from 44-177 feet in the vicinity of the site. This aquifer is also the source of the City of Douglas municipal water supply. The groundwater flow direction is from the mountain highlands toward the central portion of the valley, and then south into Mexico. Extractions from the groundwater system have resulted in pumping depressions that alter the natural flow, and shift it to the southeast and toward the extraction wells located in Douglas. The city operates eight municipal water supply wells within four miles of the site. The Department of Water Resource Well Data reports there are 122 private wells within a four mile radius of the site (45).

The climate of Douglas is characteristic of the dry desert climate of the Rio Yaqui Basin. On average, the annual rainfall totals 11.14 inches; the relative humidity is 30% (28). Vegetation is relatively sparse; surface soils are dry and consist of silty sand and gravel (9). The average annual wind speed is 8.3 mph and from the southeast out of Agua Prieta, Sonora, Mexico; winds shift and blow towards Mexico in the evening (28). Agua Prieta is less than a mile south of the site. Given the dryness of surface soils and the unpaved roads in Agua Prieta, the windy and dry weather is reported to generate moderate to heavy amounts of ambient dust in Douglas (11).

E. Health Outcome Data

Government and other agencies have collected information on the health of various populations. Health data relevant to this public health assessment are presented here, summarized in Tables 8 and 9, Appendix B, and evaluated in the Health Outcome Evaluation section.

Numerous environmental health studies have been conducted in southern Arizona; many of them included Douglas.

- In 1977, the Centers for Disease Control (CDC) led a comprehensive study of heavy metal absorption in children in smelter towns that included children from Douglas. Ninety-five children provided hair, urine and blood samples for heavy metal analyses (16).

- In 1979, researchers from the University of Utah College of Medicine, Smelter Environmental Research Association (SERA), conducted a study of the relationship between lung cancer and the distance of residences from the smelter in Douglas. Researchers obtained death certificates of Douglas residents for the years 1970 through 1977 (17).

- In 1985, ADHS measured soil-lead levels in Douglas, and blood-lead and urine-arsenic levels in Douglas children. One hundred and fourteen children participated (4).

- In 1993, the Arizona Health Care Cost Containment System (AHCCCS) instituted a blood lead screening program for eligible children 6-72 months of age. Reports of elevated blood lead levels were reported to the ADHS.

- In 1994, ADHS released an analysis of birth defect rates along the entire Arizona border. There were no elevations in the Cochise County area.

The Douglas community also has been active in generating health outcome data. The school health nurse reported and analyzed a cluster of autoimmune diseases in the Faras Elementary School in Pirtleville in 1991 (14). A Pirtleville resident is documenting first trimester spontaneous abortions in Douglas women (11). Recently, another school health nurse reported percentages of learning disabled and developmentally delayed children in Douglas elementary schools (5).

Currently, ADHS maintains cancer and birth defects registries for the state. In cooperation with ATSDR, the state health department also is planning a lung cancer mortality study that will include Douglas.

A case history at the local health department reported a single blood lead level in a 3-year-old child. The child presented with complaints of bone pain and was subsequently tested for lead poisoning. The child's level was 30 μg/dL, three times CDC's recommended level (31).

COMMUNITY HEALTH CONCERNS

Residents and officials of Douglas, AZ expressed the following health-related concerns:

1. The petitioner of the public health assessment expressed concern about occupational exposure to asbestos during the 1990 asbestos removal program at the smelter.

2. Members of the Border Ecology Project expressed concern about whether health effects could result from past exposure to smelter emissions.

3. Members of the Border Ecology Project expressed concern about potential health effects from exposure to hazardous substances they believe

were buried on site.

4. Members of the Border Ecology Project expressed concerns about the potential health effects of heavy metals leaching from on-site slag deposits to nearby Whitewater Draw.

5. Members of the Border Ecology Project are concerned that contaminants in air, surface water, and groundwater have migrated from the smelter site to residential areas in Douglas and Mexico.

6. Members of the Border Ecology Project are concerned that the elevated blood lead levels in Douglas' children have resulted from chronic exposure to lead- contaminated soil, (see Table 8 in Appendix B).

7. Members of the Border Ecology Project are concerned about the impact on public health of other potential sources of air and soil contamination in Douglas and Agua Prieta.

8. ADHS is concerned about the potential for people living and working in Douglas to inhale contaminated dust; about blood lead levels in children; and about the lack of a routine blood lead monitoring program.

9. Community members attending a community meeting reported concerns about apparent high rates of the following illnesses (30):

    - birth defects;
    - collagen diseases (lupus and rheumatoid arthritis);
    - cancers of the breast, bone, and cervix;
    - diabetes;
    - learning disabilities in children;
    - first trimester miscarriages;
    - headaches in first graders;
    - asthma;
    - allergies;
    - ear infections in children; and
    - children needing glasses.

10. Community members reported concerns about the lack of grass cover and the difficulty of maintaining grass in their yards, and about airborne dusts both inside and outside of their homes (30).

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ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

The tables in Appendix B list contaminants found in each medium on and near the site. Those contaminants are evaluated in subsequent sections of this public health assessment to help determine whether exposure to them has public health significance. ATSDR selects and discusses contaminants using certain factors: concentrations on and off site; the quality of the field and laboratory data sample design; comparison of on- and off-site concentrations to public health assessment comparison values for noncancer and cancer endpoints, and community health concerns.

The listing of a contaminant in the tables does not mean that it will cause adverse health effects if a person is exposed to the specified concentrations. Contaminants included in the tables are further evaluated in this public health assessment. The potential for adverse health effects resulting from exposure to contaminants of concern is discussed in the Public Health Implications section of this public health assessment.

Comparison values for ATSDR public health assessments are contaminant concentrations in specific media used to select contaminants for further evaluation. Appendix C describes comparison values used in this public health assessment.

A. On-site Contamination

Waste Material

In 1989, ADHS evaluated the on-site slag pile to determine if the wastes were safe to use for paving roads. Samples from the pile were analyzed for copper and lead only. Copper was detected at a level about three times higher than the normal copper-in-soil level for south-eastern Arizona. Lead was found at levels similar to background levels. The material was not classified as a hazardous material (under the Resource Conservation and Recovery Act), and its potential for leaching heavy metals into Whitewater Draw or groundwater was low (see Table 1, Appendix B)(4).

Soil

Phelps-Dodge conducted on-site soil testing during copper recovery activities in 1989. Soils were tested for heavy metals (in addition to copper). Copper, lead, and arsenic were all found above comparison values (see Table 1B in Appendix B). As mentioned earlier, these soils were subsequently removed to levels below ADHS guidelines by 1991 (45). In 1994,ADEQ reported that there may be soils on site that were still contaminated. In 1995, on-site soil testing by EPA found arsenic, cadmium, chromium, lead and mercury to be above comparison values (see Table 1C in Appendix B).

Reports by workers that cyanide wastes were buried on site in drums during removal operations triggered a U.S. Environmental Protection Agency (EPA) investigation in 1990. Workers identified suspected waste burial areas for EPA and state environmental staff; EPA staff excavated the areas. No cyanide or other hazardous materials were found on site (4, 13).

Groundwater

EPA conducted on site groundwater monitoring for heavy metals in 1989 as part of an ongoing site investigation. EPA utilized four on site wells that were in existence at the time (these wells have been abandoned, filled with cement, and sealed so that further sampling of them is not possible). Arsenic exceeded comparison values for drinking water (see Table 2A in Appendix B) (45).

Surface Water

EPA conducted on site surface water monitoring for heavy metals in 1995 as part of an ongoing site investigation. The samples, which were collected during the rainy season, were taken from surface run-off water that accumulated and formed puddles. Arsenic and lead exceeded comparison values for drinking water (see Table 2B in Appendix B).

Air

In 1990, the state OSHA unit monitored for asbestos in asbestos removal areas during site remediation (5). At the time of inspection, the employer had completed 2,710 airborne asbestos samples, including an estimated 1,800 personal breathing zone samples and 900 area samples. Asbestos levels in several of the samples exceeded OSHA standards. OSHA reports that respiratory protection had been provided at the time of testing (see Table 3 in Appendix B).

B. Off-site Contamination

Surface Soil (less than 3 inches)

In 1985, ADHS took 52 surface soil samples from a widespread area in Douglas and analyzed them for lead only. Lead levels in the soil were highly variable, ranging from 50 to 1,170 milligrams lead per kilogram (mg/kg) soil. Average soil lead levels for Douglas and Pirtleville were 254 mg/kg and 341 mg/kg, respectively; the highest levels were found in Pirtleville (see Table 4, Appendix B)(4).

EPA took seven off-site surface soil samples downwind from the Phelps-Dodge site in 1989. Distance intervals of the sample locations ranged from about one to six miles from the site. Lead, arsenic, and copper levels exceeded comparison values. Samples taken at points greater than about 2.5 miles from the site were similar to background levels for lead, arsenic, and copper (see Table 4 in Appendix B) (45).

Subsurface Soil (3-12 inches)

In 1985, two subsurface soil samples were taken (at 3 and 5 inches); both had lead levels below 250 mg/kg. Soil below 5 inches was not tested.

Groundwater - Municipal Well

ADEQ tested city well no. 6 in May 1984 for metals; arsenic and lead slightly exceeded comparison values. When all city water wells were tested in 1980, all metals were below comparison values (1). The municipal well field and pumping station are about a half mile north of the former smelter (see Table 5, Appendix B)(1, 7, 9).

ADEQ tested city wells in Agua Prieta, Sonora, Mexico, in 1988 and 1989. The wells lie less than a mile from the former smelter site. Results in 1988 found arsenic levels between 0.023 and 0.024 milligrams per liter (mg/L). In 1989, arsenic only slightly exceeded the detection limit of 0.01 mg/L. Lead was not detected in either 1988 or 1989 (1).

Surface Water

Between 1987 and 1991, ADEQ monitored Whitewater Draw for contamination with heavy metals. Heavy metals exceeded comparison values off site and downstream from the smelter (6). It should be noted that the only comparison values available for surface water analysis are those used for drinking water, thus, the comparison values are very conservative. The public health implications for surface water exposure will be further addressed in the Public Health Implications Section (see Table 6, Appendix B).

Sediment

ATSDR found no information on sediment contamination.

Ambient Air

Between 1970 and 1987, ADEQ monitored off-site ambient air for metals, benzene, and criteria pollutants (see Appendix C for a list of criteria pollutants). Maximum levels found in ambient air during the monitoring period are shown in Table 7, Appendix B (3). Arsenic, benzene, cadmium, lead, inhalable particulates (PM10), and sulfur dioxide exceeded their respective comparison values. Mean PM10 levels have consistently exceeded the NAAQS in the past, even after the smelter had closed (see Figure 2 in Appendix A) (45). Particulate sampling from 1992 averaged 40.2 $\mu g/m^3$ (19).

EPA conducted ambient air monitoring at one station in Douglas between the fall of 1973 and 1975. The monitoring program focused on sulfur dioxide emissions. Between the summer of 1973 and fall of 1974, EPA made 2416 three-hour observations, four of which exceeded the emission standard for sulfur dioxide (1300 $\mu g/m^3$). EPA also made 408 24-hour observations in this interval, and 3 exceeded the 24-hour standard (365 $\mu g/m^3$). The highest three-hour concentration was detected in 1974 and was 10144 $\mu g/m^3$, about eight times the NAAQS standard. The highest 24-hour concentration was detected between the summer of 1973 and the fall of 1974. This level was 2437 $\mu g/m^3$, about seven times the NAAQS standard (45).

Results of total suspended particulate (TSP) and sulfur dioxide monitoring by ADEQ between 1970 and 1987 show marked improvement in air quality in Douglas, especially after 1976. The highest annual mean for sulfur dioxide was 140 $\mu g/m^3$, and was detected in 1976. The lowest was detected in 1987 and was 2 $\mu g/m^3$. The highest TSP annual mean detected was in 1971 and was 303 $\mu g/m^3$; the level dropped to 97 $\mu g/m^3$ in 1987 (see Figures 3 and 4)(3).

C. Quality Assurance and Quality Control (QA/QC)

Most environmental monitoring (air, soil, surface water, and groundwater) was conducted by ADEQ. QA/QC issues were discussed with ADEQ. On-site air sampling was supervised by the Arizona OSHA unit. Soil sampling in 1985 apparently was completely random; therefore, ATSDR does not have a complete characterization of soil in Douglas. QA/QC of off-site air and all groundwater monitoring was adequate.

Information was available on QA/QC techniques used during blood lead and urine arsenic monitoring. Arsenic levels in urine and lead levels in blood were measured by the ADHS laboratory. Quality assurance samples were submitted to the CDC Reference Laboratory and met established QA/QC standards.

D. Physical and Other Hazards

No unusual physical hazards were noted on or off site other than those expected for a typical residential neighborhood (e.g., traffic hazards).

Because Douglas children are known to have elevated blood lead levels (see Table 9, Appendix B), ATSDR investigated potential additional sources of lead exposure. Additional potential sources of lead include lead-glazed ceramic dishware often used by Mexican-Americans (20); azarcon, a Hispanic folk remedy with a high lead content (21); and lead paint in homes (22).

Toxic Chemical Release Inventory

ATSDR searched the EPA Toxic Chemical Release Inventory (TRI) for the site and local area. TRI is an EPA-maintained database containing a summary of toxic chemical releases reported by industries as required by Section 313 of the Emergency Planning and Community Right-To-Know Act of 1986. No toxic releases were reported by facility name (Phelps-Dodge smelter), city (Douglas), or zip code (85607) for the years available on the data base (1987 through 1990).

PATHWAYS ANALYSES

To determine whether people are or were exposed to contaminants released from the Phelps-Dodge site, ATSDR evaluated the environmental and human components leading to exposure. The pathways analysis consists of five elements:

1. source of contamination;
2. environmental medium in which the contaminants may be present or from which they may migrate;
3. points of human exposure;
4. routes of human exposure (e.g., ingestion, inhalation, or dermal absorption); and
5. receptor population.

ATSDR considers exposure pathways completed or potential. An exposure pathway is completed when all five elements link the contaminant source to a receptor population; the exposure may have been in the past, may now exist, or may exist in the future. Pathways are potential when people could have been exposed to a contaminant in the past, could be exposed now, or may be exposed in the future. Completed and potential exposure pathways at Phelps-Dodge are shown in (Table 8), Appendix B.

A. Completed Exposure Pathways

Surface Soil Pathway

People have been exposed in the past, are now exposed, and may be exposed in the future to elevated levels of lead from ingesting contaminated residential soils in Douglas. The most significant points of exposure are those involving direct contact with lead-contaminated soils, such as yards and dirt-covered school playgrounds. In many cases, children in Douglas play directly in the dirt. Adults may be exposed by ingesting small amounts of soil while gardening or during other outdoor activities. Residents who inhale lead-contaminated dust generated by traffic on dirt roads may have additional exposures. In addition, normal climatic conditions of the desert likely result in high levels of lead-contaminated dusts remaining suspended in the air.

In the past, one likely source of elevated soil lead levels in Douglas may have been the former Phelps-Dodge Smelter. Smelting operations resulted in emissions of heavy metal particulate matter, including lead (3). Once released from facility stacks, particulate typically deposit on site, and over widespread areas including any surrounding communities. On-site soils were contaminated with heavy metals in the past; however over 15 million tons of soil were removed between 1987 and 1991. ADEQ reports that there may be soils on site that are still contaminated (47). Because residential areas are about a mile away from the site, on-site soils were and still are an unlikely source of exposure for children.

Residential soils have probably been contaminated with low levels of various heavy metals in the past. Although there is some variability in desert soils, lead is probably the most significant contaminant, given its ability to tightly bind to most soils with virtually no leaching under natural conditions

(19). Thus, lead deposited into dust and soil may be a long-term source of lead exposure (23).

Another likely source of lead contamination in Douglas may be lead from auto emissions. Leaded gasoline is available in Mexico and in some gas stations in Arizona, and elevated soil lead levels have been associated with its use. Therefore, emissions from cars fueled with leaded gasoline may contribute to lead contamination of soils. Also, as mentioned previously, Douglas is on the U.S.-Mexican border and is vulnerable to migration of lead-contaminated surface soils from Mexico because winds come from the southeast during part of the day (28), and there is considerable potential for wind erosion of surface soils in desert climates. Dusts originating in Agua Prieta, Douglas' sister city in Mexico, have increased in Douglas in recent years because of the rapid population growth and development of unpaved roads in Agua Prieta. ADEQ reports that 60% of Douglas' dusts originate in Agua Prieta (15). It is not known how much of the dust may be contaminated with lead.

On residential yards and on the school playground in Pirtleville, soil ingestion is an important route of exposure, particularly for children less than 6 years old. Children in Pirtleville may be at highest risk for exposure because soil lead levels found in that area were highest, and, because residential yards and the schoolyard have very little grass, children play directly in the dirt. Children less than six years old are at increased risk of exposure because they are more likely to be outdoors, and they have greater hand-to-mouth activity than older children. Children under 6 typically ingest an estimated 200 milligrams (mg) of soil per day; adults and older children ingest less than 100 mg daily. Children with pica behavior (a tendency to eat nonfood items such as dirt) may ingest as much as 5,000 mg soil per day (12).

Adults with a higher potential of exposure are those who remain at home or in the community during the day and those who garden or frequently work outdoors, because they have more opportunity for contacting contaminated soils. Adults who smoke are at greater risk of exposure because of their increased hand-to-mouth activity.

Soil lead levels measured in Douglas were highly variable, ranging from 50 mg/kg to 1,170 mg/kg. EPA guidance recommends "...400 mg/kg soil lead as a screening level for lead in soil for residential scenarios. Residential areas with soil lead below 400 mg/kg generally require no further action. However, in some special situations, further study is warranted below the screening level. For example...areas of higher than expected human exposure [is a] situation that could require further study." Levels in Pirtleville averaged just under 400 mg/kg, with many samples exceeding 400 mg/kg as found in 1985. EPA also found levels exceeding 400 mg/kg in 1989. Again, Douglas and Agua Prieta have little or no grass cover, unpaved roads, and a dry climate. These factors may result in higher than usual human exposures to soil (46).

Ambient Air Pathway

In the past, smelter emissions also were responsible for ambient air contamination in residential areas of Douglas. Although levels of individual contaminants were low, a number of the substances detected are known or suspected carcinogens. As a result, the ambient air exposure pathway (inhalation) is discussed further in the Public Health Implications section of this public health assessment. Substances detected off site at levels greater than comparison values were arsenic, benzene, cadmium, and manganese. Also in the past, particulate less than 10 microns in diameter (PM10) and elevated levels of sulfur dioxides have been detected (see Table 6, Appendix B).

Between 1970 and 1987, ADEQ and EPA periodically monitored off-site ambient air for concentrations of hazardous substances. Air monitoring for hazardous substances ceased when the smelter closed except for PM10. Of particular concern were arsenic, benzene, PM10 and sulfur dioxide. Arsenic is known to migrate off site and remain in communities near smelters. Arsenic levels, shown in (Table 6), Appendix B, were the highest levels of contaminants detected in Douglas during the air monitoring period. Background levels of arsenic in rural parts of the United States ranged from 0.0 to 0.0001 milligrams per cubic meter (mg/m^3) over 1 year (19). The highest level found in the Douglas residential area was 0.000121 mg/m^3, a slight elevation above background. One possible explanation for the unexpected low concentrations of arsenic may be the prevailing winds in the area, which are reported to blow towards Mexico in the evening, when emissions would have been greatest (12). Thus, the highest levels of arsenic may have been deposited in ambient air in Mexico rather than in Douglas.

Benzene also was detected in off-site residential ambient air. Unlike the other hazardous substances detected, benzene is not a heavy metal, but a volatile organic compound which is commonly released in car exhaust. Rural background levels of benzene measured in the United States average between 0.001 and 0.017 mg/m^3 (19). The highest detected level in Douglas was 0.0108 mg/m^3, within the expected background range.

The National Ambient Air Quality Standard (NAAQS) for lead in air is a mean of 0.0015 mg/m^3 over a 3-month period. NAAQ standards are established under Section 109 of the Clean Air Act for pollutants that, if present in air, might endanger the public health or welfare. Lead levels detected in residential air at Douglas periodically exceeded the NAAQS; levels were measured as high as 0.0118 mg/m^3 (3).

The NAAQS for PM10 is 0.15 mg/m^3 over a 24-hour period, not to be exceeded more than once a year. Particulate matter of that size poses a risk to public health because it is "respirable," or small enough to be deposited in lung tissue (32). ADEQ detected PM10 levels as high as 0.221 mg/m^3 in residential areas while the smelter was operating (3). The smelter no longer operates, but ADEQ reports that the dust problem from Agua Prieta has worsened over the past few years, in part because of rapid population growth. Average particulate levels also exceeded the NAAQS in the mid eighties, even after the smelter was closed (see Figure 2 in Appendix A) (15, 45).

The NAAQS for sulfur dioxide is 1.3 mg/m^3 over a three-hour period, not to be exceeded more than once a year. ADEQ and EPA detected sulfur dioxide levels over eight times this level in residential areas of Douglas in the mid-seventies. EPA also detected 24-hour concentrations about seven times the NAAQS for sulfur dioxide as well.

Past exposures to ambient air contamination were the highest in the early 1970's (and probably before) and have gradually decreased since that time. The declines in mean TSP and sulfur dioxide levels since 1970 are evidence of this trend (see Figures 3 and 4). It is unlikely that people are currently being exposed to any significant levels of the heavy metals (with the exception of lead), or sulfur dioxide because the smelter is no

longer operating. People in the area may still be exposed to lead in air because leaded gasoline sold in Mexico and Arizona is an additional source of contamination. Exposure to PM10 also may continue to be a problem because of the growing dust problem in Agua Prieta. Migration of lead to air and ambient dusts is possible, particularly because of the dry, desert climate (i.e., surface soils are loose), and because neighborhood roads are unpaved. Contaminated dusts pose a particular risk because they are easily inhaled and ingested.

Occupational Exposure - Air Pathway

During demolition activities at the Phelps-Dodge Smelter in January 1990, workers involved in asbestos removal were concerned about hazardous occupational exposures to asbestos via inhalation. Consequently, the Arizona Industrial Commission Division of Occupational Safety and Health (AICDOSH) investigated and reported "removal areas appeared to be properly organized and controlled to where the operations were not contaminating...the employees" (3). ATSDR further investigated AICDOSH files and found documentation of air monitoring that revealed asbestos levels as high as 0.9 fibers per cubic centimeter (fibers/cm^3). The National Institute of Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL) for asbestos is 0.1 fiber/cm^3. If unprotected by equipment and clothing, the workers would have inhaled hazardous levels of asbestos during removal operations. However, during its inspection, AICDOSH observed that all workers wore powered air-purifying respirators (PAPRs) during operations. In addition, the project manager reported that workers had been wearing PAPRs since "the nature of the work and the monitoring results established the need" (3). The petitioner, on the other hand, has reported that PAPRs were not provided during the first four months of the project. Removal operations have been completed and current asbestos exposures are no longer an issue; however, because of the petitioner's report, ATSDR will consider asbestos exposure a past completed exposure pathway of at least four months' duration.

B. Potential Exposure Pathways

Soil/Dust

Although no indoor dust monitoring data are available, it is very likely that lead-contaminated soils and dusts have migrated indoors to residential homes. Indoor contamination may result from contaminated soil being tracked in on shoes and clothes, or from contaminated dusts simply blowing in through open windows and doors. Adults and children are therefore potentially exposed to lead-contaminated dusts in their homes by ingestion and inhalation (24). Given the likelihood that household dusts in Douglas are contaminated with lead, the lead exposure pathway could be significant.

Surface Water

Whitewater Draw is a stream that runs on the western border of the former smelter property only during rainy seasons. While it was flowing, Phelps-Dodge discharged wastewater to the draw, and elevated levels of heavy metals were detected. Children who played in the stream in Mexico could have been exposed by ingestion to those heavy metals. While playing, those children would be expected to ingest small amounts of surface water, resulting in short-term or acute exposures. The stream flows directly from the site into Mexico. In all likelihood, neither children nor adults were frequently exposed to the stream since it is usually dry and does not support fish. During the site visit, ATSDR personnel saw no evidence of human activity around the stream bed; however, the stream was dry at the time.

Food Chain, Plants, and Livestock

The suspected origin of lead-contaminated soils in Douglas is the deposit of lead particulate from the former Phelps-Dodge Smelter and auto exhaust from Mexico and Arizona. While the smelter was in operation, lead particulate deposited on local vegetation as well as soils. Residents may have been exposed if garden produce was not rinsed before consumption. Given the level found in residential soils, the garden produce probably did not uptake significant amounts of lead from surface soils (19). During site visits, ATSDR personnel noted that residential gardens in Pirtleville consisted primarily of corn and cabbages.

Cattle ranches are 4 miles north of the former smelter stacks; it is not known whether the area has been contaminated by smelter emissions. It is possible that grasses in the area, contaminated with heavy metals are eaten by cattle and that meat from the cattle is ingested by residents. If the meat from the cattle contains elevated levels of heavy metals, the meat would be another source of heavy metal exposure for residents in the area. Currently, no data support that hypothetical exposure pathway.

Groundwater Pathway

Results of groundwater sampling in 1986 showed slight elevations of arsenic and lead levels. The source of that contamination could be naturally occurring arsenic and lead in deep soils. Migration of lead from surface soils to groundwater partially depends on the amount of organic material, the acidity, and the driving force of rainfall. The more organic material for lead to adhere to, the less lead that may migrate to groundwater. Desert soils, such as those in Douglas, have less organic material; however, desert conditions and alkalinity of soil may retard the migration of surface contamination to groundwater. It is unknown if or how much surface contamination has contributed to lead or arsenic concentrations in groundwater.

However, because the groundwater in Douglas flows toward municipal wells in Douglas, any on-site groundwater contamination may have migrated toward these wells. Arsenic was found at the highest level on site in 1989. Heavy metal monitoring of municipal water did show mild elevations of lead and arsenic concentrations in 1984. Elevated arsenic levels were also detected in Agua Prieta; however, lead was not detected. It is unknown if elevations in arsenic levels are directly related to the site, are naturally occurring, or are related to some other source.

It is also possible that on-site groundwater contamination may have intercepted private wells downgradient from the site. No monitoring data from private wells were available at the time of this report.

C. Eliminated Exposure Pathways

Waste Material

The slag pile on site contains elevated levels of copper. Access to the site and the slag pile is restricted by fences; however, that restriction is inadequate to prevent trespassing. Children and adults could gain access to the slag pile with little effort. If children played on or near the slag pile, they could ingest slag through normal hand-to-mouth activity. A level of 806 mg/kg copper (nearly three times background levels found in that area) was detected in the slag. However, ADHS reports "a child would have to ingest over 6.5 grams of slag per day to approach a copper intake level that would result in any adverse health effect (gastrointestinal upset)" (4). Slag itself is hard and rocky and typically in one-inch chunks; therefore, incidental ingestion and subsequent adverse health affects related to heavy metal contamination are highly unlikely (12, 45).

The potential for heavy metals found in the slag to leach to surface water has not been thoroughly investigated. ADEQ reports that there is potential for copper and lead to leach to surface or groundwater under the right conditions, although the leach tests were not extraordinarily high (12, 45, 47).

PUBLIC HEALTH IMPLICATIONS

The Public Health Implications section of this public health assessment evaluates the toxicological effects of exposure to specific contaminants, state and local health databases, and specific community health concerns.

A. Toxicological Evaluation

The most likely pathways of exposure to contaminants of concern for people who live near the Phelps-Dodge smelter are 1) breathing air (especially in the past when the smelter was operating); and 2) ingesting dust and soils. Another potential, but less likely, pathway of exposure is contact with contaminants in the surface water of Whitewater Draw (when the stream is flowing).

Evaluating potential toxic effects includes estimating the amount of contaminants that a person contacts daily, which depends on the frequency and duration of exposure (e.g., short-term or continuous). The public health risk is greater for people exposed for some critical length of time to contaminants at levels greater than established health guidelines.

Health guidelines are developed for contaminants commonly found at hazardous waste sites. Examples of health guidelines are the ATSDR minimal risk level (MRL) and the EPA reference dose (RfD). The MRL and RfDs are estimates of daily human exposure to a contaminant below which adverse health effects are not expected. MRLs usually are calculated for ingestion and inhalation, and for acute (less than 14 days), intermediate (15 to 365 days), or chronic (more than 365 days) lengths of exposure.

ATSDR discusses many health guidelines in its Toxicological Profiles, which also provide chemical-specific information on health effects, environmental transport, and human exposure. For this public health assessment, those profiles were consulted for toxicological evaluations of arsenic (26), asbestos (35), benzene (36), cadmium (37), copper (38), and lead (24).

Lead

Heightened concern about the health effects of lead has resulted in increased public health efforts to minimize environmental exposures. The concerns stem from evidence that children and developing fetuses are especially sensitive. Lead is particularly toxic to children because it affects physiologic systems important to their development and maturation. Blood lead levels as low as 10 μg lead per deciliter (μg/dL) of blood have been associated with impaired learning in children.

Exposure to lead paint or paint chips remains the most common cause of severe lead poisoning in children. Other potentially important sources of lead exposure include soil and dust, as well as "take home" exposures from parental occupations and hobbies, water, and food. In Hispanic communities, folk remedies such as "azarcon" and lead glazed ceramic cookware are also sources of lead exposure for children (20, 21, 22). The discussion below focuses on lead exposure through contact with contaminated soil, groundwater, and air. While not the only source of lead exposure for this community, these environmental media may make a significant contribution to elevated lead levels in children, thus warranting discussion here in addressing the public health implications of the Phelps-Dodge site.

In addition to the affects of lead on children, there is qualitative evidence to support the conclusion that, at high exposure levels, lead can significantly adversely affect reproduction. Increasingly, miscarriages have been reported in women living close to a lead smelter (23).

Soil. Whether lead is toxic or not depends upon the amount or dose a person receives, the duration of exposure (acute, intermediate or chronic), and variation in people's responses to exposure. Exposure to high levels of lead in soil (100-1,000 milligrams of lead per kilogram soil [mg/kg]) can result in elevated concentrations of lead in blood (23). Chronic ingestion of lead-contaminated soils by children through normal hand-to-mouth activity can lead to impaired learning (especially in children with pica behavior who ingest excessive amounts of non-food items).

The average levels of lead found in soil off the Phelps-Dodge smelter site (in the Pirtleville community and Douglas) ranged from 100 to 341 mg/kg. Residential soils closest to the smelter (i.e., in the Pirtleville area) typically were most contaminated with lead. Those lead levels suggest the need for blood lead testing of children. Although the Phelps-Dodge smelter is no longer discharging lead, soil lead levels will remain elevated for years, and the dry climate contributes to dusty conditions, thereby increasing exposures.

Groundwater and Surface water. Migration of lead from surface soil to groundwater is unlikely given the strong adsorption of lead to soil. The maximum level of lead found in off-site groundwater was 20 μg/L. This exceeded the EPA's Maximum Containment Level of 15 μg/L. Current public health efforts are aimed at reducing lead levels in water to zero, which suggests the need at the site to continue to monitor groundwater used for drinking.

The surface water lead levels (maximum of 360 μg/L) are not of public health concern because ingestion is considered incidental (i.e., the contaminated water is not a drinking water source, and people would ingest only very small amounts as a result of other activities).

Arsenic

Surface water. The Whitewater Draw is not used for drinking water, and exposures to it are expected to be short term (not more than 14 days). A reasonable maximum exposure for school-age children, who might play occasionally in the Whitewater Draw, is assumed to be a few ounces (i.e., 10-100 ml) of water ingested per day three days a week. ATSDR estimated conservative surface water ingestion doses using the highest concentration of arsenic found in Whitewater Draw. The estimated arsenic exposures near the site are far below levels (during short-term exposures) that cause adverse effects.

Air. An increased risk of lung cancer has been reported in populations of arsenic-exposed smelter workers. Douglas residents, who are exposed to arsenic in off-site ambient air, have a considerably lower risk of cancer. The highest arsenic concentration measured in ambient air, 0.1 μg/m^3 (Table 6), is a measurement of arsenic levels in ambient air between 1970 and 1987. Assuming that people were exposed to that amount of arsenic continuously (every day) for 15 years, one case of cancer, at most would be expected for every 10,000 Douglas residents. If a typical (median) arsenic concentration is assumed to be representative of exposure, we can conclude that cancer is unlikely to result from breathing arsenic in the air at this site.

Soil. Currently, no data on levels of arsenic in off-site soil are available for toxicological evaluation.

Asbestos

Asbestos is considered a human carcinogen because workers with occupational exposure have been found to have an increased risk of two types of cancer: cancer of the lung tissue and mesothelioma, a cancer of the thin membrane surrounding the lung. The relative risk of lung cancer is much higher for asbestos workers who smoke than for those who do not.

Occupational exposure to asbestos is also associated with asbestosis, a lung injury that causes shortness of breath.

Air. Airborne asbestos was reported in 1990 during demolition of the Phelps-Dodge smelter, which included removal of asbestos. The asbestos levels detected were as high as 0.9 fiber per cubic centimeter (fiber/cm^3) of air. The Occupational Safety and Health Administration (OSHA) permissible exposure level (PEL) for asbestos over an eight-hour period is 0.2 fiber/cm^3; the National Institute of Occupational Health and Safety recommends 0.1 fiber/cm^3. Assuming that asbestos removal workers were exposed continually to the maximum level of asbestos measured (i.e., they did not have adequate protective breathing apparatus during the first few months of asbestos removal), they may have an increased lung cancer risk.

Benzene

Air. Benzene is released into the atmosphere from both natural and artificial processes. The most significant outdoor environmental source appears to be the burning of gasoline in automobiles. Levels of benzene measured in the atmosphere range from about 0.001 milligrams per cubic meter (mg/m^3) in rural areas to maximum levels of more than 0.1 mg/m^3 in some urban areas.

In the past, benzene was one of the most common industrial solvents; it is now rarely used in the workplace. The main reason for the reduction in use has been concern about whether it causes cancer of the white blood cells (primarily acute myelogenous leukemia) and aplastic anemia in exposed workers. In addition, exposure to the relatively high levels of benzene found in some industrial settings can result in workers having reduced blood platelets, red blood cells, and white blood cells. Depression of immune function also has been documented (36).

The highest benzene level detected (0.01 mg/m^3) in ambient air samples taken near the Phelps-Dodge smelter is well within the range of values typical for ambient air in the United States, but about 10 times higher than values commonly seen in rural ambient air. Nevertheless, no adverse health effects (cancer or noncancer) would be expected in people exposed to benzene at that level.

Cadmium

Groundwater and surface water. Estimated ingestion doses of children exposed to cadmium in the site area, which were calculated using the highest concentrations of cadmium observed in groundwater, are slightly lower than health guidelines used by ATSDR (Table 4). Cadmium concentrations in the surface water (Table 5) are about 10 times higher than those found in groundwater samples. The potential for contact with cadmium in surface water is not great (see previous discussion of exposure to arsenic in surface water). Currently, there is no significant community exposure to cadmium in groundwater or surface water, but there appears to be a potential threat of groundwater contamination and a need to monitor groundwater sources used for drinking.

Air. Cadmium was detected at 0.000078 mg/m^3 in air samples (Table 6). At that level, the estimated amount of cadmium people might inhale does not exceed the ATSDR health guideline (i.e., the chronic MRL). Therefore, no adverse noncancer health effects (e.g., kidney disease) are expected.

In terms of cancer risk, some studies suggest a risk of cancer (respiratory, prostate, and genitourinary) for workers in various metals industries who are exposed to high levels of cadmium. It is very unlikely that exposure to the levels of cadmium in ambient air in Douglas would cause cancer in residents.

Air Particulates

The National Ambient Air Quality Standards (NAAQS) are guidelines for air pollutants that can endanger the public health or welfare. The NAAQS for particulate matter with a diameter less than 10 microns (PM10) is 0.15 mg/m^3 for a 24-hour period, not to be exceeded more than once a year. The presence of PM10 in air is significant to public health because particles of that size are small enough to penetrate deep into the lung. PM10 levels as high as 0.221 mg/m^3 were reported in residential areas while the Phelps-Dodge smelter was operating (1970-1987) (3), and may have adversely affected health and the quality of life for residents of Douglas. In 1992, PM10 levels averaged 0.04 mg/m^3. The maximum level detected was 0.137 mg/m^3, above the NAAQS of 0.05 mg/m^3. This suggest that PM10 continues to be a health concern for Douglas residents, even though the smelter is no longer operating.

Sulfur Dioxide

Residents were exposed to sulfur dioxide in the past during operation of the smelter; current exposure is not considered of public health concern. The NAAQS for sulfur dioxide is 1.3 mg/m^3 for a 3-hour period, not to be exceeded more than once a year. Sulfur dioxide levels were detected at levels as high as 9 mg/m^3 in residential areas.

Some evidence supports an association between particulate pollution and respiratory problems in susceptible people, including children and people with respiratory ailments (asthma) (39).

Trace Elements and Metals

Surface water. Several trace elements (i.e., barium, chromium, manganese, selenium, and zinc) typically found in raw water supplies and soil in the United States were found in Whitewater Draw surface water. At low levels, chromium, copper, manganese, selenium, and zinc are essential trace elements in the diet and are vital to several enzyme systems or processes in the human body. Barium, on the other hand, has no known human nutritional benefit.

ATSDR calculated reasonable estimated exposure doses (as was done for arsenic in surface water) using the highest levels of barium, chromium, manganese, selenium, and zinc found in surface water (Table 5); people were not exposed to the elements and metals at levels that exceed ATSDR health guidelines. Therefore, exposures to the elements and metals were not of public health concern.

Air. Manganese was detected in off-site air (0.0005 mg/m^3), but not at a level of public health concern. Manganese levels in air did not exceed the ATSDR chronic inhalation MRL.

B. Health Outcome Data Evaluation

Evaluation of health outcome data may give a picture of the general health of a community. Elevated rates of a particular disease should not automatically be associated with hazardous substances in the environment. On the other hand, even if there is no apparent evidence of elevated rates of disease in a community, a contaminant may still be responsible for illness or disease.

ATSDR uses routinely gathered data when conducting public health assessments. Such health outcome data typically are reported for people in population groups such as cities and counties. The people likely to have been affected by the contaminants associated with a particular site, however, are usually part of smaller groups of people (e.g., subdivisions, streets). Because of the limitations of current analytical methods, any evidence of contaminant-associated illness or disease in the smaller group may be hidden within the rate of disease of the larger groups.

In addition, when exposed or potentially exposed populations are small, the number of people who may develop a particular illness or disease is also small. Small changes in the number of affected people from year to year can cause a large change in the rate; such a rate is considered "unstable." In epidemiology, it is difficult to determine if a change in an unstable rate is due to normal fluctuation in numbers of diseased persons in a population, or some change in that population's environment.

ATSDR evaluated health outcome data pertinent to this public health assessment. Summaries of the following evaluations are shown in Tables 8 and 9, Appendix B.

Center for Disease Control Study (16)

In 1975, the Center for Disease Control researched absorption of heavy metals by children living in smelter towns; Douglas was one of the towns included in the study (the study was published in 1977). Results were compared with data on 258 children of the same age in three communities without smelters (see (Table 8), Appendix B, for a summary of the average levels detected in Douglas children).

The biomonitoring techniques used in the study were all appropriate measures of exposure; some have limitations, however, which are discussed in the following paragraphs. Measurement of lead in blood is used to help determine if exposure to lead has occurred within the past 4 to 8 weeks. Measurement of arsenic in urine is the most reliable means of detecting recent (within the past several days) arsenic exposures. Measurement

of arsenic from hair samples can detect exposure within the past 6 to 12 months to high levels of arsenic (41). Measurements of cadmium, lead, and arsenic in hair samples may not be entirely reliable, however, because those measurements may reflect not only the amount of metals uptake into the hair shaft from the system, but also the amount of metal deposited on the hair. Only the metals uptake into the hair shaft is a useful measure of exposure (26).

Evaluation of the metals data indicated that Douglas children had increased exposure to arsenic, lead, and cadmium. Their lead, arsenic, and cadmium levels were elevated compared with children from other Arizona communities without smelters (41).

In addition, the biomonitoring data indicated that the children's exposures may have been of public health significance. Average blood lead levels were more than double the current CDC-recommended level of 10 µg/dL. Fifteen children had blood lead levels greater than 29.4 µg/dL. Chronic elevated levels of lead in the blood have been associated with impaired learning ability in children (see discussion in the previous Toxicological Evaluation section). The data indicate that the children tested in 1975 had blood lead levels which have been associated with nervous system effects, including impaired learning, decreased stature or growth, decreased hearing acuity, and decreased ability to maintain a steady posture (22).

1985 Arizona Department of Health Services Followup to the 1975 CDC study (4).

As was the case in 1975, the results of the 1985 monitoring of lead in the blood of Douglas children indicated that they had been exposed (see Table 9, Appendix B). Blood samples from 114 children were tested; the average blood lead levels exceeded the current CDC-recommended level of 10 µg/dL, but were lower than the blood lead levels measured in 1977. The children were categorized according to exposure parameters (e.g., the presence or absence of pica behavior or distance of residence from the Phelps-Dodge Smelter). Overall, the children's blood lead levels ranged from 3 to 24.8 µg/dL. Children without pica behavior and those who lived closest to the Phelps-Dodge stacks had the highest average blood lead levels. Blood lead levels correlated with soil lead levels; on average, soil lead levels were greater in soils closest to the Phelps-Dodge smelter. Surprisingly, it was found that, on average, children with pica behavior had lower blood lead levels. Researchers believed the finding may have been caused because of confusion about the definition of pica among the mothers interviewed.

Some quality control information was available for this monitoring. For the blood lead measurements, ADHS split the samples and sent them to their lab and to the CDC. The results indicated that the ADHS lab detected blood levels that were generally about 33% higher than the levels detected by CDC. If the average blood lead levels found by ADHS are reduced by 33%, the results still indicate averages of about 10 µg/dL.

ADHS also measured for arsenic in 134 urine samples from the children. Six children had urine arsenic levels greater than 50 µg/dL. Two children had urine arsenic levels greater than 100 µg/dL (130 µg/dL). The elevated arsenic levels could be associated with diet as well as with environmental exposure. Generally, urine arsenic levels in Douglas children were in the range of what would be expected in the general population.

Blood lead monitoring information since 1992 (48)

The Cochise County Health Department diagnosed a child with a blood lead level of 30 µg/dL in January 1992. The child had a history of pica behavior and lived in an area that had elevated soil lead levels in 1985 (averaging 250-350 mg/kg lead in soil). The child was referred to the University of Arizona for treatment. The local sanitarian conducted an exposure assessment to determine possible sources of lead exposure for the child. The sanitarian identified elevated levels of lead in soil and a piece of furniture in the yard that had chipping lead paint. The paint was tested and found to contain high levels of lead (>10,000 parts per million). Exposure to the leaded paint in the furniture was probably the main source of the child's elevated blood lead level.

In 1993, 144 Douglas/Pirtleville children were tested for lead under the AHCCCS program. Three elevated blood lead levels were detected. Two were less than 20 µg/dL, so the parents received counseling. The other was a previously identified child for whom lead-based paint had been already identified as a likely source of exposure.

In 1994, seven cases of elevated blood lead levels were identified (the total number of children tested is unknown at this time). Three cases were less than 20 µg/dL. The most likely sources of exposure in the investigated cases were identified as lead-based paint, paint-contaminated soil, and the folk medicine, Azarcon. All four cases live at least 2.5 miles from the Phelps-Dodge site.

1979 Smelter Environmental Research Association (SERA) Study (17)

Lung cancer incidence from 1970 to 1977, within a 20-kilometer radius of nonferrous smelters in six western states, was evaluated using the case-control approach. A case-control study compares two populations. In this example, the lung cancer rates in people who live near smelters were compared with lung cancer rates in people who do not live near smelters. Also, rates of other cancers (not associated with exposure to smelters) were compared in the two populations, to control for populations who may have a general increase in all types of cancer, not just lung cancer. Douglas, AZ, was one area studied in 1979 using this case-control approach. Addresses of lung cancer patients at time of diagnosis of lung cancer were obtained and plotted on U.S. Geological Survey maps. Distance and location of the addresses from smelters were measured.

Because no state cancer registry existed at the time of the study, information about cancer incidence in Douglas was gathered from death certificates. A sample of 120 cancer deaths was obtained (56 cases, 62 controls). Information on occupation and sex were available and controlled for (using the Mantel-Haenszel chi square test for significance). The study found that developing lung cancer was not related to location of residence; the incidence of cancer was no higher in people who lived closer to the smelters. However, the very small sample size of each smelter and nonsmelter area means that there would have to be a large difference in lung cancer rate cases and controls before such a difference would be observed. Standard mortality ratios (the number of diseases observed in the exposed population divided by the number expected for that population) were also calculated for lung cancer mortality in both men and women (see Table 9, Appendix B). The ratios indicated that there was no statistically significant increase in lung cancer deaths over the number expected for either men or women.

Several limitations to this study should be noted. First, the authors did not discuss the control population. The authors also did not separate the lung cancer rates by age group (a confounding factor) before calculating the standard mortality ratio. A confounder is a factor that could also be related to the health outcome of interest (i.e., lung cancer). By not controlling for confounders, researchers may bias the results of the study. Important confounding factors for lung cancer, such as smoking, were not controlled.

The small sample size of the study population in Douglas also is a limitation of the study. Previously in this public health assessment, it was estimated that chronic ambient air exposures to contaminants at levels detected off site could result in a low increased cancer risk. However, the very small sample size of lung cancer deaths in Douglas means that a large difference between cases and controls must be shown (i.e., more cancer in cases than controls) before it could be concluded that smelter emissions were associated with lung cancer. The sample size was not large enough to detect a small increase in the rate of lung cancer deaths (41).

In summary, because of numerous methodologic problems, the results of the SERA study have limited application in evaluating lung cancer in Douglas. ADHS is conducting another study of populations in smelter areas, and Douglas is included. This study will further investigate health outcome data for populations exposed to smelter emissions.

Autoimmune Diseases

School health officials evaluated five cases of autoimmune illnesses among teachers at the Faras Elementary School. Investigation indicated that the causes of the five illnesses were not related to each other or to environmental exposures that may have occurred while the teachers worked at the elementary school (14). For instance, cases were diagnosed before living in Douglas, and other cases had genetic etiologies (14).

Learning Disabilities

Studies indicate that learning disabilities are associated with lead exposure during development of the fetus. Other factors associated with learning disabilities include genetics, malnutrition, or injury. Percentages of learning disabilities in children attending elementary schools in Douglas are similar to each other. Faras Elementary School had the highest percentage of learning-disabled students (15%) (34).

Although the percentage of learning-disabled students at Faras Elementary is greater than at other Douglas schools, the differences between the schools are so slight that the cause of the differences cannot be determined or correlated with environmental exposure.

Birth Defects Registries

The Arizona Birth Defects Monitoring Program provided information about the rate of birth defects for Cochise County for 1987. The birth defects rate is defined as the rate of birth defects per 1,000 live and still births. The birth defects rate for Cochise County for 1987 was below the state rate. The ADHS Arizona Birth Defects Monitoring Program recently released a report that addresses the occurrence of neural tube defects (anencephaly and spina bifida) in southern Arizona. Results indicated that rates of neural tube defects were not elevated in Cochise County. However, Cochise County rates have limited value for characterizing birth defects in Douglas because Cochise County has a much larger population. Because of the difference in population size, a high or low rate of birth defects in Douglas might not be reflected in the county rate.

Summary of Health Outcome Data Evaluation Section

Blood lead levels were sufficiently elevated in 1977, 1985 and since 1992 for those children to be at risk for adverse neurological effects, such as decreased ability to learn in school. Soil lead contamination may be one source of lead exposure for these children; however, other sources should be considered as well. Cancer rates in 1979 showed no significant increase in Douglas over controls. Because of numerous methodological problems, the results of the SERA study have limited application in evaluating lung cancer rates in Douglas. Lung cancer rates are currently being studied by ADHS. Birth defect and learning disability rates did not appear to be significantly elevated, and the cluster of autoimmune diseases at the Faras Elementary School were not related to exposure to site contaminants.

C. Community Health Concerns Evaluation

ATSDR has addressed each of the community concerns about health.

1. **The petitioner expressed concern about exposure to asbestos during asbestos removal operations at the smelter.**

   On-site monitoring during asbestos removal operations detected ambient asbestos levels as high as 0.9 fiber per cubic centimeter (fiber/cm^3). Currently, the National Institute of Occupational Safety and Health's recommended action level for asbestos is 0.1 fiber/cm^3. Although reports by OSHA stated that removal operations were conducted in compliance with safety regulations, asbestos removal employees reported that respirators were not provided at the onset of the operation. Assuming that workers were exposed (8 hours a day for 3 months to the maximum level of asbestos measured) without adequate breathing apparatus, the exposed workers may have an increased lung cancer risk, particularly if they also smoked cigarettes.

2. **Members of the Border Ecology Project expressed concern about the public health impact of past emissions from the smelter.**

   While the smelter was in operation, lead emissions could have contributed to elevating blood lead levels in children. Severe cases of lead poisoning in children usually result from ingesting lead paint or some other direct ingestion of food or water highly contaminated with lead. However, new

research indicates that even low levels of lead in children's blood (10 μg/dL) may have subtle adverse health effects such as impaired learning ability. Exposure to lead in air and soil may have contributed to the elevated blood lead levels found in Douglas children in 1985.

People also were exposed to sulfur dioxide during past smelter operations. The NAAQS for sulfur dioxide is 1.3 mg/m^3 for a 3-hour period, not to be exceeded more than once a year. Sulfur dioxide levels were detected at levels as high as 9 mg/m^3 in residential areas, but it is not known how often and to what extent sulfur dioxide levels exceeded NAAQ standards. Exposure to sulfur dioxide at those levels could have exacerbated respiratory problems in susceptible people, such as children or people with respiratory ailments (e.g., asthma) (39). ADHS is conducting a study of populations surrounding smelters, and Douglas is included. Results will help evaluate the public health impact of past emissions exposures.

3. **Members of the Border Ecology Project expressed concern about potential health effects of hazardous substances they believe were buried on site.**

   In 1990, EPA investigated claims of buried cyanide on site. Smelter workers identified areas where wastes were suspected of being buried, and EPA then dug beneath the areas. The investigation did not find hazardous substances buried on site. ATSDR will assist in contacting appropriate staff at EPA to investigate any other reports of buried hazardous wastes on site.

4. **Members of the Border Ecology Project expressed concerns about the potential health effects of heavy metals in on-site slag deposits leaching to the nearby Whitewater Draw.**

   ADHS reports that heavy metals identified in the on-site slag pile are not prone to leaching. Analysis of surface water samples from Whitewater Draw revealed only trace amounts of heavy metals. The levels found are unacceptable for drinking water, but are not considered a public health threat for human contact are during normal recreation.

5. **Members of the Border Ecology Project are concerned that contaminants in air, surface water, and groundwater have migrated from the smelter site to residential areas in Douglas and Mexico.**

   Pathways analyses and off-site monitoring data reveal that contaminated air has migrated to residential areas in Douglas (see Community Health Concern Evaluation #2). Given the proximity of the former smelter to Agua Prieta, past migration of smelter emissions to residential areas in Mexico was likely.

   From available data, ingestion of groundwater does not currently pose a risk to the health of residents of Douglas. Migration of lead-contaminated surface soil to groundwater is unlikely because lead strongly adsorbs to soil. Migration of other heavy metals from on-site soil to groundwater may be possible. The actual direction of groundwater flow is unknown at this time. Changes due to pumping may have reversed the direction of groundwater direction. If on-site groundwater has been contaminated, it may migrate in a southerly direction into Mexico. ATSDR staff noted that elevated levels of arsenic and cadmium were found in municipal groundwater wells in Mexico. ATSDR is cooperating with Mexican authorities to further investigate possible environmental health threats, including contaminated groundwater, in Agua Prieta.

6. **Members of the Border Ecology Project are concerned that the elevated blood lead levels in children living in Douglas are the result of chronic exposure to lead-contaminated soil.**

   The Centers for Disease Control recently reduced the blood lead standard to 10 g/dL. Judged against this new standard, Douglas children on the average had mildly elevated blood lead levels in 1985. As recently as January 1992, a blood lead level of 30 g/dL was detected in a 3- year-old child with pica.

   Currently, contaminated soil and dust may be a source of lead exposure in Douglas. When the smelter was operating, lead particulates in ambient air may have been an additional source of lead exposure. Other sources of lead exposure for Douglas children include lead paint and paint chips, leaded gasoline in Mexico, and possibly lead-glazed ceramic cookware and folk remedies such as Azarcon.

7. **Members of the Border Ecology Project are concerned about the effects on soil in Douglas and Agua Prieta of other potential airborne industrial discharges.**

   According to available environmental monitoring data, the Phelps-Dodge Smelter was the primary source of airborne industrial contaminants in the area. A search of EPA's Toxic Chemical Release Inventory database did not indicate any other sources of heavy metal contamination in the city of Douglas, or in the zip code region. If specific information on other industrial sources of environmental contamination becomes available in the future, ATSDR will evaluate that information. Although it is gradually being phased out, leaded gasoline is available and is used in Mexico. Auto emissions from cars that use leaded gasoline also may contribute to elevated levels of lead in soil in Douglas. In the past, leaded gasoline was a significant source of lead exposure for children in the United States.

8. **ADHS expressed concern about the potential for people to inhale contaminated dust in Douglas; about elevated blood lead levels in children; and about the lack of a routine blood lead monitoring program.**

   According to the exposure pathways analyses in this public health assessment, inhalation and ingestion of lead- contaminated dusts in Douglas may be a significant source of lead exposure for children in the area, although dusts have not been monitored to confirm the inhalation pathway.

   Chronic elevated levels of lead in blood have been associated with impaired learning ability in children (see the Toxicological Evaluation section of this public health assessment). Blood lead monitoring results from Douglas indicate that some children tested in 1975 and 1985 had blood lead levels that have been associated with nervous system effects, including impaired learning, decreased stature or growth, decreased hearing acuity,

and decreased ability to maintain a steady posture (22).

9. **Community members are concerned about apparent high rates of the following illnesses:**

birth defects - Arizona maintains a birth defects registry, which indicates that the overall birth defects rate for Cochise County is not greater than the state rate (see the Health Outcome Data Evaluation section of this public health assessment).

collagen diseases - There is no evidence that supports or refutes an association between exposure to site-related contaminants and collagen diseases in the literature.

cancers of the breast, bone, and cervix - There is no evidence that supports or refutes an association between exposure to site-related contaminants and cancers of the breast, bone, or cervix.

diabetes - There is no evidence that supports or refutes an association between exposure to site-related contaminants and diabetes.

learning disabilities in children - Rates of learning disabilities in Douglas children are recorded in Appendix B. Because learning disabilities may have several or even unknown causes, relating the disability to environmental factors, such as lead exposure, is very difficult to do. Research indicates that elevated lead levels in children may affect their IQ. There are no studies that relate learning disability rates in schools to lead contamination. Therefore, it is possible that environmental lead exposures in Douglas may have affected the children's behavior and IQ, but we cannot conclude that the rate of learning disabilities in Douglas schools has also been affected. Currently, Douglas schools rate of learning disability is similar to state rates.

first-trimester miscarriages - Evidence supports the conclusion that, at high exposure levels, lead has significant adverse effects on reproduction. For example, an increased frequency of miscarriage has been reported in women living closest to lead smelters. Lead exposures at copper smelters, such as the Phelps-Dodge smelter, would be significantly lower; therefore, the risk of reproductive effects would be much less.

asthma - Although none of the contaminants detected in off-site air cause asthma, many may aggravate the existing condition. Sulfur dioxide and dust (inhalable particulate) are lung irritants that can cause transient asthmatic symptoms or chest discomfort following acute exposures. The concentrations of those contaminants in ambient air (measured during the operation of the smelter, 1970-1987) were great enough to cause those adverse effects in sensitive subpopulations.

allergies - Allergies would not be caused by contaminants found at this site. However, residents who are allergic to dust, or who are hypersensitive to contaminants, such as sulfur dioxide, found off site, may have experienced a worsening of symptoms while the smelter was operating. Residents with dust allergies may have noticed an increase in symptoms during the past few years because of the increase in ambient dust.

ear infections in children - There is no evidence that supports or refutes an association between exposure to site-related contaminants and ear infections in children.

children needing glasses - There is no evidence that supports or refutes an association between exposure to site-related contaminants and worsening eyesight. Some contaminants released to air in the past may have caused eye irritations (e.g., sulfur dioxide).

10. **Community concerns about the following environmental conditions and their effect on public health also were identified:**

lack of ground surface vegetation and the difficulty of maintaining grass in yards - Decreased ground cover and difficulty in growing grass is typical of the desert environment. However, poor ground cover can result in increased exposure to lead-contaminated soils, (e.g., because there is no grass barrier between the children and the soil during outdoor activity). Lack of ground cover also means that soils are more prone to wind erosion, and levels of ambient dusts are likely to be greater, further increasing exposures. Because it may result in increasing exposures of children to lead-contaminated soil, lack of ground surface cover is a valid concern. The soil lead pathway is discussed in greater detail in the Pathways Analyses section of this public health assessment.

dusts in the air and in homes - It is likely that lead-contaminated soil has migrated indoors and resulted in formation of lead-contaminated household dusts. Exposure to those dusts also may be a significant exposure pathway, although no monitoring data support it. Dusts in ambient air have been a growing problem in Douglas during the past few years. Ambient dusts may represent significant exposure because they may be inhaled as well as ingested. It is not currently known if ambient dusts are contaminated with heavy metals.

PETITIONED PUBLIC HEALTH ASSESSMENT

PHELPS DODGE CORP DOUGLAS REDUCTION WORKS
DOUGLAS, COCHISE COUNTY, ARIZONA

CONCLUSIONS

Soil

1. The Phelps-Dodge Smelter site has probably contributed to lead contamination of off-site soils. This site posed a public health hazard for people living in Douglas and Agua Prieta because of past, and possibly present long-term exposure of children to these lead-contaminated soils.
2. Chronic ingestion of lead-contaminated soils during normal hand-to-mouth activity may have contributed to elevated blood lead levels and which may have impaired learning in children. Lead paint and other sources of lead exposure also exist in both Douglas and Agua Prieta.

Air

3. In the past, chronic exposures to emissions from the Phelps-Dodge smelter could have increased the risk for adverse health affects in Douglas and Agua Prieta residents. When the smelter was operating, chronic exposure to lead in the air was an additional source of lead exposure for children. Chronic inhalation of sulfur dioxide and inhalable particulate matter has been associated with respiratory problems and may particularly affect sensitive subpopulations, including children and people with respiratory ailments (e.g., asthma).
4. Workers involved with demolition of the smelter and removal activities in 1990 who did not use respiratory protection were exposed to elevated levels of asbestos fibers. Those workers who did not wear appropriate respiratory protection and worked at the site for a year or more are at a low increased risk for lung cancer.

Health Outcome Data

5. Available health outcome data indicate that, in 1975 and 1985, Douglas children had blood lead levels that, on the average, exceeded current CDC-recommended levels.
6. Available health outcome data were insufficient to evaluate the potential environmental impact of site-related contaminants on rates of lung cancer, spontaneous abortion, birth defects, and learning disabilities.

Other

7. Contaminants found on site were also detected in municipal well water off site and in Whitewater Draw, but concentrations were not elevated enough to cause adverse health effects. Concerns over groundwater quality can be greater in Agua Prieta, since the flow of both surface and groundwater is from north (Douglas) to south (Agua Prieta).
8. ATSDR encountered the following data inadequacies during the conduct of this public health assessment:
    - lack of current environmental data showing levels of lead and other metals in residential surface soils;
    - lack of sampling of indoor dusts for lead;
    - lack of data on current blood lead levels in Douglas and Pirtleville children; and

- lack of information about the leachability of heavy metals in surface soil and slag to groundwater, and monitoring data for off-site groundwater and private wells.

RECOMMENDATIONS

A. Recommendations and HARP Statement

Cease/Reduce Exposure Recommendations

1. Educate the community about all sources of environmental lead exposure and methods for reducing exposures.

2. Educate local health professionals about assessing all sources of lead exposure and about the signs and symptoms of lead poisoning in children.

Site Characterization Recommendations

1. Monitor off-site soils, indoor dust, and airborne particulate matter for metals in Douglas and Agua Prieta.

2. Continue to monitor heavy metals in Douglas municipal well water.

3. Monitor off-site private wells for heavy metals.

Additional Health Information Recommendations

1. Conduct a communitywide blood lead screening program for children in Douglas.

2. Appropriate screening of local children on the Mexican side of the border with blood lead tests should be conducted.

3. Continue to work with Pan American Health Organization and Mexico to determine need for evaluation (i.e., to conduct a health assessment) in Agua Prieta, Sonora, Mexico.

Health Activities Recommendation Panel (HARP) Recommendations

In accordance with the Comprehensive Environmental Response Compensation, and Liability Act of 1980 as amended, ATSDR and the State of Arizona evaluated the Phelps-Dodge Smelter site for appropriate health follow-up activities. The data and information developed in the Phelps-Dodge Smelter Site Public Health Assessment have been evaluated for appropriate public health actions. Because people have been exposed in the past to lead-contaminated soils, and because exposures are likely to continue, HARP has determined that two follow-up actions are indicated. First, a community health education program is needed for residents of Douglas. Second, a long-term blood lead testing program is appropriate for children in Douglas, as outlined in the Centers for Disease Control and Prevention Guide to Preventing Lead Poisoning in Children.

B. Public Health Actions

The Public Health Action Plan (PHAP) for the Phelps-Dodge site contains a description of actions to be taken by ATSDR and/or ADHS at and in the vicinity of the site subsequent to the completion of this public health assessment. The purpose of the PHAP is to ensure that this public health assessment not only identifies public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included, is a commitment on the part of ATSDR/ADHS to follow up on this plan to ensure that it is implemented.

1. The Division of Health Education will provide environmental health education for the community to assist them in understanding and preventing possible adverse health outcomes associated with exposure to hazardous substances. The program will be implemented during the public comment period of this public health assessment.

2. ATSDR will continue to coordinate and assist as needed with ADHS in implementing the lung cancer mortality study involving Douglas.

3. ATSDR will coordinate with the appropriate environmental agencies and ADHS to develop plans to implement the site characterization and blood lead screening recommendations contained in this public health assessment.

4. ATSDR will coordinate with EPA, Region IX and their ongoing site investigation of the Phelps-Dodge site, and in implementing the site characterization recommendations in this public health assessment.

5. The Border Ecology Project and the county sanitarian have been actively pursuing environmental issues in Agua Prieta.

6. As discussed at the Binational Health Coalition Meeting in August 11,1995, there are plans to develop local capacity to test for lead in Sonora, Mexico.

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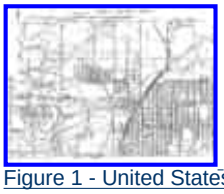


Figure 1 - United States Geological Survey Map of Douglas, AZ

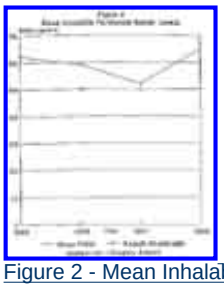
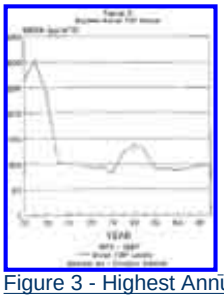


Figure 2 - Mean Inhalable Particulate Matter Levels



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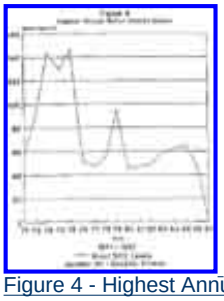
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TABLE 1A: CONTAMINANT CONCENTRATIONS IN ON-SITE SLAG PILE

CONTAMINANT	MAXIMUM CONCENTRATION (mg/kg)	BACKGROUND RANGE (mg/kg) SOURCE		YEAR
copper	806	2-300	bkgrn	1989
lead	80	400	EPA	1989

TABLE 1B - CONTAMINANT CONCENTRATIONS IN ON-SITE SURFACE SOIL PRIOR TO REMOVAL

Contaminant	Maximum concentration (mg/kg)	Mean concentration (mg/kg)	Comparison value (mg/kg)	Source	Year
arsenic	1840	422	20	EMEG	1989
cadmium	250	124	50000	EMEG	1989
chromium	30.3	18	300	EMEG	1989
copper	164000	108000	2-300	bkgrnd	1989
lead	6050	1671	400	EPA	1989

TABLE 1C: CONTAMINANT CONCENTRATIONS IN ON-SITE SURFACE SOIL

CONTAMINANT	MAXIMUM CONCENTRATION (mg/kg)	COMPARISON VALUE (mg/kg)	SOURCE	YEAR
arsenic	118	0.6	EMEG	1995
cadmium	63.2	1.0	EMEG	1995
chromium	44.4	10.0	RMEG	1995
copper	13200	*	*	1995
lead	1220	400	EPA	1995
mercury	4.5	4	EMEG	1995

* no comparison value available

TABLE 2A: CONTAMINANT CONCENTRATION IN ON-SITE GROUND WATER

CONTAMINANT	MAXIMUM CONCENTRATION (mg/L)	COMPARISON VALUE (mg/L)	SOURCE	YEAR
arsenic	0.0432	0.003	EMEG	1989
copper	0.0358	1.3	MCL	1989
lead	0.0027	0.015	MCL	1989

TABLE 2B: CONTAMINANT CONCENTRATIONS IN ON-SITE SURFACE WATER

CONTAMINANT	MAXIMUM CONCENTRATION (mg/L)	COMPARISON VALUE (mg/L)	SOURCE	YEAR
arsenic	0.014	0.003	EMEG	1995
copper	0.061	1.3	MCL	1995
lead	0.021	0.015	MCL	1995

TABLE 3 - CONTAMINANT CONCENTRATIONS IN ON-SITE AIR

CONTAMINANT	MAXIMUM CONCENTRATION (fibers/cc)	COMPAR. VALUE (fibers/cc)	SOURCE	CARCIN. CLASS	COMPAR. VALUE EXCEEDED?
asbestos	0.924	0.1	REL	A	Yes

TABLE 4: CONTAMINANT CONCENTRATIONS IN OFF-SITE RESIDENTIAL SOIL

CONTAMINANT	MAXIMUM CONCENTRATION (mg/kg)	MEAN CONCENTRATION (mg/kg)	COMPARISON VALUE		COMP. VALUE EXCEEDED?	YEAR
			(mg/kg)	SOURCE		
lead	1170	254	400	EPA	Yes	1985
lead	564	172	400	EPA	Yes	1989
arsenic	35.8	15	20	EMEG	Yes	1989
cadmium	13.7	5	50000	EMEG	No	1989
chromium	15	12	300	EMEG	No	1989
copper	5330	1670	2 - 300	bkgrn	Yes	1989

TABLE 5: CONTAMINANT CONCENTRATIONS IN OFF-SITE GROUNDWATER

CONTAMINANT	MAXIMUM CONCENTRATION (mg/l)	COMPAR. VALUE (mg/l)	SOURCE	CARCIN. CLASS	COMP. VALUE EXCEEDED?	YEAR
arsenic	0.001	0.00002	CREG	A	Yes	1984
barium	0.08	0.7	RMEG		No	1984
cadmium	0.002	0.002	CREG		No	1984
chromium	0.003	0.1	MCLG		No	1984
lead	0.02	0.015	MCLG	B2	Yes	1984
mercury	0.0001	0.002	LTHA		No	1984
selenium	0.023	0.03	EMEG		No	1984
silver	0.003	0.05	RMEG		No	1984
zinc	0.08	2.1	LTHA		No	1984

TABLE 6: CONTAMINANT CONCENTRATIONS IN WHITE WATER DRAW

CONTAMINANT	MAXIMUM CONCENTRATION (MG/L)	COMPAR. VALUE (MG/L)	SOURCE	CARCIN. CLASS	COMP. VALUE EXCEEDED?
arsenic	0.1	0.003	RMEG	A	Yes
barium	3.33	0.7	RMEG		Yes
cadmium	0.031	0.002	EMEG		Yes
chromium	0.5	0.1	MCLG		Yes
copper	0.71	1.3	MCLG		No
lead	0.36	0.015	MCLG	B2	Yes
manganese	8.94	1	RMEG		Yes
mercury	0.002	0.002	LTHA		No
selenium	0.258	0.03	EMEG		Yes
zinc	1.14	2.1	LTHA		No

TABLE 7: CONTAMINANT CONCENTRATIONS IN OFF-SITE AIR

CONTAMINANT	MAXIMUM CONCENTRATION (mg/m^3)	COMPAR. VALUE (mg/m^3)	SOURCE	CARCIN. CLASS	COMP. VALUE EXCEEDED?
arsenic	0.000121	2.3E-07	CREG	A	Yes
benzene	0.0108	0.0001	CREG	A	Yes
cadmium	7.8E-05	5.6E-07	CREG	B1	Yes
cobalt	2.5E-05				
copper	0.0081				
lead	1.18E-05	0.0015	NAAQS		No
manganese	0.0005	3E-07	EMEG		Yes
nickel	0.0001			A	
particulates	1.756				
PM10	0.221	0.05	NAAQS		Yes
sulfur dioxide	10 (3hr)	0.365	NAAQS(3hr)		Yes
zinc	0.0043				

TABLE 8: PHELPS-DODGE PATHWAYS SUMMARY

COMPLETED PATHWAYS

PATHWAY NAME:	AMBIENT AIR	SURFACE SOIL	OCCUPATIONAL EXP.
Source:	Smelter Emissions	Smelter Emissions	demolition wastes
Environmental Medium:	Air	soil and dust	air
Exposure Point:	residential areas	residential areas	on-site
Exposure Route:	Inhalation	ingestion inhalation	inhalation ingestion
Receptor Population:	Adults and Children	Adults & Children	workers
Exposure Duration:	Chronic	Chronic	intermediate
Time Period:	Past	past, present, future	past
Contaminants of Concern:	Arsenic, cadmium, lead, PM10, SO2, Manganese	Lead	asbestos
Estimated Number Exposed (see demographics section)	Douglas + Agua Prieta: 90,000 within 1 mile: 200	90,000 Pirtleville: 1200 Douglas < 18: 4359	unknown

POTENTIAL PATHWAYS

PATHWAY NAME:	SURFACE WATER	FOOD CHAIN	SOIL/DUST	GROUNDWATER
Source:	slag/leachate	smelter emissions car emissions	smelter emissions car emissions	smelter groundwater
Environmental Medium:	surface water	food chain	dust	Off-site municipal wells
Exposure Point:	White Water Draw	plants & livestock	inside homes	
Exposure Route:	ingestion	ingestion	ingestion/inhalation	ingestion
Receptor Population:	children	consumers	adults & children	adults & children
Exposure Duration:	acute	intermediate	chronic	chronic
Time Period:	past	past, present, future	past, present, future	past, present, future
Contaminants of Concern:	metals	lead	lead	arsenic, lead

ELIMINATED PATHWAY

PATHWAY NAME:	SLAG PILE
Source:	smelter
Environmental Medium:	slag
Exposure Point:	on site
Exposure Route:	*
Receptor Population:	*

TABLE 9: SUMMARY OF BIO MONITORING DATA FOR DOUGLAS, AZ

DATE	HEALTH OUTCOME	PARAMETER	DATA	COMPARISON VALUE		(Reference Number)
				VALUE	SOURCE	
1985	Mean Blood Lead Levels, children	Pica children (n = 10)	11.5ug/dl	10 ug/dl	CDC	(4)
		non-Pica children (n = 104)	13.1ug/dl	10 ug/dl	CDC	
		0 - 2 miles from stack (n = 40)	13.7ug/dl	10 ug/dl	CDC	
		2 - 5 miles from stack (n = 74)	12.7ug/dl	10 ug/dl	CDC	
	Urine Arsenic Levels, children	percent above normal	4.5% (n = 6)	50 ug/L (normal)	CDC	
		percent above excessive exposure level	1.4% (n = 2)	100 ug/L (excessive level)	CDC	
1975	Mean Hair Arsenic Levels, children 1-5 years old	Douglas (n = 95)	0.43ug/g	1.0 ug/g	ATSDR	(16)
	Mean Urine Arsenic Levels	Douglas (n = 95)	18.7ug/L	50 ug/L	CDC	
	Mean Blood Lead Levels	Douglas (n = 95)	20.47ug/dl	10 ug/dl	CDC	
	Mean Hair Lead Levels	Douglas (n = 95)	25.94ug/g			
	Hair Cadmium Levels	Douglas (n = 95)	1.72ug/g			

TABLE 10: OTHER HEALTH OUTCOME DATA FOR DOUGLAS, AZ

DATE	HEALTH OUTCOME	PARAMETER	DATA	(Reference Number)
1992	Special Education, (incuding learning disabled and mentally handicapped) listed as percentage of enrolled students	Sarah Miley Elementary	11%	(34)
		Clawson Elementary	8%	
		Faras Elementary	15%	
		A Avenue Elementary	10%	
1979	Total number lung cancer cases 1970 - 1977	Douglas, Az population	56	(17)

Lung cancer Standard Mortality Ratio (SMR)	males in Douglas	SMR = 161
	females in Douglas	SMR = 130
Lung cancer cases	males < 7 km from smelter	20
	males > 15 km from smelter	28
	females < 7 km from smelter	5
	females > 15 km from smelter	3

APPENDIX C - COMPARISON VALUES

Comparison Values

When conducting public health assessments, ATSDR uses comparison values -- contaminant concentrations in specific media -- to select contaminants for further evaluation. The values provide guidelines for estimating a dose at which health effects might be seen. Comparison values used in the Environmental Contamination and Other Hazards and the Public Health Implications sections of this public health assessment are listed and described in the following paragraphs.

* CREG= Cancer Risk Evaluation Guides
* DWEL= Drinking Water Equivalent Level (μg/L)
* EMEG= Environmental Media Evaluation Guides
* MCL = Maximum Contaminant Level (μg/L)
* MCLG= Maximum Contaminant Level Goal (μg/L)
* MRL = Minimal Risk Level (mg/kg/day)
  IMRL=Intermediate Risk Level
  CMRL=Chronic Risk Level
* PEL= Permissible Exposure Limit (mg/m^3)
* REL= Recommended Exposure Limit (mg/m^3)
* RfD= Reference Dose (mg/kg/day)
* RfC= Reference Concentration (mg/m^3)
* ppm= milligrams per liter (mg/L water)
  milligrams per kilogram (mg/kg soil)
* ppb= micrograms per liter (μg/L water)
  micrograms per kilogram (μg/kg soil)
* kg= kilogram
* mg= milligram
* μg= microgram
* pg= picogram
* L = liter
* m^3= meters cubed
* NAAQS = National Ambient Air Quality Standards

Cancer Risk Evaluation Guides (CREGs) are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million persons (10E-6) exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors.

The drinking water equivalent level (DWEL) is a lifetime exposure level specific for drinking water (assuming that all exposure is from that medium) at which adverse, noncancer health effects are not expected.

Environmental Media Evaluation Guides (EMEGs) are calculated from ATSDR minimal risk levels (MRLs); they consider body weight and ingestion rates.

Maximum Contaminant Levels (MCLs) are contaminant concentrations 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 (for an adult).

Maximum Contaminant Level Goals (MCLGs) are drinking water health goals set at levels at which no known or anticipated adverse effect on the health of persons is expected and which allow an adequate margin of safety. Such levels consider the possible impact of synergistic effects, long-term and multi-stage exposures, and the existence of susceptible groups in the population. When there is no safe threshold for a contaminant, the MCLG should be set at zero.

A Minimal Risk Level (MRL) is an estimate of daily human exposure to a chemical (in mg/kg/day) likely to be without an appreciable risk of deleterious effects (noncancer) over a specified duration of exposure. MRLs are derived from data in human and animal studies and are reported for acute ($\leq$ 14 days), intermediate (15-364 days), and chronic ($\geq$ 365 days) exposures. MRLs are published in ATSDR Toxicological Profiles for specific chemicals.

The Occupational Safety and Health Administration's Permissible Exposure Limit (PEL) in air is an 8-hour, time-weighted average developed for the workplace. The level may be exceeded, but the sum of the exposure levels averaged over 8 hours must not exceed the limit. The National Institute for Occupational Safety and Health recommends exposure limits (RELs) for the workplace. RELs are based on time-weighted average (TWA) concentrations for up to a 10-hour workday during a 40-hour work week.

EPA's Reference Dose (RfD) and Reference Concentration (RfC) are estimates of the daily exposure to a contaminant unlikely to cause adverse health effects. RfDs and RfCs do not consider cancer.

The Clean Air Act of 1990 established National Ambient Air Quality Standards (NAAQS) for six criteria pollutants. Concentrations exceeding NAAQS in ambient air may endanger public health.

EPA classifies the carcinogenic potential of contaminants using the weight of evidence of toxicological data. The Agency has established five classes of carcinogenicity:

A. human carcinogen,
B1 and B2. probable human carcinogen,
C. possible human carcinogen,
D. not classifiable as to human carcinogenicity, and
E. evidence of noncarcinogenicity in humans.

Further, the B1 classification is supported by sufficient human evidence. The B2 classification is supported by sufficient animal evidence, but insufficient human evidence.

References

1. Agency for Toxic Substances and Disease Registry. Public Health Assessment Guidance Manual. Atlanta: ATSDR, March 1992.

2. National Institute of Occupational Safety and Health. Pocket Guide to Chemical Hazards. Washington D.C.: Department of Health and Human Services, June 1990.

APPENDIX D - RESPONSES TO PUBLIC COMMENTS

RESPONSES TO PUBLIC COMMENTS

***ATSDR received many comments on the Public Release of this Public Health Assessment. Several of the comments have been addressed by making changes or additions in the public health assessment text or tables. Other issues that would be better answered by another agency such as EPA have been referred. The remaining questions and comments have been addressed by ATSDR separately in this Appendix.* Responses by ATSDR are indicated in *italics*.**

Comments are addressed using the following outline:

I. COMMENTS REGARDING CONCLUSIONS OF THIS PUBLIC HEALTH ASSESSMENT

A. GENERAL COMMENTS
B. EPA LEAD GUIDELINES

II. HEALTH EFFECT ISSUES

A. GENERAL
B. LEAD EXPOSURE
C. OTHER

III. COMPETING INTERESTS

A. LEAD DISCUSSION
B. ASBESTOS DISCUSSIONS
C. OTHER

IV. RATIONALE FOR CONDUCTING PUBLIC HEALTH ASSESSMENTS

V. OTHER COMMENTS

I. COMMENTS REGARDING CONCLUSIONS OF THIS PUBLIC HEALTH ASSESSMENT

Several comments dispute whether the Phelps Dodge site presented a public health hazard to the Douglas and Aqua Prieta community. For a site to be considered a public health hazard, two elements must be present. 1) Evidence exists that exposures have occurred, are occurring, or likely to occur in the future. It is our opinion that exposures have occurred via contaminated soil and ambient air. 2) The estimated exposures are to a substance or substances at concentrations in the environment that, upon long-term exposures (greater than 1 year), can cause adverse health effects to any segment of the receptor population. It is our opinion that levels of lead in surface soil was (and may still be) in sufficient amounts while the plant was operating to present a health risk for long-term exposure for children. Also, levels of PM10 and sulfur dioxide in air were in sufficient amounts to present a health risk for long-term exposure. With these two criteria met, it is our opinion that the site posed a public health hazard.

It should be noted that the purpose of describing the public health category of a site is to determine the most appropriate health activities to protect public health. In this case, ATSDR recommended lead poisoning prevention activities for the community, local health care providers, and the state health department.

A. GENERAL COMMENTS

1) Phelps Dodge strenuously opposes the conclusions of the assessment...the only remedy is for the ATSDR to reject the document in its entirety by issuing a statement renouncing its conclusions. Anything less will constitute approval of an Assessment which makes mockery of the scientific process.

> *As stated above, it is our opinion that this site meets the criteria for designation as a public health hazard. We have no plans for changing the conclusions; they are completely consistent with the public health assessment process and guidelines.*

2) Given the content of the report....the conclusion is unwarranted. There is no demonstration...that the alleged elevated soil lead levels are a hazard or that they are derived...from the Douglas Reduction Works (DRW)...nor is there any information...to conclude that learning impairment existed as a problem in Douglas children.

> *As stated above, it is our opinion that the levels of lead in off-site soil were and may still be a health hazard, and that the smelter, while operational, contributed to lead contamination off site. Determining whether health effects (such as learning impairment) are directly attributable to exposures is not an essential criteria in determining whether or not a site is a public health hazard. As stated above, the possibility for an adverse health effect is the criteria needed. The potential for soil exposure to contribute to elevated blood lead levels in Douglas' children is the reason we recommended lead poisoning prevention activities.*

3) The existing DRW site does not present a public health hazard.

> *We are most concerned about off-site contamination that happened while the smelter was operational. Now that the smelter is gone, the potential for the site to be a source of off-site surface soil and ambient air contamination is reduced. Investigations are ongoing to assess the potential for groundwater contamination. Also, EPA is also investigating off-site surface soil contamination that may still persist. Of course, the smelter itself no longer presents a public health hazard, since it no longer exists.*

4) There is no evidence provided in this report that 1) there were excessive emissions, 2) that those emissions reached the citizens of Douglas, or 3) that other conditions did not totally overshadow any contribution of contaminants from the DRW site.

> *It is ATSDR's opinion that exposures to emissions from the smelter did happen, and that those exposures to soil and air contamination were at concentrations that could result in health effects. It is based on this reasoning that we deemed the site a public health hazard and proceeded with public health activities, focusing on lead poisoning prevention.*

B. EPA LEAD GUIDELINES

There was disagreement among commenters as to what the EPA Guidelines are for lead levels in soil, and whether those guidelines support or refute ATSDR's conclusions. The most recent EPA guidelines recommend:

> *"...400 ppm soil lead as a screening level for lead in soil for residential scenarios. Residential areas with soil lead below 400 ppm generally require no further action. However, in some special situations, further study is warranted below the screening level. For example...areas of higher than expected human exposure [is a] situation that could require further study."*

Levels in Pirtleville averaged just under 400 ppm, with many samples exceeding 400 ppm as found in 1985. EPA also found levels exceeding 400 ppm in 1989. In addition, it is our opinion that conditions in Douglas, including little or no grass cover, unpaved roads, and a dry climate, may result in higher than usual human exposures to soil. Therefore, we believe that EPA's guidance supports our conclusions that lead concentrations in residential soils are a public health hazard, and lead poisoning prevention activities are warranted.

5) Based on 1989 EPA Sampling Data, soil lead levels in the Douglas Area do not pose a public health hazard.

> *EPA only took seven soil samples, which makes it difficult to make any conclusions about overall off-site soil conditions. However, as noted above, levels did exceed the guidance value of 400 ppm.*

6) EPA Guidance on health protective soil lead levels refute the authors contention that current soil lead levels create a public health hazard... numerous studies...refute the authors contention.

It is our opinion that EPA Guidance does not refute our conclusion, in fact, their guidance is supportive. See discussion above.

7) Authors do not choose to refer to the current EPA guideline for residential soil lead levels, namely 500 mg/kg. The levels in Douglas generally appear to be below this level.

The new EPA Guidance has been added to the Public Health Assessment. Many soil lead levels are above EPA Guidelines. The guidance value is 400 mg/kg, not 500 mg/kg.

II. HEALTH EFFECTS ISSUES

To determine whether we think health effects might be expected from a given exposure, we first consider whether people came into contact with contaminants. If they have, then we consider whether they could have absorbed (by breathing, swallowing, or skin contact) a high enough dose of the contaminant to cause health effects. We strive to characterize exposures and possible health implications as accurately as possible. However, complete data are often not available, and in that event, exposure assumptions are conservative. This means we tend to make our conclusions based on prudent public health practice rather than an underestimate of the hazard to human health. This ensures that we will make decisions that are highly protective of public health.

A. GENERAL

8) [Inappropriate data presentation on Tables] Reporting maximum levels without providing ranges, numbers of samples, standard deviations, or other indications of the data variability is very misleading.

Please note that means are provided on Tables 1B and 4 in Appendix B and in Figures 2, 3, and 4 in Appendix A. Data variability and numbers of samples are discussed in the text as well, in the Environmental Contamination and Other Hazards Section, and in the Exposure Pathways Section. Maximums are presented and discussed for public health purposes, please see note above.

9) The data presented in the tables are biased because only the maximum concentration measured from a single sample is reported....mean or median concentrations resulting from analyses of all samples should be reported.

Please see the above response.

10) I have never known anyone who was medically impaired by the smelter emissions (past the annoyance stage). I do know doctors who state that they have never treated anyone who was injured by the smelter smoke.

The public health assessment process dictates that, if a potential for a health hazard exists, protective actions need to be taken. The purpose of a public health assessment is not to determine whether people's health were impacted by smelter smoke or contamination. We determine if the potential exists. In this case, we believe that elevated levels of contamination in off-site soil and air were a public health hazard, and actions, such as lead poisoning prevention, needed to be implemented.

B. LEAD EXPOSURE

Some of the comments concerned the reported blood lead levels, especially those from 1985. There may have been some quality control issues with the results, and estimates indicate that the levels may have been about 33 % lower than reported (averaging about 9.8 µg/dL instead of 13.7 µg/dL). Some commenters argue that, since this average is below the CDC guideline of 10 µg/dL, there is no need for lead poisoning prevention activities in Douglas. However, the exact wording of CDC's guidelines is as follows:

"If many children in the community have blood lead levels 10 µg/dL, community interventions (primary prevention activities) should be considered by appropriate agencies."

Whether the average blood lead levels in Douglas were exactly 9.8 µg/dL, around 10 µg/dL, or 13.7 µg/dL, there are still many children with blood lead levels 10 µg/dL. Therefore, community interventions to prevent lead poisoning in children, are an appropriate recommendation, and a need for the Douglas community.

11) The mean blood lead level of children tested in Douglas in 1985 was below CDC's recommended safe level of 10 µg/dL.

The estimated mean was calculated at about 10 µg/dL, not measured. Again, whether the mean was 10 µg/dL or 13.7 µg/dL, CDC Guidelines dictate community interventions.

12) [CDC blood lead guidelines and the lack of comment concerning current controversies]..clearly there has been much discussion and revelation concerning the work by Needleman and his collaborators. Recent investigations strongly support the fact that these studies overestimated risk.

CDC's Guidelines are not solely based on Dr. Needleman's work (which has withstood extensive review) . The concern about adverse effects on

central nervous system functioning at blood lead levels as low as 10 µg/dL is based on a large number of rigorous epidemiologic and experimental studies. Evaluation of 24 major studies provides strong support for the belief that children's IQ scores are inversely related to lead burden.

13) Table 8 shows that mean levels 0-2 miles from the stack were 13.7 µg/dL compared to 12.7 µg/dL at 2-5 miles from the stack...the authors seem to rely here on the raw data without any statistical verification of significance.

Both averages were over the CDC guideline value of 10 µg/dL and indicated the need for public health intervention (see opening comments). Determining public health needs is the purpose of this assessment, and this data helped determine the need for lead poisoning prevention activities for Douglas. This recommendation would have been made regardless of whether or not 13.7 was significantly different from 12.7.

C. OTHER

14) It should be a high concern to design a comprehensible health screening for arsenic and cadmium, but the study does not conclude that these are contaminants worthy of monitoring in the human body.

For health screening of heavy metals such as arsenic and chromium to be meaningful, exposures must be current. Biomonitoring is not useful in determining the extent of past exposures, because the metals are no longer present in blood or urine. There is currently no evidence that excessive exposures to arsenic and cadmium are happening. If environmental monitoring indicates that exposures are ongoing, then ATSDR will consider a recommendation for health screenings for arsenic and cadmium.

15) Past air emissions from the DRW site have not increased the risk of cancer or disease in the local population.

It is our opinion that past air emissions from the smelter were a public health hazard for the local population. Air monitoring in the residential area indicated that exposures to sulfur dioxide, lead, and inhalable particulate were occurring, and at levels that, on a long-term basis, may cause adverse health effects.

III. COMPETING INTERESTS

Several commenters believe that the public health assessment was skewed and biased towards focusing blame on the former smelter. The major concern of a health assessment is to use existing data to analyze whether a health threat exists and, if so, to determine what actions need to be taken to protect the health of the public. Determining the source of contamination is important if it will affect our recommendations about how to reduce or stop exposure, but establishing the responsibility or the degree of responsibility for contamination is not part of ATSDR's mandate. When investigating a site, we consider the public health effect of any contamination we identify, not just contamination that can be directly linked to the site and only the site.

A. LEAD DISCUSSIONS

16) Emissions from vehicles using leaded gasoline in Mexico, and other sources of lead, contribute wholly or in part to soil/lead and blood/lead levels in the Douglas area...the conclusion blindly assumes that past operations at the DRW site were the sole cause of the allegedly increased soil lead levels in the area.

We believe that our conclusions do not make this assumption. Based on air emissions data and on-site and off-site soil monitoring, we do conclude that the smelter probably did contribute to lead contamination in Douglas. The percentage of the smelter's contribution to soil contamination is not discussed and is beyond the scope of the public health assessment (see discussion above).

17) Tone of the report and assumption that most of the community lead is from DRW.

The focus of this public health assessment is the former smelter, as requested in the petition from community members. However, we do discuss other sources of lead contamination within the Public Health Assessment, please see the Pathway Analysis Section. Again, it is not our mandate to assume or estimate the degree to which one source may have contributed to off-site contamination.

18) Are lead and arsenic separable in the analysis...If the lead and arsenic are released from stack emissions simultaneously, and if wind erosion carries soil-contaminated lead to Douglas, why would these metals not be found elevated together?

The maximum release of lead from the stack was 0.0118 mg/m^3, while the maximum release of arsenic from the stack was 0.000121 mg/m^3. Different emission amounts may result in different concentrations in surrounding soil. However, as stated above, establishing the degree of responsibility for contamination is not part of ATSDR's mandate. Our goal is to use existing data, analyze whether a health threat exists, and implement actions to protect public health.

19) Approach of the authors was decidedly designed to emphasize the possible contribution of DRW....the authors minimized many sources [of lead exposure] and neglected others totally.

Again, the petition and community health officials specifically cited the Phelps Dodge Reduction Works. Other sources were discussed, and their identification was essential in conducting appropriate community and health profession education.

20) The authors are misleading in asserting that DRW is the only known industrial source of lead pollution in a section that also mentions gasoline and auto exhaust.

By industrial source, we mean a stationary industrial site. There were no industrial releases reported on the Toxic Release Inventory Database for Douglas from years 1987-1990. We recognize that gasoline exhaust is another source of lead pollution for Douglas and Aqua Prieta. Please note the discussion in the "Exposure Pathway Analyses" section.

21) The authors relied heavily on a case report about a child with a blood lead level of 30 µg/dL ...there was a note that there was chipped, leaded paint on outdoor furniture.

This information has been added, as well as additional blood lead monitoring data from 1991 until 1993. Please see the Health Outcome Data Evaluation Section.

22) The report seems to imply that the only source of leaded gasoline is Mexico.

We recognize that leaded gasoline is also still sold in some gas stations in Arizona. This information has been added to the public health assessment.

B. ASBESTOS DISCUSSIONS

Several of the comments debate the discussions regarding the workers that alleged occupational asbestos exposure during demolition activities. The purpose of including this discussion in the public health assessment was to provide public health guidance for those workers, in case there had been improper respiratory protection months before the OSHA inspection. If protection had been adequate during those months, this section may be disregarded. If not, then we hope that the information addressing their concerns is helpful, and that they consult their physicians for appropriate follow up for asbestos exposure.

23) [In regards to asbestos exposure] The document ignores expert agency reviews which were contemporaneous.

We do not believe that this Public Health Assessment ignores expert reviews. Please note that the OSHA inspection report is discussed in the Environmental Contamination and Other Hazards Section, and is cited as reference number 5.

24) [In regards to asbestos exposure] The authors do not identify whether [elevated levels of asbestos] were found during the time that the complainant stated he was not wearing a respirator, or whether it occurred when he was undisputedly wearing approved respiratory protection.

Elevated levels were found on both occasions. See the discussion in the Environmental Contamination and Other Hazards Section.

25) The authors do not consider the accuracy of the petitioner's claim.

The purpose of including a petitioner's concern is to address his or her health concerns regarding possible asbestos exposure.

26) Because state agencies determined that no improper asbestos exposure occurred, the authors of the assessment had no basis for accepting this petition...or for concluding that an asbestos exposure pathway ever existed.

We did not conclude that an exposure pathway for asbestos existed, just that it may have been possible. Again, the asbestos discussion was included to address worker health concerns.

C. OTHER

25) The arsenic data: other possible conclusions and author bias. The fact that authors "expected" high levels of arsenic demonstrates their bias and lack of objectivity.

The assumption is based on typical ambient arsenic levels around copper smelters as stated in the Hazardous Substance Data Base.

26) There are many forms of arsenic in the environment, including arsenic species in foods. If the samples were not tested for inorganic arsenic, their relevance would be highly questionable.

We agree that there are many forms of arsenic in the environment, however, note that we did not conclude that the concentrations of arsenic in the environment in Douglas presented a public health hazard.

27) There is no evidence that past or present emissions from the DRW or any other source threaten to contaminate groundwater.

It is our opinion that there is not enough information at this time to determine whether or not the slight elevations of arsenic and lead in groundwater are site-related, naturally occurring, or are related to some other source.

IV. RATIONALE FOR CONDUCTING A PUBLIC HEALTH ASSESSMENT

Several comments regard ATSDR's decision to conduct a public health assessment for this site. The wording in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) reads as follows:

> *"The Administrator of ATSDR may perform health assessments for releases or facilities where individual persons or licensed physicians provide information that individuals have been exposed to a hazardous substance, for which the probable source of such exposure is a release. In addition to other methods (formal or informal) of providing such information, such individual persons or licensed physicians may submit a petition to the Administrator of ATSDR providing such information and requesting a health assessment."*

It is ATSDR's opinion that the petition and other requests for an ATSDR health assessment at the Phelps Dodge site met the criteria for conducting a health assessment according to CERCLA.

28) Phelps Dodge also questions the ATSDR's authority to undertake the Assessment at all....even if ATSDR's decision to perform the Assessment in response to the former employee's petition was proper, the scope of the Assessment has gone far beyond the on-site exposure to asbestos which was the basis for that petition.

> *ATSDR received other requests and concerns from community members and officials regarding past air and soil contamination, in addition to the petitioners request. It is our opinion that the public health assessment complies with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). CERCLA states under section 110 subsection 6(F) that "the term 'health assessment' shall include preliminary assessments of potential risk to human health posed by individual sites and facilities, based on such factors as the nature and extent of contamination, the existence of potential pathways of human exposure (including ground or surface water contamination, air emission, and food chain contamination), the size and potential susceptibility of the community within the likely pathways of exposure, the comparison of expected human exposure levels to the short-term and long-term health effects associated with identified hazardous substances and any available recommended exposure or tolerance limits for such hazardous substances, and the comparison of existing morbidity and mortality data on diseases that may be associated with the observed levels of exposure" (49).*

29) I am not aware that ATSDR is the proper agency to handle workplace requests. It is my understanding that these issues are for OSHA and perhaps NIOSH to address.

> *OSHA was involved with the workplace asbestos-exposure issue. See the Environmental Contamination and Other Hazards Section. Also, note that ATSDR may respond to "any individual" as stated in CERCLA.*

V. OTHER COMMENTS

30) The DRW site is not now, and never has been, the site of a municipal landfill. The City of Douglas purchased the land from Phelps Dodge to operate a landfill, but that land is not on the DRW site.

> *Sentence clarified to show that the landfill is on former DRW property.*

31) The northern portion of the facility has an eight-foot high, chain-link fence.

> *Sentence added on page 5.*

32) The authors claim that while it was flowing, elevated levels of heavy metals were detected in Whitewater Draw. ADEQ had admitted that proper sampling protocol was not followed in gathering its Whitewater Draw surface water samples.

> *ATSDR did not conclude that Whitewater Draw presented a public health hazard. It is unlikely that additional QA/QC data from ADEQ would change that conclusion.*

33) The authors state that discharges made to Whitewater Draw from the DRW site were "not permitted by EPA"...the intimation in this choice of language is that these discharges were illegal.

> *The reason that a permit was not needed is explained on both page 4 and 8 where this statement occurs; i.e. that a court decision determined that Whitewater Draw was not a "navigable water of the United States".*

34) Whitewater Draw actually flows on the eastern border of the DRW site.

> *Sentence on page 8 corrected.*

35) Since the closure of the smelter, literally, hundreds of yucca plants, all north of the smelter, in the old emissions belt, are now dying and dead. Before closure, one rarely saw a dead yucca, maybe one in a thousand, due to old age.

> *ATSDR will pass this information on to EPA.*

36) Report title: There was no health assessment conducted in this study...no directed examinations of residents with a standard protocol was utilized for this "study".

A health assessment is not meant to be a study. It is the first step in evaluating the health of communities impacted by a release of a hazardous substance. A health assessment considers the community as an aggregate, and its exposure to a hazardous substance release. The legal definition of a health assessment as stated in CERCLA is as follows:

> *"..the term 'health assessment' shall include preliminary assessments of the potential risk to human health posed by individual sites and facilities, based on such factors as the nature and extent of contamination, the existence of potential pathways of human exposure, the size and potential susceptibility of the community within the likely pathways of exposure, the comparison of expected human exposure levels to the short-term and long-term health effects associated with identified hazardous substances and any available recommended exposure or tolerance limits for such hazardous substances, and the comparison of existing morbidity and mortality data .."*

It is our opinion that the Phelps Dodge Public Health Assessment meets this definition. CERCLA goes on to state that an epidemiological study (such as suggested in the above comment) may be considered as a subsequent public health activity.

37) Do "zero" levels exist?

This statement refers to the Ambient Air Pathway discussion, "Background levels of arsenic in rural parts of the United States ranged from 0.0 to 0.0001 mg/m^3". This is a direct quote from the Hazardous Substance Database. The "zero" level probably means that the air monitoring instruments could not detect arsenic.

38) Significant figures and conventions to rounding numbers. [For instance, in regards to the discussion of ambient air concentrations of arsenic] The statement that 0.000121 is greater than 0.0001 mg/m^3 is ignorant...wrong, inflammatory, and likely to produce undue anxiety among the community.

Whether 0.000121 is slightly above 0.0001 or essentially equal will not impact ATSDR's conclusion that, based on the air monitoring data, arsenic did not pose a public health hazard for residents. Because of the qualitative nature of assessments, rounding measured levels to significant figures would have no influence on the conclusions of this document.

39) I have difficulty with some low-level elevations above a CDC-guideline being listed as a "Health Status" in the conclusions.

"Health Status" has been changed to "Health Outcome Data".

40) Contradictory reasoning: that smelting increased during daylight hours when smoke tended to travel to Mexico. Smelting was generally increased in the evening and at night when air inversion patterns reversed and smoke tended to stay above the ground and/or flow into Mexico.

Sentence corrected.

41) With 200 acres of slag over nearly 90 years from two smelters, the contaminant levels in the waste will vary enormously. This should be noted in the report.

We have no data to indicate that contaminant levels in the slag pile vary enormously, but we acknowledge that variability is possible. However, note that the public health assessment concludes that human exposure to slag (via ingestion) is a very unlikely human exposure pathway.

42) There is an obvious need to expand leachability and toxicity testing into Mexico [because of groundwater monitoring results in both Agua Prieta and Douglas].

ATSDR has recommended ongoing groundwater monitoring to ensure that levels of heavy metals in Douglas' drinking water are within MCLs, and have worked with the Pan American Health Organization and Mexican Federal Health authorities to encourage Agua Prieta health officials to conduct similar activities. EPA will conduct investigations to determine whether the site is eligible for listing on the National Priorities List under CERCLA. We will pass this concern on to EPA.

43) We would like it noted that after crossing the border, Whitewater Draw becomes Rio Agua Prieta, a perennial body of water that is vulnerable to any contamination generated by the Phelps Dodge site.

Noted.

44) We take issue with ATSDR'S health outcome (table 9) that describes the area of concern as having a population of 12,822 when the actual population impacted probably exceeds 90,000 on both sides of the border.

The public health assessment was revised to include this information.

45) Instead of discussing this important fact [that benzene and arsenic have been within background levels], they are discussed and revealed in a circuitous manner.

The public health implications of benzene and arsenic levels are discussed within the framework of the Public Health Assessment Guidelines.

FIGURE 1 - USGS MAP OF DOUGLAS

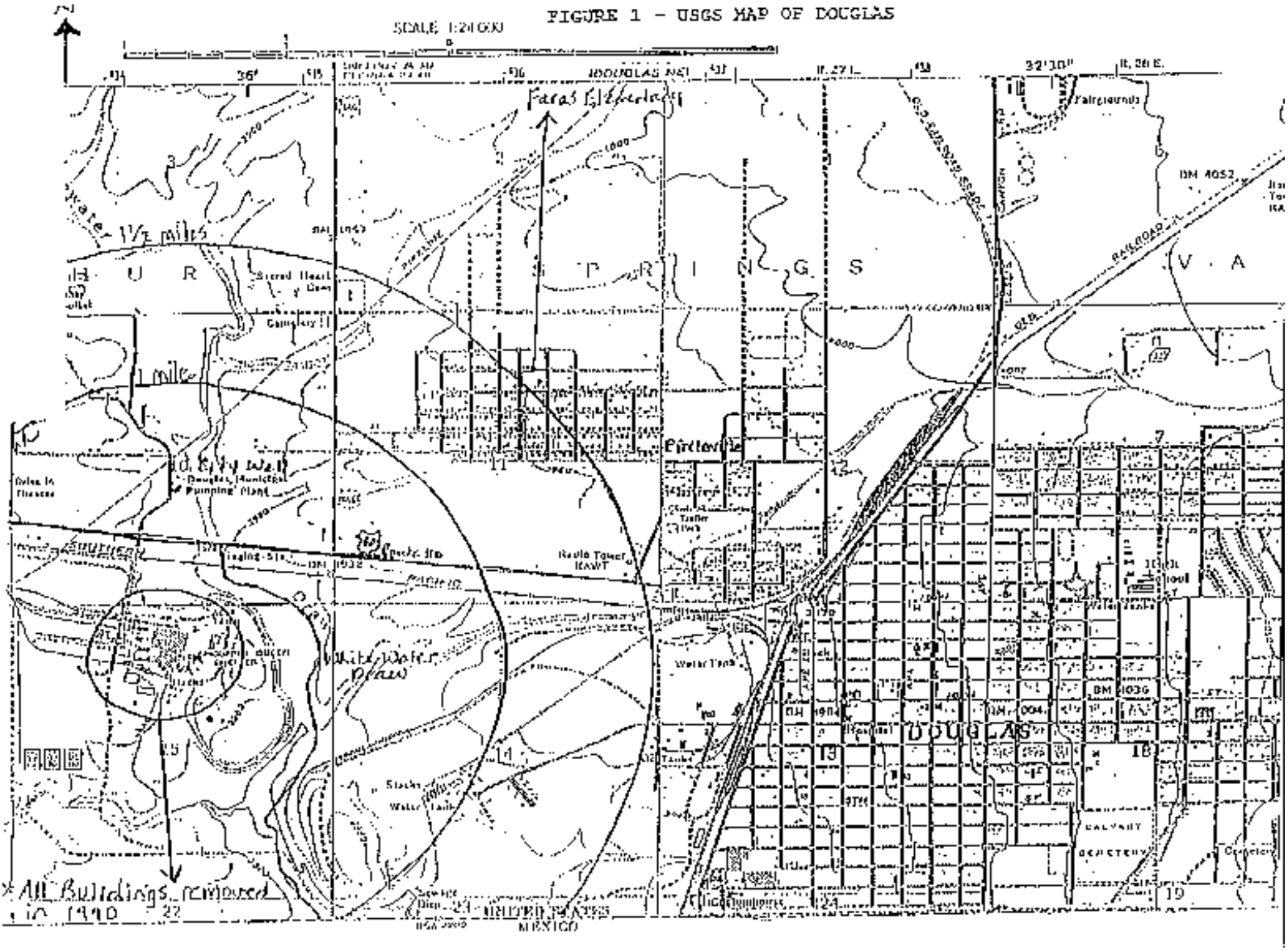
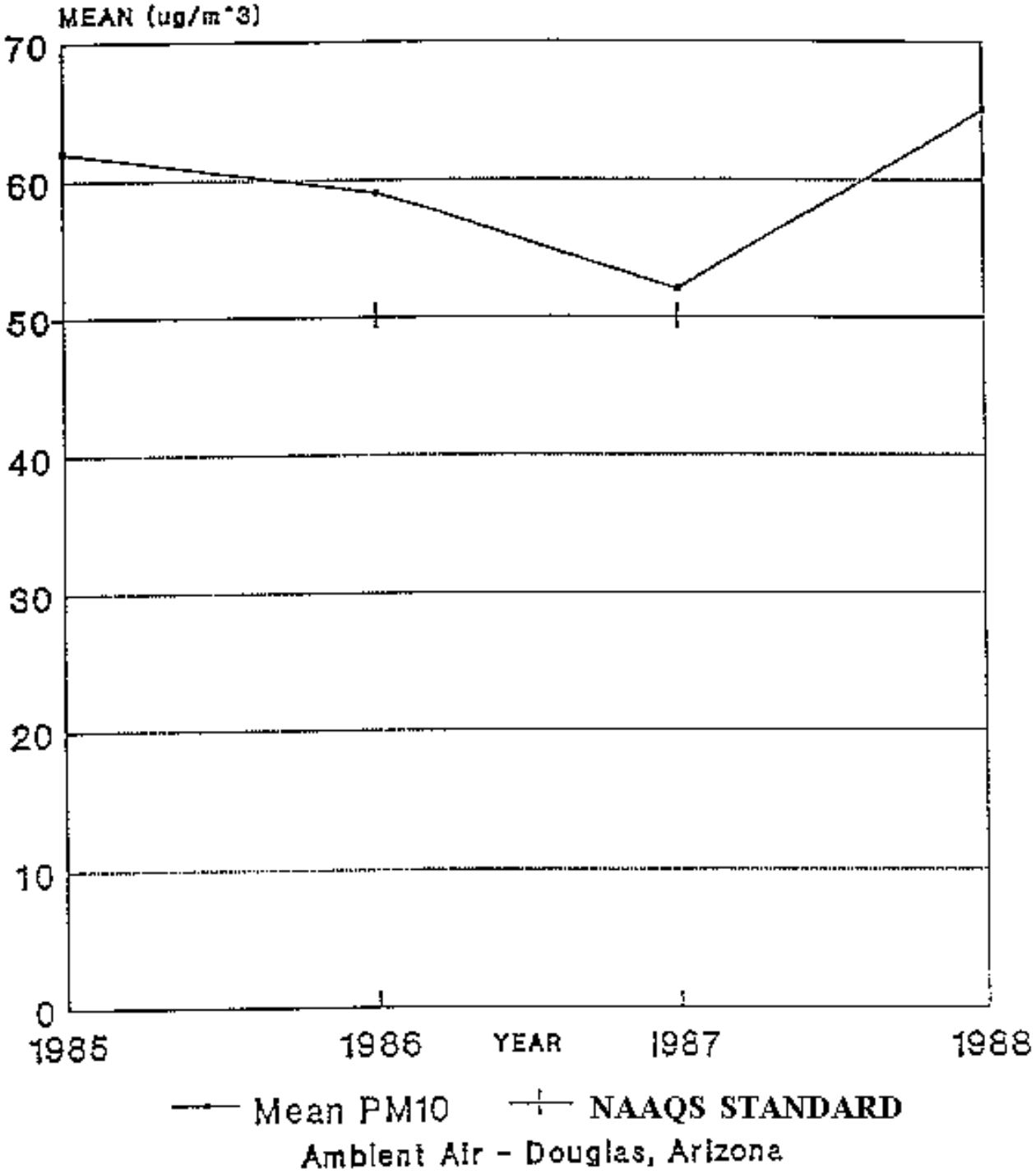
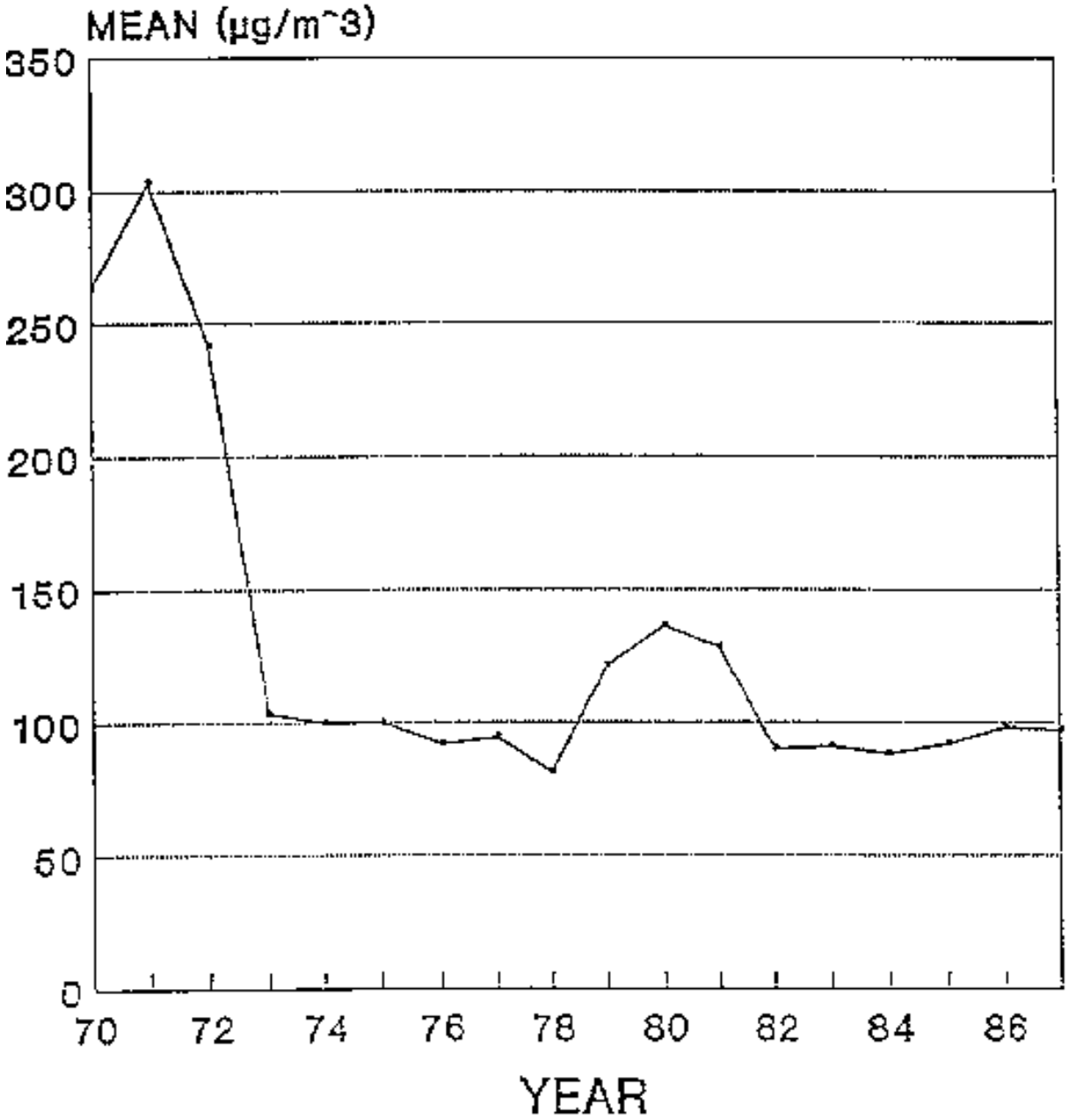


Figure 2
Mean Inhalable Particulate Matter Levels



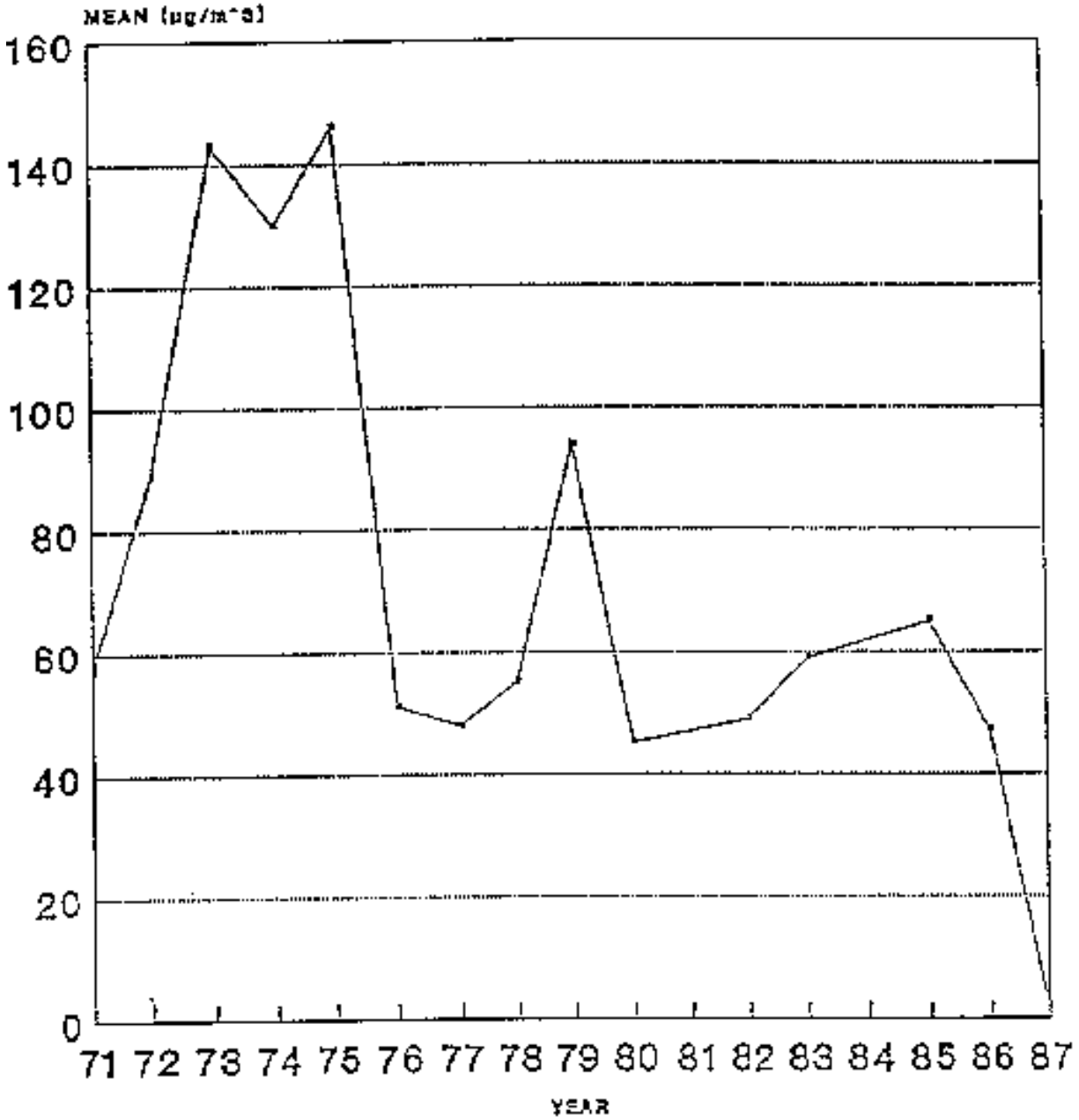
Ambient Air - Douglas, Arizona

Figure 3
Highest Annual TSP Means



1970 - 1987
Mean TSP Levels
Ambient Air - Douglas, Arizona

Figure 4
Highest Annual Sulfur Dioxide Means



1971 - 1987
Mean SO2 Levels
Ambient Air - Douglas, Arizona