# Public Health Assessment

## ASARCO
## HAYDEN SMELTER SITE
## HAYDEN, ARIZONA

**CERCLIS #**
**AZD008397127**

## Prepared by


## Office of Environmental Health

***Environmental Health Consultation Services***

**Arizona Department of Health Services**



**Under Cooperative Agreement with the Agency for Toxic Substances and Disease Registry (ATSDR)**

**FORWARD**

The Agency for Toxic Substances and Disease Registry (ATSDR), was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the Superfund law. This law set up a fund to identify and clean up our country's hazardous waste sites. The United States Environmental Protection Agency (USEPA) and the individual states regulate the investigation and clean up of the sites under this law.

Since 1986, ATSDR has been required by law to conduct a public health assessment (PHA) at each of the sites on the USEPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts PHA's when petitioned by concerned individuals. PHA's are carried out by environmental and health scientists from ATSDR and from states with which ATSDR has cooperative agreements. The Arizona Department of Health Services (ADHS) has a cooperative agreement with ATSDR to conduct PHA's on their behalf.

**Exposure:** As the first step in the evaluation, ADHS and ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data, but reviews information provided by USEPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

**Health Effects:** If the review of the environmental data shows that people have or could have come into contact with hazardous substances, ADHS and ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR and ADHS recognize that children, because of their play activities and their growing bodies may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR and ADHS consider children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high-risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR and ADHS use scientific information, which can include the results of medical, toxicological, and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is the case, the report will suggest what further public health actions are needed.

**Conclusions**: The PHA presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high-risk groups (such as children, elderly, chronically ill, and people engaging in high risk activities), they will be summarized in the conclusion in the PHA. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR and ADHS are primarily health advisory agencies, so usually these PHA's identify what actions are appropriate to be undertaken by environmental agencies, or other responsible parties, to protect public health. However, if there is an urgent public health threat, ATSDR and ADHS can issue a public health advisory warning people of the danger. ATSDR and ADHS can also initiate public health education activities or pilot studies of health effects, full scale epidemiology investigations, disease registries, surveillance studies or research on specific hazardous substances.

**Interactive Process:** The PHA is an interactive process. ATSDR and ADHS solicit and evaluate information from numerous city, state, and federal agencies, the companies responsible for the clean up, and the community. It then shares its conclusions with them. Agencies are asked to respond to an early version of the PHA and to make sure that the data they have provided is accurate and current.

**Community:** ATSDR and ADHS also need to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR and ADHS actively gather information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals, and community groups. To ensure that the PHA responds to the community's health concerns, an early version is also distributed to the public for inclusion of their comments. All the comments received from the public are addressed in the final version of the PHA.

**Comments:** If after reading this PHA, you have questions or comments, we encourage you to send them to us. Letters should be addressed as follows:

Attention: Chief, Office of Environmental Health
Arizona Department of Health Services
3815 N. Black Canyon Highway
Phoenix, Arizona 85015

## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ADHS | Arizona Department of Health Services |
| ADEQ | Arizona Department of Environmental Quality |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| COC | contaminant of concern |
| HBGL | Health-based Guidance Levels |
| MCL | maximum contaminant level |
| $mg/m^3$ | milligrams per cubic meter |
| MRL | minimum risk level |
| NA | not applicable |
| ND | non-detect |
| NS | not sampled |
| PM-10 | particulate matter < 10 microns in size |
| SRLs | Soil Remediation Levels |
| USEPA | United States Environmental Protection Agency |
| µg/L | micrograms per liter |
| $\mu g/m^3$ | micrograms per cubic meter |
| mg/kg | milligrams per kilogram |

## GLOSSARY

*detection limit* — the minimum concentrations that must be accurately and precisely measured by the laboratory and/or specified in the quality assurance plan.

*dose* — the amount of a contamination that is absorbed or deposited in the human body for an increment of time. A total dose is the sum of doses received by a person from a contaminant in a given interval resulting from interaction with all environmental media that contain the contaminant.

*exposure* — an event that occurs when there is contact at a boundary between a human being and the environment with a contaminant for a specific concentration for an interval of time. The units of exposure are concentration multiplied by time( i.e., parts per million times number of days.)

*exposure pathway* — the means by which a contaminant is introduced into the body i.e. dermal, inhalation, or ingestion. Also see route of exposure.

*maximum contaminant level (MCL)* — enforceable drinking water standards that are protective of public health to the extent feasible.

*milligram per kilogram* — a common basis of reporting concentrations in soils. One milligram per kilogram equals one part per million.

*minimal risk level* (MRL) — an estimate of daily exposure of a human being to a chemical (in milligrams per kilogram per day) that is likely to be without an appreciable risk of adverse non cancerous health effects over a specified duration of exposure.

*particulate* — small, discrete, solid or liquid bodies, especially those suspended in a liquid or air medium.

*quality assurance* — a planned system of activities whose purpose is to provide assurance of the reliability and defensibility of the data.

*quality control(QC)* — a routine application of procedures for controlling the monitoring process. QC is the responsibility of all those performing hands-on operations in the filed and in the laboratory.

*route of exposure* — means by which the contaminant moves through the environment by a transporting medium such as air, soil, or water. Also see exposure pathway.

*soil remediation levels* — health-based soil screening levels. SRLs protect against toxic doses of systemic toxicants.

## EXECUTIVE SUMMARY

The Arizona Department of Health Services (ADHS) has prepared this public health assessment (PHA) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). The objective of this PHA is to evaluate whether a public health hazard exists as a result of environmental exposures in Hayden and Winkelman, Arizona.

The towns of Hayden and Winkelman, Arizona are located near a smelter operated by ASARCO, Inc. Some of the residents of these towns have expressed concerns that metals from smelter emissions over the years have been causing health problems. The ADHS Office of Environmental Health (OEH) was made aware of these community health concerns through the United States Environmental Protection Agency (EPA) Region IX Environmental Justice Programs office.

This report uses environmental data collected from water, soil, and air in the Hayden and Winkelman area to estimate environmental exposures. The study also evaluates available health outcome data from previous epidemiological and biological-monitoring studies conducted in the area.

The report concludes that exposure to sulfur dioxide occasionally poses a short-term public health hazard to sensitive asthmatics. These episodes of higher levels of sulfur dioxide occur infrequently. They do not appear to pose a health hazard to persons without sensitive airways or asthma. Other environmental exposures do not appear to pose a public health hazard.

# 1.0 BACKGROUND

## 1.1 SITE DESCRIPTION AND HISTORY

Hayden, Arizona, is located approximately 90 miles southeast of Phoenix on State Highway 177, along the Gila River, below the confluence of the Gila and San Pedro Rivers. The town was founded in 1912 to provide housing for the workers at the Ray open pit mine complex and the copper smelter complex, originally built by the Kennecott Copper Company. The town has a current population of approximately 900, and shares many services, including the local school district, with the town of Winkelman, population 600, located one mile to the south. The towns also share a common history regarding the emissions from the smelter operations.

There have been several smelters on the site of the current Asarco smelter, with emissions being discharged into the air in Hayden and Winkelman since operations began in 1909. Historic emissions contained large quantities of lead, arsenic, sulfur dioxide ($SO_2$), particulate matter, and other materials. These contaminants drifted over the entire region in the air and many of the materials contained in these emissions fell out of the atmosphere and settled on the ground.

The first emission controls placed upon the smelters were installed in 1920. These electrostatic precipitators were designed to remove particulate matter from the stack emissions. The smelters within the complex operated with these minimal emission controls prior to 1969, when requirements under the forthcoming Clean Air Act amendments of 1970 required that controls be installed to limit $SO_2$ emissions. Acid plants were added in 1969 and 1971 to reduce $SO_2$ and particulate emissions. Additional controls were added to the current smelter in 1984, further reducing the $SO_2$ emissions. The current smelter stack height was designed to elevate the emissions above the valley air shed and better facilitate dispersion.

The residential areas of Hayden are located on two ridges that run parallel to each other, in an east/west direction, east of Highway 177. Houses line the main street on the north ridge. Houses on the south ridge are scattered among several streets intersecting Velasco Avenue.

The main street in Hayden is Hayden Avenue, which runs east-west from the smelter property line on the eastern edge of town, to Fourth Street, a distance of approximately 3/8 mile. It is along this street that the primary business district is located.

The ASARCO smelter is a large complex of approximately 200 acres at the eastern end of the town. Two large emission stacks dominate the horizon. One is about 1,000 feet tall and the other is 250 feet tall. There are also several smaller stacks visible at buildings throughout the complex. A large slag pile, a solid glass-like waste material, is on the eastern end of the facility, adjacent to the town.

Winkelman is one mile south of Hayden. The schools for children in the area are in Winkelman. There are several streets of houses as well as a few businesses along Highway 177.

## 1.2 SITE VISITS

ADHS staff visited the area several times, beginning January 7, 1999. Specific dates are:

| | |
|---|---|
| January 7, 1999 | ADHS obtained soil samples from the area. |
| April 5, 1999 | ADHS met with local community leaders to determine the best course of action to meet community needs. |
| April 19, 1999 | ADHS presented the biomonitoring project to Hayden Town Council. |
| May 10, 1999 | ADHS presented the biomonitoring project to Winkelman Town Council. |
| May 17, 1999 | ADHS answered questions from the Hayden Town Council. |
| June – Oct. 1999 | Public health surveys were conducted in Hayden and Winkelman. |
| March 16, 2000 | ADHS presented findings of the public health survey and biomonitoring project to the community during 2 open house meetings. |

| | |
|---|---|
| May 20, 2002 | ADHS presented the Public Health Assessment—Draft for Public Comment to the Hayden Town Council. |
| June 10, 2002 | ADHS presented the Public Health Assessment—Draft for Public Comment to the Winkelman Town Council. |
| June 18, 2002 | ADHS presented the Public Health Assessment—Draft for Public Comment during a public meeting at the Senior Center in Hayden. |

These site visits consisted of meeting with community members during City Council meetings or informal gatherings to provide the community with updated information on the progress of the research being conducted in the area. A number of health education and informational sheets were distributed during the site visits

Site visits also included observations of the current site conditions and operations.

## 1.3 DEMOGRAPHICS, LAND USE, AND NATURAL RESOURCE USE

### Demographics

The towns of Hayden and Winkelman consist of homes primarily built during the 1940s and 1950s to accommodate the large worker population needed in the area to operate the Ray open pit copper mine and the copper smelter in Hayden.

The area is typical of rural Arizona, with churches, small stores, and other facilities located along the main street of the town. Hayden is east of Highway 177, on a hillside, below the actual smelter works. The entire town covers an area of less than one square mile, and contains approximately 365 homes. The schools for the area are in Winkelman, and consist of an elementary and high school. Winkelman has approximately 100 homes in the developed area of the town. The approximate population of Hayden and Winkelman is 1,500 people.

### Land Use

The actual smelter site consists of a large complex of buildings, many of which are former smaller smelters, replaced by the current large smelter now in operation. The entire complex covers approximately 200 acres. The smelter facility is on the east side of Hayden. In addition a large pile of waste product called mine tailings is directly east of Hayden on the west side of Highway 177. The mine tailings pile rises approximately 100 feet above the lowest area and extends for approximately ½ mile along the west side of Highway 177. The town of Hayden is divided by a private road used by the trucks hauling ore from the railroad unloading site to the smelter. This division takes place in a naturally occurring low area between the ridges upon which Hayden is built. The downtown area lies within the south portion of town and consists of storefronts along Hayden Avenue. The largest concentration of homes is along San Pedro Avenue on the northern ridge of the town.

There are 28 active production water wells in the area. These wells serve the towns of Hayden and Winkelman and consist of several separate water systems and public water suppliers.

## 1.4 HEALTH OUTCOME DATA

There have been several studies conducted over the past 10 years examining possible adverse health effects from environmental exposures, including lung cancer, as a result of living near non-ferrous metal smelters in Arizona.

- *1995 Lung Cancer Mortality Study*

A study completed in December 1995 examined lung cancer mortality rates in six Arizona copper smelter towns (Globe, Kearny, Superior, Miami, Hayden, and Winkelman). This study was prompted by a 1990 ADHS study, which found lung cancer mortality rates 50% higher for the Gila Basin residents compared to the Phoenix/Tucson metropolitan areas [1].

The 1995 study provided little evidence of a positive association between lung cancer mortality and any of the indices of residential smelter emissions considered. Some variation in the estimated risk of lung cancer was found for males and for females by town of residence at the time of death, though these associations were not statistically significant. Also, there were some slightly increased risks of lung cancer for males and females for the calculated measures of residential smelter emissions. However, the odds ratios did not clearly increase with level of exposure and were not statistically significant. A parallel study of four other Arizona copper smelter towns also found little evidence of a positive association between lung cancer risk and any indices of residential exposure to smelter emissions considered [2].

The validity of these findings for residential smelter emissions is supported by the major strengths of this study which include the high response rates and the completeness of the individual-level residential, occupational, and smoking data obtained via proxy respondents. The 1995 study found that among male residents, there was some evidence of an association between lung cancer risk and copper smelter-related occupational exposure that differed by town of residence at the time of death [1]. The study grouped all of the smelter towns together, and no individual conclusions regarding Hayden and Winkelman were drawn.

- *1999 ADHS-University of Arizona Blood Lead and Urinary Arsenic Study*

In 1999, the Arizona Prevention Center, an affiliate of the University of Arizona (UA) dealing with environmental and occupational issues, and ADHS conducted a health survey of the residents of Hayden and Winkleman to determine childhood blood lead levels and child and adult urinary arsenic levels. This survey was conducted over a two-month period during June and July 1999, by graduate students and faculty of the UA Medical School. Funding for this study was provided through an agreement between ASARCO and the Arizona Department of Health Services.

Random sampling of residents was conducted, with the emphasis placed on screening children less than 3 years of age for blood lead. Adults and children were screened for urinary arsenic. The urinary arsenic analysis measured both organic and inorganic arsenic compounds. Inorganic arsenic compounds were the focus of this screening since organic arsenic is significantly less toxic than inorganic arsenic.

All 14 children tested in Hayden and Winkelman had blood lead concentrations below the CDC intervention level of 10 micrograms per deciliter (µg/dL), with an average blood lead concentration of 3.6 µg/dL. No evidence of excessive environmental lead exposure was found in the study participants.

The average urinary total arsenic concentration of individuals tested in Hayden and Winkelman was 13.7 micrograms per liter (µg/L), which is substantially less than the study reference level of 30 µg/L. Urinary arsenic concentrations were not adjusted for creatinine. The reference level of 30 µg/L was established as the marker level by the UA investigators for persons who consume water with an arsenic concentration of 50 µg/L.

Five (2%) of 224 individuals tested in Hayden and Winkelman had inorganic urinary arsenic concentrations exceeding 30 µg/L. The maximum concentration measured was 47 µg/L. The possible adverse effects of such levels are not known. Recent renovation activities in these three households, including removal of old paints, may have resulted in exposure to arsenic containing house dust. Section 5.2 provides more details about the study results and design.

## 2.0 COMMUNITY HEALTH CONCERNS

ADHS has spoken with members of the community regarding their concerns about exposure to the emissions from the smelter. Some members were concerned the emissions were impacting their health, while others were not. Most persons accepted the fact that the smelter produced air pollution, and that by working and living in the area they would be exposed to whatever was being emitted from the smelter. While most of the residents did not say they did not like the air pollution the smelter was producing, they spoke in veiled references to it. Comments such as "not being able to have a barbeque at night, because going outside makes you sick" were common.

Many people expressed their health concerns to the UA survey teams. Persons expressing concern cited emissions from the smelter as a cause of illness in the community.

## 3.0 ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

The tables in this section list the contaminants of concern. These contaminants are evaluated in the subsequent sections of the public health assessment to determine whether exposure to them has public health significance. ADHS selected the contaminants based upon the following factors:

1. Concentrations of contaminants on-site;
2. Field data quality, laboratory data quality, and sample design;
3. Comparison of on-site concentrations with background concentrations;
4. Comparison of on-site concentrations with health-based comparison values for environmental media; and
5. Community health concerns

Contaminants were selected as chemicals of concern based upon a comparison of site concentrations to various environmental standards including ATSDR Comparison Values; Residential Arizona Soil Remediation Levels (SRLs); USEPA Maximum Contaminant Levels (MCLs); and Arizona Air Quality Guidelines (AQGs). AQGs are guidelines calculated by ADHS for airborne chemicals for use by permitting agencies to establish emissions limits from industrial sources.

Identifying a contaminant as a chemical of concern does not mean that the contaminant will cause adverse health effects from exposures. Instead, the list indicates which contaminants will be evaluated further in the public health assessment.

A toxicological evaluation of the potential health impact was conducted for those contaminants selected as chemicals of concern. Dose calculations were compared to Minimum Risk Levels (MRLs) established by ATSDR for exposure to specific contaminants.

## 3.1 ENVIRONMENTAL CONTAMINATION

### 3.1.1 Water

Water delivered to the residents of both Hayden and Winkelman comes from a number of wells in the area and under the control of several different water systems. Testing of the water from each of these systems for contaminants is conducted under the Federal Safe Drinking Water Act. The two water systems that serve Hayden and Winkelman are currently in compliance with these requirements, according to the Arizona Department of Environmental Quality.

The latest information on testing for contaminants under the Safe Drinking Water Act standards shows there are measurable amounts of several contaminants in each of the water systems that serve Hayden and Winkelman. These contaminants are arsenic, antimony, beryllium, cadmium, chromium, fluoride, mercury, selenium, and thallium. In addition, the water supply was also tested for asbestos fibers. The amounts were all below the EPA Maximum Contaminant Level (MCL) for each metal, and asbestos was below the maximum fiber count. Concentrations of the contaminants were also compared to ATSDR Comparison Values (CVs) to determine if they should be further evaluated.

ATSDR has developed CVs for common chemicals to determine if contaminants are present in the environment at levels that warrant further human exposure evaluation. The CV is a concentration of a chemical in water below which adverse health effects are unlikely to occur regardless of how people may come into contact with the contaminant. CVs are not used to determine the specific adverse health effects from exposure, rather they are used to determine if there is the need for a more thorough, contaminant-specific investigation.

Arsenic concentrations in the various water systems serving the area were below the CV for adults, but above the CV for children, and arsenic has been selected as a contaminant of concern in drinking water. None of the other contaminants were selected as contaminants of concern since average concentrations were below CVs. See Table 1 for results of water quality testing of local wells.

**Table 1. Water Quality Information from Local Water Systems**

| Chemical | Number of samples | Mean of samples in µg/L | EPA MCL* | ATSDR Comparison values (CVs) µg/L | Mean Above MCL or CV | Selected as COC** |
|---|---|---|---|---|---|---|
| Arsenic | 13 | 6.5 | 50 | 3 | **Yes** | **Yes** |
| Antimony | 5 | 3.7 | 6 | 4 | No | No |
| Asbestos | 8 | 0.2 | 7 MFL# | NA | No | No |
| Beryllium | 5 | 2.6 | 4 | 10 | No | No |
| Cadmium | 11 | 2.5 | 5 | 5 | No | No |
| Chromium | 14 | 15 | 100 | 100 | No | No |
| Fluoride | 23 | 1,592 | 4,000 | NA | No | No |
| Mercury | 16 | 1.2 | 2 | NA | No | No |
| Selenium | 13 | 6 | 50 | 50 | No | No |
| Thallium | 5 | 1.5 | 2 | NA | No | No |

All units in micrograms per liter (µg/L)
Minimum concentrations for all metals were at the non-detect level for the analysis method
* Maximum Contaminant Level established for drinking water provided by a regulated water supplier
** Contaminant of Concern
\# MFL micro fibers per liter

### 3.1.2 Air

The Arizona Department of Environmental Quality (ADEQ) maintains a dicot particulate sampler at the Hayden Jail. This sampler collects particulate samples in the range of less than 2.5—10 microns. The samples are analyzed for metals including lead, arsenic, cadmium, and zinc. The samples collected over the past several years have shown that arsenic and $SO_2$ present in concentrations that exceed the ATSDR CVs in air.

*Arsenic*
The ATSDR CV for arsenic of 0.0002 micrograms per cubic meter ($\mu g/m^3$) for an annual average was used to select arsenic as a contaminant of concern in air. Annual averages of arsenic in outdoor air have consistently been in excess of the CV, and arsenic has been selected as a contaminant of concern in air.

**Table 2. Arsenic air quality data from Hayden, Arizona monitor**

| Year | Arsenic Annual Average in µg/m$^3$* | ATSDR Comparison Value(CV) µg/ m$^3$ | Exceeds CV? |
|---|---|---|---|
| 1991 | 0.200 | 0.0002 | **Yes** |
| 1992 | 0.168 | 0.0002 | **Yes** |
| 1993 | 0.102 | 0.0002 | **Yes** |
| 1994 | 0.095 | 0.0002 | **Yes** |
| 1995 | 0.092 | 0.0002 | **Yes** |
| 1996 | 0.111 | 0.0002 | **Yes** |
| 1997 | 0.184 | 0.0002 | **Yes** |
| 1998 | 0.080 | 0.0002 | **Yes** |

*Lead*
No CV exists for lead in air, so the EPA air quality standard for lead, set at 1.5 µg/m$^3$ average per calendar quarter was used as a reference value for lead. Lead levels in outdoor air have consistently been below this reference value, and lead has not been selected as a contaminant of concern in outdoor air.

**Table 3. Lead air quality data from Hayden, Arizona monitor for quarterly average in micrograms per cubic meter (µg/ m$^3$), 1993-1997**

| Year | Lead 1st Quarter µg/ m$^3$ | Lead 2nd Quarter µg/ m$^3$ | Lead 3rd Quarter µg/ m$^3$ | Lead 4th Quarter µg/ m$^3$ | Annual Average | National Ambient Air Quality Standard | Exceeds NAAQs? |
|---|---|---|---|---|---|---|---|
| 1993 | 0.07 | 0.07 | 0.1 | 0.13 | 0.09 | 1.5 | No |
| 1994 | 0.46 | 0.41 | 0.26 | 0.23 | 0.34 | 1.5 | No |
| 1995 | 0.24 | 0.18 | 0.42 | 0.58 | 0.35 | 1.5 | No |
| 1996 | 0.42 | 0.32 | 0.26 | 0.21 | 0.3 | 1.5 | No |
| 1997 | 0.27 | 0.42 | 0.29 | 0.51 | 0.37 | 1.5 | No |

*Sulfur dioxide ($SO_2$)*
ADEQ also analyzes the samples for sulfur dioxide particulates, since this area is a non-attainment area for $SO_2$ air quality standards**.** A review of the sample results over the past five years indicates the area has not exceeded the USEPA standard for sulfur dioxide. However, average annual sulfur dioxide levels have consistently been in excess of the ATSDR CV; therefore, sulfur dioxide is selected as a contaminant of concern in outdoor air.

**Table 4. Sulfur Dioxide 3 hour maximum concentrations**

| Year | 3 Hour Maximum µg/ $m^3$ | ATSDR Acute Exposure Comparison Value µg/ $m^3$ | Exceeds CV? |
|---|---|---|---|
| 1990 | 1,137 | 25 | **Yes** |
| 1991 | 511 | 25 | **Yes** |
| 1992 | 815 | 25 | **Yes** |
| 1993 | 372 | 25 | **Yes** |
| 1994 | 464 | 25 | **Yes** |
| 1995 | 435 | 25 | **Yes** |
| 1996 | 527 | 25 | **Yes** |
| 1997 | 697 | 25 | **Yes** |
| 1998 | 595 | 25 | **Yes** |

### 3.1.3 Soil

In January 1999, soil samples from a depth of 0–6" were taken by ADHS from various areas of the two communities, and a control sample was also taken several miles north of Hayden, for comparison purposes. Samples were analyzed in the Arizona state laboratory using a screening test based upon EPA test methods for heavy metals. Table 5 summarizes the soil sampling results.

**Table 5. Metal Concentrations in soils collected from a depth of 0–6" Hayden, Arizona January 1999**

| Metal | # of samples | Mean Soil Concentration mg/kg | ATSDR Comparison Value(CV) mg/kg | Residential Arizona Soil Remediation Level(SRL)* mg/kg | Exceeds CV or SRL? |
|---|---|---|---|---|---|
| Arsenic | 10 | 5 | 20 | 10 | No |
| Barium | 10 | 29 | NA | 5,300 | No |
| Cadmium | 10 | 59 | NA | 38 | No |
| Chromium | 10 | 1.7 | NA | 2,100 | No |
| Cobalt | 10 | 8 | NA | 4,600 | No |
| Copper | 10 | 6 | NA | 2,800 | No |
| Lead | 10 | 643 | NA | 400 | Yes |
| Manganese | 10 | 237 | NA | 3,200 | No |
| Nickel | 10 | 9.6 | NA | 1,500 | No |
| Selenium | 10 | 20 | 300 | 3,380 | No |
| Silver | 10 | 1 | NA | 380 | No |
| Zinc | 10 | 66 | 20,000 | 23,000 | No |

* SRL: Soil Remediation Level is a clean-up standard adopted in administrative rule by the ADEQ. SRLs are protective of human health (AAC R18-7-201 through R18-7-208).

None of the metals for which analyses were conducted exceeded CVs or Residential SRLs. However, both lead and arsenic were selected as COCs in soils because of community concerns and because lead slightly exceeded the SRL.

### 3.2 PHYSICAL AND OTHER HAZARDS

Because the entire area surrounding the smelter, including Hayden and Winkelman proper, are considered on-site, there were many observed physical hazards. These included exposed metal piping, abandoned vehicles, and steep terrain. There are many areas of discarded machinery as well as the large slag pile at the north side of Hayden that could be considered attractive for playing children.

## 4.0 EXPOSURE PATHWAY ANALYSES

ADHS evaluated the environmental and human components that lead to human exposure to determine whether people are exposed to contaminants from the site. An exposure pathway consists of five elements: a source of contamination; transport through an environmental medium; a point of exposure; a route of exposure; and a receptor population.

ADHS categorizes an exposure pathway as a completed or potential exposure pathway if the exposure pathway cannot be eliminated. In completed exposure pathways, all five elements exist, and exposure to a contaminant has occurred in the past, is occurring, or will occur in the future. In potential pathways, at least one of the five elements is missing but could exist. Potential pathways indicate that exposure to a contaminant could have occurred in the past, could be occurring or could occur in the future.

An exposure pathway can be eliminated if at least one of the five elements is missing and will never be present. Table 6 identifies the completed exposure pathways. Table 7 estimates the number of exposed persons for completed exposure pathways. The discussion that follows these two tables incorporates only those pathways that are important and relevant to the site. The tables also illustrate some of those exposure pathways that have been eliminated.

### 4.1 COMPLETED EXPOSURE PATHWAYS

Currently, complete exposure pathways exist in the area on and around the site. Tables 6 and 7 present this information in a summarized format.

**Table 6. Completed Exposure Pathways**

| Pathway | Exposure Pathway Elements | | | | | Time |
|---|---|---|---|---|---|---|
| | Source | Medium | Point of Exposure | Route of Exposure | Exposed Population | |
| Surface Soil | ASARCO Smelter | Surface Soil | Surface soil throughout entire area | Ingestion Inhalation Dermal | Residents of entire area | Past Present Future |
| Water | Natural and possibly ASARCO | Groundwater (Public wells) | Residences, tap water | Ingestion | All residents of area | Past Present Future |
| Air | ASARCO Smelter | Air | Entire Area | Inhalation | Residents in entire area | Past Present Future |

**Table 7. Estimated population for completed exposure**

| Estimated Populations that are affected by a Completed Exposure Pathway* | | |
|---|---|---|
| **Location** | **Estimated Persons** | **Pathway** |
| Hayden/Winkelman | 1,500 | Surface Soil<br>Public Water Supply<br>Ambient Air |

* Refer to Table 6 for completed exposure pathways.

#### 4.1.1 Air Pathway

One source of the exposures to contaminants in air is emissions from the smelter; however, other sources, such as vehicle exhaust, can also contribute to ambient air pollution. Transport occurs by physical movement of the emissions from the smelter into the air and from fugitive dust emissions from soils in the area. This would include the large deposit of waste tailings west of the towns. All persons who are in the towns are exposed through inhalation of the contaminants. In addition to the emissions from the smelter, soil particles containing the contaminants that are blown into populated area are inhaled, contributing to the total amount of contamination that is taken into the exposed individuals.

#### 4.1.2 Water Pathway

Water delivered to the residents of Hayden and Winkelman contains measurable concentrations of arsenic. Regular testing by the local water providers for arsenic has resulted in arsenic detection. Drinking water is obtained from several wells located throughout the area. Because of the ore bearing nature of the soils, arsenic is commonly present in these bodies, and as a result is present in many groundwater aquifers. These levels range from 2.5 micrograms per liter (µg/L) to 34.5µg/L, as reported by the local water providers in the latest sampling data available. The mean level of arsenic in the drinking water is 6.5 µg/L. The mean concentrations are below the 50 µg/L maximum contaminant level (MCL) set by the EPA for drinking water. The current MCL for arsenic will be lowered to 10 µg/L beginning in 2006. Persons are exposed through ingestion and dermal contact with water containing arsenic.

### 4.1.3 Soil Pathway

Because contaminated dust particles deposit on soil and other surfaces, people are expected to come into direct contact with the contaminants when they play outside or garden. Incidental ingestion of soil containing the contaminants of concern results primarily from hand to mouth activity. Children are most likely to ingest more soil because of the way they play.

## 4.2 POTENTIAL EXPOSURE PATHWAYS

Should high winds occur at the time air emissions are highest, people living and working beyond the area defined as the currently exposed population could also be exposed. Additionally, if groundwater contamination extends to drinking water supplies beyond the defined area, then additional people could be exposed to contaminants in their drinking water. These scenarios are not likely to occur often, if at all; therefore, exposures outside the defined areas around the site are unlikely.

# 5.0 PUBLIC HEALTH IMPLICATIONS

## 5.1 EXPOSURE AND TOXICOLOGICAL EVALUATION

ADHS based this toxicological evaluation on previously described exposure scenarios for the residents of the area and health effect studies. These evaluations consist of the analysis of exposures of persons exposed to contaminants in the air, in soil, and in the water. The contaminants of concern for this site are lead, arsenic, and sulfur dioxide.

*Quantifying Exposures*

ADHS has made several assumptions regarding dose intake and assumptions used to quantify exposures. Many variables were based on observations made at the site and on conversations with members of the community and with staff from ADEQ.

Persons in these communities are exposed to the contaminants present in emissions from the site, in contaminated dust and soil, and in water. Contaminated dust and emissions can settle on objects, such as toys left outside. Children are especially prone to putting their hands and toys in their mouths without washing them first. Any contamination or naturally occurring metals present on surfaces that people have contacted with their hands can then be ingested.

When evaluating exposure, ADHS assumes that these persons will breath contaminated fugitive dust and emissions from the site 24 hours per day for 30 years. Persons living in the area are assumed to have dermal contact with the soil for 30 years. In addition, adults residing in the area are assumed to drink water containing arsenic at the rate of two liters of water per day for 30 years. Higher soil ingestion rates and lower body weights were assumed when estimating children’s exposure in order to more accurately evaluate health risks for children. The equations used to estimate exposure doses are presented in the Appendix.

Exposures to the contaminants of concern have been quantified using standard exposure assessment methods. Inhalation, ingestion, and dermal absorption are the routes of exposure for the completed exposure pathways. Although the dermal exposure pathway is evaluated, the actual dermal absorption of the contaminants of concern is not quantified. This is because little, if any, of the contaminants of concern go through the skin.

Exposures to arsenic present in drinking water were evaluated based on the assumption that groundwater is the source of all drinking water. Surface water runoff from waste piles into the Gila River is a possible source of some of the groundwater arsenic because the Gila River recharges groundwater in some areas. No data were available to conclusively link surface runoff with the groundwater arsenic levels.

*Evaluating Exposure Levels*

To evaluate health effects, ATSDR has developed a Minimal Risk Level (MRL) for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily human exposure to a contaminant below which non-cancer, adverse health effects are unlikely to occur. MRLs are not used to predict specific adverse health effects from exposure. MRLs are established as screening tools to use to determine whether further evaluation of the contaminant is warranted. MRLs are not used to establish a safe level of contaminants at a site. MRLs are developed for each route of exposure, such as inhalation and ingestion, and for a length of exposure, such as acute (less than 14 days), intermediate (14 to 365 days), and chronic (greater than 365 days).

Chemical-specific information is contained in documents known as toxicological profiles, which are published by ATSDR. These chemical-specific profiles provide information on health effects, environmental transport, human exposure, and regulatory status. In the following discussion, we used ATSDR Toxicological Profiles for arsenic, lead, and sulfur dioxide. In addition to the Toxicological Profiles, ADHS also used information from a number of other sources. These sources are listed in the reference section of this PHA.

Additional evaluation is necessary to determine whether a health hazard exists when exposure estimates exceed MRLs. Literature sources are reviewed to determine what doses and exposure scenarios are associated with specific health effects. The No Observed Adverse Effect Level (NOAEL) is the exposure dose at which no adverse effect was observed on the animal or human population in the study. The Lowest Observed Adverse Effect Level (LOAEL) for a contaminant is the lowest exposure dose observed that resulted in a measurable adverse health effect in the animal or human population in the study. Whenever possible, NOAELs and LOAELs obtained from human studies are reviewed when evaluating possible health effects as a result of exposure to the contaminant. However, if no human studies exist, studies on laboratory animals are reviewed, and the health assessor might include safety factors to address human differences when evaluating whether health effects might be possible.

In addition to NOAELs and LOAELs used to evaluate non-cancer health effects, Cancer Exposure Levels (CELs) have been established for chemicals known to cause cancer in humans. The CEL is the lowest exposure level associated with the onset of carcinogenesis in experimental or epidemiologic studies. EPA assesses cancer effects by calculating the risk that any one individual might develop cancer as a result of exposure of one million people to the contaminant.

**Arsenic**

*Exposure Dose Calculations*
ADHS used standard default exposure calculations (EPA 1991 OSWER directive) to determine the average daily absorbed dose of arsenic for both adults and children. The adult calculations assume that adult residents inhale 20 cubic meters of air per day for 30 years, drink two liters of water per day for 30 years, have an incidental soil ingestion rate of 100 milligrams per day, have approximately 5,000 square centimeters of exposed skin, and have a body weight of 70 kilogram. Calculations for children are based upon inhalation of 10 cubic meters of air per day for six years, ingestion of one liter of water per day for six years, incidental soil ingestion of 200 milligrams per day, 2,000 square centimeters of exposed skin, and have a body weight of 15 kg.

*Screening Levels for Arsenic*
No Observed Adverse Effect Levels, or NOAELs, range from 0.0004 to 0.0009 mg/kg/day. Based upon these data, the acute oral MRL has been established at 0.005 mg/kg/day, and the chronic oral MRL is 0.0003 mg/kg/day. These MRLs were derived by dividing the NOAEL of 0.0008 mg/kg/day by an uncertainty factor of 3 for human variability. The study used to derive the MRL was conducted by Tseng, et al., and the form of arsenic was specified only as inorganic arsenic [3].

No MRL has been established for inhalation or dermal absorption of arsenic [3]. Chronic NOAELs for human inhalation of arsenic range from 0.000055 $mg/m^3$ to 0.6 $mg/m^3$ . The LOAELs for human inhalation range from 0.6 $mg/m^3$ to 0.0007 $mg/m^3$. No CEL has been established for inhalation of arsenic. CELs for ingestion of arsenic range from 0.0011 mg/kg/day for lung cancer to 3.67 mg/kg/day for bladder cancer. Exposure to arsenic is also associated with skin cancer. The lowest CEL for skin cancer is 0.014 mg/kg/day.

*Arsenic in Drinking Water*
Mean concentrations of arsenic in the primary water system that serves the area are lower than the newly adopted EPA Maximum Contaminant Level of 10 µg/L. The current MCL for arsenic is 50 µg/L, but EPA has set a more protective standard of 10 µg/L to go into effect in 2006.

The adult estimated exposure dose for arsenic of 0.0003 mg/kg day is equal to the MRL, suggesting that arsenic exposure from drinking water does not pose a non-cancer health hazard. The childhood estimated exposure dose for arsenic of 0.00065 mg/kg/day is approximately twice the MRL and is in the middle of the NOAEL range of 0.0004 to 0.0009 mg/kg/day. A child's estimated dose of 0.00065 mg/kg/day is approximately 10 times lower than the LOAEL of 0.005 mg/kg/day, suggesting that exposure to arsenic in drinking water does not pose a health hazard.

The adult estimated dose does not exceed a CEL; therefore, cancer is not likely to result from exposure to arsenic in the drinking water. If estimating cancer risk, the lifetime excess cancer risk estimate from exposure to arsenic in drinking water is approximately 2 in 10,000, which is a moderate increased cancer risk. Cancer risk estimates are conservative and likely overestimate the actual risk.

*Arsenic in Soils*
Mean concentrations of arsenic in soil samples collected in the area are 5 mg/kg, which is less that the CV for arsenic in soil of 20 mg/kg. The adult estimated exposure dose for arsenic of 0.000009 mg/kg day and the estimated child dose of 0.00009 mg/kg/day are lower than the MRL of 0.0003, suggesting that arsenic exposure from soils does not pose a non-cancer health hazard. The lifetime excess cancer risk estimate from exposure to soils is estimated to be approximately 6 in 1 million. Exposure to that level does not exceed a CEL and would not present an increased cancer risk.

*Arsenic in Ambient Air*
The average annual concentration of arsenic in ambient air in the area between 1991 and 2000 was 0.129 $\mu g/m^3$, which is equivalent to a daily childhood dose of 0.00008 mg/kg/day and an adult dose of 0.000004 mg/kg/day.

No MRL has been established for inhalation of arsenic [3]. The chronic NOAELs for childhood exposure through inhalation range from 0.00003 mg/kg/day to 0.4 mg/kg/day. LOAELs for childhood inhalation exposure range from 0.0004 mg/kg/day to 0.4 mg/kg/day.

The estimated arsenic dose for adults is 10 times less than the lowest limit of the NOAEL range. The estimated exposure dose for children is at the lowest limit of the NOAEL range, and 5 times less than any LOAEL, suggesting that arsenic does not present a non-cancer health hazard for children or adults.

No CEL has been established for inhalation of arsenic. The lifetime excess cancer risk estimate from exposure to arsenic in air is estimated to be approximately 7 in 100,000. This is a slight increased cancer risk.

*Arsenic Exposure from All Pathways*
The total childhood estimated exposure dose from all pathways for arsenic of 0.0008 mg/kg/day is within the NOAEL range of 0.0004 to 0.0009 mg/kg/day. Estimated adult exposure of 0.0001 mg/kg/day is less than the NOAEL range. A child's estimated dose of 0.0007 mg/kg/day is 10 times lower than the LOAEL of 0.005 mg/kg/day, suggesting that exposure to arsenic does not pose a non-cancer health hazard.

Long-term ingestion of arsenic is associated with development of cancer, primarily skin cancer. The lifetime excess cancer risk estimate from exposure to arsenic from all sources is estimated to be approximately 2 in 10,000. This is a moderate increased cancer risk. Arsenic in drinking water is responsible for the majority of the total exposure and cancer risk. See the *Health Outcome Data* section of this document for information on arsenic urine screening performed in the community.

**Table 8. Comparison of Estimated Exposed Dose to Health Guidelines for Arsenic**

| Pathway | Child Exposure Dose (mg/kg-day) | Health Guideline* mg/kg-day | | |
|---|---|---|---|---|
| | | MRL | NOAEL | LOAEL |
| **Water Ingestion** | 0.00065 | **0.0003** | **0.0004** | 0.005 |
| **Soil Ingestion** | 0.00009 | 0.003 | 0.0004 | 0.005 |
| **Inhalation** | 0.00008 | N/A | **0.00003** | 0.0004 |

*Bold items indicate estimated dose exceeds guideline

**Lead**

Lead is a soft metal often found in combination with other valuable metals in soils mined for their metal content. Because of the varied nature of lead-containing compounds, ATSDR has not developed an MRL for lead; however, ATSDR has developed a mathematical model designed to estimate the amount of lead taken into the body based upon the actual concentrations of lead in soil (See Appendix for model). EPA has found that lead in soil above 400 mg/kg may pose a health hazard if absorbed by humans [5].

Children less than 6 years of age are most at risk of exposure to the lead from the smelter emissions. This is because of increased sensitivity to lead, higher absorption and retention rates of lead, and increased exposure due to hand to mouth activities. Some adverse health effects have been documented in children at blood lead levels of 10 micrograms per deciliter (µg/dL) of whole blood, but the Centers for Disease Control and Prevention (CDC) is considering whether subtle effects might occur at lower levels. The most common health effects among children with elevated blood lead levels are decreased performance on psychometric tests, fine motor dysfunction, and altered behavioral patterns [5]. The most likely exposure pathway for these children is ingestion of lead through hand to mouth activity. Dermal contact with lead contaminated soils can result in increased ingestion of lead through hand to mouth behavior [5]. Inhalation of the soil particles also may contribute to the overall uptake of lead from this site. People are exposed to the smelter emissions through inhalation of emissions and contaminated dust particles. Once inhaled, the contaminated particles can then be ingested or enter directly into the lung. Because of the size of contaminated particles, they are more likely to enter the body through the digestive tract rather than through the lung.

ADHS used ATSDR's integrated exposure regression analysis method to estimate exposure doses. (See Appendices for the Lead Model).

### Table 9. Estimated blood lead levels from exposure to environmental and dietary lead for Hayden and Winkelman

| Media | Concentration* | Relative Time Spent (fraction of a day) | Slope Factor** | Estimated Blood Lead Level micrograms per deciliter (µg/dL) | |
|---|---|---|---|---|---|
| Outdoor Air | 0.366 µg/$m^3$# | 0.2 | 1.32 (low)[1] | 0.0965 | |
| | | | 2.52 (high)[1] | | 0.184 |
| Indoor Air | 0.03 µg/$m^3$ | 0.8 | 1.32 (low)[2] | 0.1288 | |
| | | | 2.52 (high)[2] | | 0.2459 |
| Food | 5 µg/day | 1 | 0.24 [3] | 1.2 | |
| Water | 4 µg/day | 1 | 0.16 [4] | 0.64 | |
| Soil | 29 mg/kg ## | 0.2 | 0.00583 (low)[5] | 0.0336 | |
| | | | 0.00777 (high)[5] | | 0.0449 |
| Dust | 70 mg/kg | 0.8 | 0.00628 (low)[6] | 0.3517 | |
| | | | 0.008 (high)[6] | | 0.448 |
| | | | **Total** | **2.45** | **2.76** |

# 6 year average ambient air concentrations as measured by the ADEQ monitor in Hayden/Winkelman
## Average concentration of samples collected and analyzed by ADHS from Hayden/Winkelman area

* Suggested default values references:

| | | |
|---|---|---|
| Outdoor Air | 0.1–0.2 µg/$m^3$ | Eldred and Cahill 1994 [7] |
| Indoor Air | 0.1–0.2 µg/$m^3$ | EPA 1986 [8] |
| Food | 5 µg/day | Bolger et al 1991 [6] |
| Water | 4 µg/day | EPA 1991 [9] |
| Dust | 10–70 mg/kg | Shacklette and Boerngen 1972 [10] |

** Slope values references

| | | | |
|---|---|---|---|
| [1,2]Outdoor, Indoor air | 1.32 (low)–2.52 (high) | µg/dL per µg Pb/$m^3$ | Angle et al 1984 [11] |
| [3]Food | 0.24 | µg/dL per µg Pb/day | Ryu et al 1983[12] |
| [4]Water | 0.16 | µg/dL per µg Pb/day | Laxen et al 1977 [13] |
| [5]Soil | 0.00583 (low)–0.008 (high) | µg/dL per µg Pb/kg | Angle et al 1984 [11] |
| [6]Dust | 0.00628 (low)–0.008 (high) | µg/dL per µg Pb/kg | Angle et al 1984 [11] |

This model suggests that childhood blood lead levels will not exceed 10 µg/dL. However, because most houses in the Hayden/Winkelman area were built before 1978, they may contain lead-based paint. If the paint is deteriorating, it would increase the amount of lead-containing dust in the home, and could increase lead exposure, especially in children. See the *Health Outcome Data* section for information on blood lead screening performed in the community.

**Sulfur Dioxide**

Sulfur Dioxide ($SO_2$) is a colorless gas with a strong odor. Ambient $SO_2$ results largely from stationary sources that burn coal and oil, refineries, pulp and paper mills, and from nonferrous metal smelters. In the Hayden/Winkelman area $SO_2$ is present as a result of stack emissions from the smelter. The odor threshold for $SO_2$ is approximately 7,500 µg/$m^3$.

$SO_2$ and other oxides of sulfur combine with oxygen to form sulfates, and with water vapor, form aerosols of sulfurous and sulfuric acid. These acid mists can irritate the respiratory systems of humans and animals and injure plants. Particulate sulfates also reduce visibility.

$SO_2$ acts as a chemical irritant to the respiratory tract. Exposure to 13,000 μg/$m^3$ for durations of 1 to 4 hours do not alter the pulmonary function of healthy individuals [14,15,16,17]. However, controlled clinical studies suggest that asthmatics are more sensitive to exposure to sulfur dioxide than persons without asthma.

The Lowest Observed Adverse Effect Level (LOAEL) for sensitive persons, such as asthmatics, with hypersensitive airways is between 250 to 1,300 μg/$m^3$. Exercising asthmatics are sensitive to the pulmonary effects of sulfur dioxide at concentrations as low as 250 μg/$m^3$. Reactions can include bronchoconstriction, increased airway resistance, decreased expiratory flow rates, and wheezing. The time required for $SO_2$ to elicit bronchoconstriction in exercising asthmatics is short. Measurable changes may occur after only two minutes of exposure to 1,000 to 2,600 μg/$m^3$. Following a single exposure during exercise, airway resistance in asthmatics appears to recover to normal levels within one to two hours [14, 15, 16, 17].

Developing a No Observed Adverse Effect Level (NOAEL) for sulfur dioxide in humans is very difficult because moderate exercise, weather conditions, infectious diseases, and other environmental triggers can also affect airway reactivity.

Monitoring data in Hayden suggest that there are short-term episodes when sulfur dioxide concentrations can affect the airways of asthmatics and other sensitive individuals (Table 10). Three-hour maximum concentrations from 1991 to 2001 exceeded the MRL and the LOAEL at least once per year in Hayden. Maximum 3-hour averages ranged from 372 μg/$m^3$ to 1,137 μg/$m^3$. These data suggest that a potential health hazard periodically exists for asthmatics and other sensitive individuals from exposure to sulfur dioxide. Most persons without sensitive airways are unlikely to be affected by these periodic episodes of increased sulfur dioxide levels because the lowest effect level for healthy non-asthmatic individuals is approximately 2,500 μg/$m^3$.

Annual average sulfur dioxide levels are consistently approximately equal to the MRL of 25 μg/$m^3$, with annual averages ranging from 16 to 30 μg/$m^3$. Annual concentrations are consistently 10 times less than the short-term LOAEL of 250 μg/$m^3$, however this LOAEL has been developed for acute exposures. No LOAEL has been established for long-term exposure to sulfur dioxide. Due to the lack of data regarding the long-term effects of exposure to low levels of sulfur dioxide, it is unknown whether a long-term health hazard exists in the area.

**Table 10. Maximum 3-hour sulfur dioxide averages from ADEQ monitor in Hayden, Arizona, 1990–2001**

| Year | 3 hour maximum µg/m$^3$ | LOAEL µg/m$^3$ | Exceeds LOAEL? |
|---|---|---|---|
| 1990 | 1,137 | 250 | **Yes** |
| 1991 | 511 | 250 | **Yes** |
| 1992 | 815 | 250 | **Yes** |
| 1993 | 372 | 250 | **Yes** |
| 1994 | 464 | 250 | **Yes** |
| 1995 | 435 | 250 | **Yes** |
| 1996 | 527 | 250 | **Yes** |
| 1997 | 697 | 250 | **Yes** |
| 1998 | 595 | 250 | **Yes** |
| 1999 | 475 | 250 | **Yes** |
| 2000 | 322 | 250 | **Yes** |
| 2001 | 785 | 250 | **Yes** |

**Table 11. Average annual sulfur dioxide concentrations in Hayden, Arizona, 1990–1999**

| Year | Average annual $SO_2$ concentration µg/m$^3$ | MRL | Exceeds MRL? |
|---|---|---|---|
| 1990 | 26 | 25 | **Yes** |
| 1991 | 27 | 25 | **Yes** |
| 1992 | 24 | 25 | No |
| 1993 | 16 | 25 | No |
| 1994 | 25 | 25 | **Yes** |
| 1995 | 30 | 25 | **Yes** |
| 1996 | 30 | 25 | **Yes** |
| 1997 | 26 | 25 | **Yes** |
| 1998 | 23 | 25 | No |
| 1999 | 26 | 25 | **Yes** |

## 5.2 HEALTH OUTCOME DATA

### 1999 Blood Lead and Urinary Arsenic Study

A child blood lead and basic population urinary arsenic survey was conducted in Hayden and Winkelman between June 25 and October 17, 1999. This survey was conducted by the University of Arizona Center for Prevention under a contract with ADHS. The specific goals were to establish a baseline for blood lead levels in children less than 3 years of age and urinary arsenic levels for the population as a whole in Hayden and Winkleman. This survey was conducted over a 4-month period by graduate students and faculty of the University of Arizona. [19]

Sampling of residents was conducted, with the emphasis placed on screening children less than 3 years of age for blood lead. Adults and children were screened for urinary arsenic. The urinary arsenic analysis measured both organic and inorganic arsenic compounds. Inorganic arsenic compounds were the focus of this screening because organic arsenic is less toxic than inorganic arsenic.

The University of Arizona developed a reference level for urinary arsenic of 30 µg/L. Residents who tested higher than 30 µg/L were contacted to determine if a source of the arsenic could be found. The reference level was based on the approximate median level found in several clinical studies.

The investigators elected to measure total and inorganic arsenic levels as opposed to arsenic levels controlled for creatinine. Biological monitoring for urinary arsenic levels in a clinical setting are often measured and reported as total arsenic in mg/L of urine, and clinical management and treatment decisions are developed following measurement of urinary arsenic levels without controlling for creatinine levels [20]. This method is acceptable for screening purposes; however, to better measure exposure to inorganic arsenic and determine when follow-up should occur, ATSDR controls for creatinin and uses 20 µg/L as the comparison value.

All children aged 6–36 months in Hayden and Winkelman were eligible for blood lead testing, and all individuals able to collect urine in a cup were eligible for urinary arsenic testing. The study was approved by the Human Subjects Committees at the University of Arizona and ADHS. Participation was voluntary, and written informed consent was obtained from participants or their guardians.

All housing units in Hayden and Winkelman were approached by door-to-door survey, with each unit revisited up to five times before a household was considered unreachable. For study participants, a brief questionnaire was used to collect demographic and potential metal exposure information. Blood for lead analysis was collected from children by finger stick. Urine samples for arsenic were obtained from participating individuals, generally as a first morning void. Between July 11 and October 17, 1999, seven children from 6–36 months of age were tested according to the protocol and study design. At the request of their parents, an additional seven children younger than six months or older than 3 years of age were tested. Blood lead concentrations ranged from below detectable limits to 9 µg/dL, with an average blood lead level of 3.6 µg/dL. Children with blood lead levels less than 10 µg/dL are not considered lead poisoned, based on current CDC guidelines. Although no information was available from children in families choosing not to participate in this voluntary study, no cases of lead poisoning in children from Hayden or Winkelman were found. Limitations of the investigation include the fact that blood lead testing only capture exposures that occurred recently. The results do not indicate what past exposure might have been or predict what future exposure may be.

Between June 25 and October 17, 1999, 224 people in Hayden and Winkelman were tested for urinary arsenic concentrations. Participation rates in eligible households were 52% in Hayden and 46% in Winkelman. For all urine samples, the average total arsenic concentration was 13.7 µg/L, ranging from below detectable limits to 114 µg/L. For the 18 samples with total arsenic concentrations exceeding 30 µg/L, speciated analysis was used to measure inorganic arsenic. Five samples from three households were found to contain more than 30 µg/L of inorganic arsenic, with concentrations ranging from 30 to 47 µg/L. No further follow-up was performed to resample those people and control for creatinine or to determine what exposure sources might be, such as seafood consumption. Investigators did learn that some home renovations, including painting, had occurred recently in all three households. Some paints contain arsenic or mercury as mildew retardants.

The average urinary total arsenic concentration in Hayden and Winkelman was 13.7 µg/L, which is substantially less than the study reference level of 30 µg/L. Five (2%) of 224 individuals tested in Hayden and Winkelman had inorganic urinary arsenic concentrations exceeding 30 µg/L. The maximum concentration measured was 47 µg/L.

Test results from the blood lead screening and the urinary arsenic screening were provided to participants. Participants were encouraged to share their results with their health care providers if they wanted medical advice.

## 5.3 COMMUNITY HEALTH CONCERNS EVALUATION

ADHS continues to answer questions regarding the health of residents in the area, although specific, personal health conditions are usually not discussed during these conversations. ADHS has attended several open house events in Hayden and Winkelman to answer questions from the public. ADHS has also issued advertisements in the local paper that detailed findings from the University of Arizona (UA) survey. In two meetings on March 15, 2000, the first was held after lunch and attended by senior citizens from the area, while no one from the community attended the later afternoon meeting to discuss the survey results. Numerous “quality of life” issues, such as inability to spend evenings outdoors because of unpleasant odors, were raised during the survey. ADHS did not receive any telephone calls from area residents regarding the survey results.

## 5.4 ATSDR’S CHILD HEALTH INITIATIVE

ADHS has included the following information in accordance with ATSDR’s Child Health Initiative.

ATSDR recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination of their water, soil, air, or food. Children are at greater risk than adults from certain kinds of exposures to hazardous substances emitted from waste sites and emergency events. They are more likely to be exposed because they play outdoors and they often bring food into contaminated areas. They are shorter than adults, which means they breathe dust, soil, and heavy vapors close to the ground. Children are also smaller, resulting in higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care.

For this PHA, specific dose calculations for arsenic and lead were used to estimate doses children would receive. Data obtained from the various monitors in the Hayden and Winkelman area were used to determine if the doses would exceed the MRLs or other guidelines. These guidelines were used to determine if adverse health effects could be present in the children of the area.

The MRLs and LOAELs used to evaluate the potential health effects from sulfur dioxide reflect conditions that might affect sensitive asthmatic children and adolescents. The conclusion that sulfur dioxide may periodically pose a health risk to sensitive individuals is specifically focused on children and adolescents with asthma.

## 6.0 CONCLUSIONS

- Outdoor air in the Hayden and Winkelman area meets all federal and state air quality standards for criteria air pollutants including sulfur dioxide. Brief episodes of elevated sulfur dioxide in air may cause short-term respiratory symptoms for sensitive asthmatics a few times per month. Levels of sulfur dioxide in air are unlikely to cause respiratory symptoms in persons without pre-existing respiratory conditions.

- Exposures to water and soil pose no apparent public health hazard.

### Data Gaps

Because of the lack of data regarding the long-term effects of exposure to low levels of sulfur dioxide, it is unknown whether a long-term health hazard exists in the area.

Although environmental or dietary factors that resulted in urinary arsenic levels in excess of the 30 µg/L action level for 5 of the 224 individuals tested for urinary arsenic were reflected in the survey, follow-up interviews with the residents suggested that home renovations may have contributed to the elevated arsenic levels. However, no follow-up sampling was conducted to better define the nature of the exposure, nor was paint testing conducted to confirm the theory that paint was contributing to the exposure.

Note: Further environmental investigation is currently under way. Results of the new data will be evaluated for public health implications. Conclusions drawn for this public health assessment were based on data available at the time the document was released. Conclusions could change if data indicate that exposure has increased or decreased.

## 7.0 RECOMMENDATIONS

- Explore the development of a system that would provide access to current air quality data by asthmatics and other persons with sensitive airways in the Hayden and Winkelman area.

- Distribute health education material to the local population regarding the health effects from exposure to sulfur dioxide and effective methods of preventing health effects, including limiting outdoor exercise when levels are elevated.

## 8.0 PUBLIC HEALTH ACTION PLAN

The Public Health Action Plan (PHAP) for the ASARCO Hayden Smelter site contains a description of actions taken, to be taken, or under consideration by the Agency for Toxic Substances and Disease Registry (ATSDR) and the Arizona Department of Health Services (ADHS) at or near the site. The purpose of the PHAP is to ensure that this public health assessment not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. ADHS and ATSDR will follow-up on this plan to ensure that actions are carried out.

***Actions Completed***

1. On January 7, 1999, ADHS obtained environmental samples within Hayden and Winkelman to determine both background levels of metals and area levels of these metals.

2. On April 5, 1999, ADHS met with community leaders to learn how the community wanted to provide and receive information.

3. On April 19, 1999, ADHS presented the proposed study to the Hayden Town Council.

4. On May 10, 1999, ADHS presented the proposed study to the Winkelman Town Council.

5. On May 17, 1999, ADHS met with the Hayden Town Council and answered questions at the meeting.

6. From June to October 1999, the University of Arizona conducted public health surveys of the residents of Hayden and Winkelman. Blood lead levels were evaluated for children 6 to 36 months and for some children up to 72 months of age and urinary arsenic levels were checked in adults and children. All test results were presented to the participants along with recommendations to seek follow-up care if levels were elevated above the standards used for this study.

7. On March 8, 2000, a public notice was posted in the *Copper Basin News* to advise the public of the results of the health survey. Notification of public meetings on March 16, 2000 are also given.

8. On March 16, 2000, findings of the heath survey were presented during two meetings in Hayden and Winkelman with local residents.

9. On May 20, 2002, ADHS presented the Public Health Assessment–Draft for Public Comment to the Hayden Town Council.

10. On June 10, 2002, ADHS presented the Public Health Assessment–Draft for Public Comment to the Winkelman Town Council.

11. On June 18, 2002, ADHS presented the Public Health Assessment–Draft for Public Comment during a public meeting at the Senior Center in Hayden.

***Actions proposed***

1. ADHS plans to meet with residents to discuss the findings of the ASARCO Hayden Smelter Site Public Health Assessment. The goals of the meeting are to provide information about sulfur dioxide and to explain ways to minimize exposure.

2. ADHS will continue to address community concerns as residents request assistance.

3. ADHS will collaborate with ASARCO and community leaders to evaluate the possibility of implementing a sulfur dioxide notification program.

## Preparers of Report

**Arizona Department of Health Services, Office of Environmental Health**
Brian W. Hasty, M.T.
Will Humble, M.P.H., Chief, Office of Environmental Health, Principal Investigator

**ATSDR Technical Project Officer**
Gail Godfrey
Environmental Health Scientist
Division of Health Assessment and Consultation
Superfund Site Assessment Branch
State Program Section

**ATSDR Regional Representative**
William Nelson
Regional Services, Region IX
Office of the Assistant Administrator

## REFERENCES


1. Marsh GM, Stone RA, Esmen NA, Gula MJ, Gause CK, Rodney S, Prybylski D. 1995. A Population-Based case-control study of lung cancer mortality in Gila Basin smelter towns.

2. USDHHS 1995. U.S. Public Health Service, Agency for Toxic Substances and Disease Registry. A Population-Based case-control study of lung cancer mortality in four Arizona smelter towns.

3. USDHHS 1998. U.S. Public Health Service, Agency for Toxic Substances and Disease Registry. Draft Toxicological Profile for Arsenic.

4. Registry of Toxic Effects of Chemical Substances [database online]. Denver, CO: Micromedex, Inc.; 1998.

5. USDHHS 1997. U.S. Public Health Service, Agency for Toxic Substances and Disease Registry. Draft Toxicological Profile for Lead.

6. Bolger PM, Carrington CD, Caper SG et al. 1991. Reductions in dietary lead exposure in the Untied States. Chemical Speciation and Bioavailability 3(314):31-36

7. Eldred RA, Cahill TA, 1994. Trends in elemental concentrations of fine particles at remote sites in the United States of America. *Atmospheric Environ 28:1009-1019*

*8.* EPA 1986. Air Quality criteria for lead. Research Triangle Park, NC: US Environmental Protection Agency, Office of Research and Development, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office. EPA 600/8-83-028F.

9. EPA 1991d. Maximum contaminant level goals and national primary drinking water regulations for lead and copper. *Federal Register 56: 26461-26564*

10. Angle CR, Marcus A, Cheng I-H, et al. 1984. Omaha childhood blood lead and environmental lead: A linear total exposure model. *Environmental Res 35: 160-170.*

11. Laxen DP, Raab GM, Fulton M 1987. Children's blood lead and exposure to lead in household dust and water–a basis for an environmental standard lead in dust. *Sc. Total Environ 66: 235-244*

12. Ryu JE, Ziegler EE, Nelson SE, et al. 1983. Dietary intake of lead and blood lead concentrations in early infancy. *Am J Dis Child 137: 986-991.*

13. Shacklette HT, Boerngen JG. 1972. Elemental composition of surficial materials in the conterminous United States. Washington D.C.: US Department of the Interior, Geological Survey; Geological Survey Professional Paper no. 1270.

14.. Balmes JR, Fine JM, Sheppard D. 1987. Symptomatic bronchoconstriction after short-term inhalation of sulfur dioxide. *American Review of Respiratory Diseases*. 136:1117.

15. Gong, Jr., Lachenbruch PA, Harber P., Linn WS. 1995. Comparative short-term health responses to sulfur dioxide exposure and other common stressors in a panel of asthmatics. *Toxicology and Industrial Health*. 11:467-487.

16. Horstmann DH, Seal E, Folinsbee LJ, *et al.* 1988. The relationship between exposure duration and sulfur dioxide- induced bronchoconstriction in asthmatic subjects. *American Industrial Hygiene Association.* 49: 38.

17 Sheppard D. 1988. Sulfur dioxide and asthma - a double edged sword? *Journal of Allergy and Clinical Medicine.* 82:961.

18. USDHHS. 1998. Toxicological Profile for Sulfur Trioxide and Sulfuric Acid. Agency for Toxic Substances and Disease Registry. December 1998.

19. Burgess J., Carter D., O'Rourke M. 1999. Hayden/Winkelman Arsenic and Lead Survey. Occupational and Environmental Health Unit, University of Arizona Prevention Center. March 2000.

20. Sullivan J., Krieger G. eds. *Hazardous Materials Toxicology- Clinical Principles of Environmental Health.* Williams & Wilkins Press. Baltimore, MD. p. 818-823.

# APPENDIX

## ATSDR LEAD MODEL

Numerous longitudinal and cross-sectional studies have attempted to correlate environmental lead levels with blood lead levels. The studies have provided a number of regression analyses and corresponding slope factors for various media including air, soil, dust, water, and food. In an attempt to use this valuable body of data, ATSDR has developed an integrated exposure regression analysis. This approach utilizes slope values from selected studies to integrate all exposures from various pathways, thus providing a cumulative exposure estimate expressed as total blood lead. The worktable in the text can be used to calculate a cumulative exposure estimate on a site-specific basis. To use the table, environmental levels for outdoor air, indoor air, food, water, soil, and dust are needed. In the absence of such data, default values can be used. In most situations, default values will be background levels unless data are available to indicate otherwise. Based on the US Food and Drug Administration's Total Diet Study data, lead intake from food for infants and toddlers is about 5 micrograms per day. In some cases, a missing value can be estimated from a known value**.** For example, EPA has suggested that indoor air can be considered 0.03 times the level of outdoor air.

Empirically determined or default environmental levels are multiplied by the percentage of time one is exposed to a particular source and then multiplied by an appropriate regression slope factor. Slope factor studies were based upon an assumption that exposure is continuous. The slope factors can be derived from regression analysis studies that determine blood lead levels for a similar route of exposure. Typically, these studies identify standard errors describing the regression line of a particular source of lead exposure. These standard errors can be used to provide an upper and lower confidence limit contribution of each estimate of blood lead. The individual source contributions can then be summed to provide an overall range estimate of blood lead. While it is known that such summing of standard errors can lead to errors of population dynamics, detailed demographic analysis (e.g., Monte Carlo simulations) would likely lead to a model without much utility. As a screening tool, estimates provided by the table have a much greater utility than single value central tendency estimates, yet still provide a simple-to-use model that allows the health assessor an easy means to estimate source contributions to blood lead [5].

## EXPOSURE DOSE EQUATIONS

ADHS used the ATSDR exposure assessment documents to quantify exposure doses for persons living in the Hayden and Winkelman area. The doses were calculated using the following equations:

***Inhalation of emissions*:**

$$CDI = \frac{CA \times IR \times EF \times ED}{BW \times AT}$$

CDI: chronic daily intake (mg/kg/day)
CA: concentrations in air (mg/m$^3$)
IR: intake rate (m$^3$/day)
EF: exposure frequency (days/yr)
ED: exposure duration (yrs)
BW: body weight (kg)
AT : Averaging time (days)

***Ingestion of chemicals in soil:***

$$CDI = \frac{CS \times CF \times IR \times EF \times ED}{BW \times AT}$$

CDI: chronic daily intake (mg/kg/day)
CS: concentrations in soil(mg/kg)
CF: conversion factor ($10^{-6}$ kg/mg)
IR: intake rate (mg/day)
EF: exposure frequency (days/yr)
ED: exposure duration (yrs)
BW: body weight (kg)
AT : Averaging time (days)

***Ingestion of chemicals in water:***

$$CDI = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

CDI: chronic daily intake (ug/l/day)
CW: concentration in water (ug/L)
IR: intake rate (l/day)
EF: exposure frequency (days/yr)
ED: exposure duration (yrs)
BW: body weight (kg)
AT : Averaging time (days)

---

| Variable Assumptions | Adults | Children |
|---|---|---|
| IR(inhalation): | 20 | 10 |
| IR(ingestion, soil): | 100 | 200 |
| IR(ingestion, water): | 2 | 1 |
| EF: | 350 | 350 |
| ED: | 30 | 6 |
| BW: | 70 | 15 |
| AT: | 10950 | 2190 |

***Dermal contact with chemicals in soil*:**

$$\textbf{Absorbed dose} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Absorbed Dose: daily intake (mg/kg/day)
CS: Chemical concentration in soil (mg/kg)
CF: Conversion factor (10E-6 kg/mg)
SA: Skin surface area available for contact ($cm^2$/event)
AF: Soil to skin adherence factor ($mg/cm^2$)
ABS: Absorption factor (unitless)
EF: Exposure frequency (events/year)
ED: Exposure duration (years)
BW: Body weight (kg)
AT: Averaging time (period over which exposure is averaged in days)

## Appendix–Public Comments and Responses

ADHS and ATSDR provided an opportunity for the public to comment on this document. No public comments were received before the end of the comment period on July 5, 2001. ADHS and ATSDR did receive comments from EPA, ADEQ, and ASARCO.

**EPA Comments:**

*Comment*
EPA wrote that the MRL for arsenic of 0.0003 mg/kg-day was exceeded for childhood exposure. The commenter recommended discussing the comparison of estimated exposure doses to the NOAEL in more detail.

*Response*
ADHS agreed with the comment and re-formatted Section 5.1. Additional discussion about the full range of NOAEL values was also included. Additional language was added that compares estimated exposure doses to the LOAEL range.

*Comment*
EPA wrote that is it unclear in the text how childhood exposures are examined as it relates to the Child Health Initiative.

*Response*
The exposure dose calculations for children were clarified in Section 5.1. Text was added to the *Child Health Initiative* section to tie the concepts together.

*Comment*
EPA expressed concern that cancer risks from arsenic are not identified.

*Response*
A discussion of cancer risks was included for arsenic exposure.

*Comment*
EPA wrote that oral MRLs were used to evaluate arsenic inhalation exposure. The commenter suggested using an alternative approach to evaluate inhalation exposure.

*Response*
The analysis and text were changed so that inhalation exposure is evaluated by comparing estimated doses to inhalation-specific toxicity values.

*Comment*
EPA wrote that the discussion of arsenic in air is unclear. Concerns were expressed that levels exceed Arizona guidelines for air quality.

*Response*
The discussion of health risks was changed. Environmental levels are compared with ATSDR CVs, and estimated doses are compared with NOAELs and LOAELs from toxicological studies.

*Comment*
EPA expressed concern about the reference value used by the University of Arizona in their 1999 study of urinary arsenic levels in residents of Hayden and Winkelman.

*Response*
Language has been added that discusses the limitations of the study. The study, as conducted, was acceptable as a screening tool to see if arsenic urine levels were considered higher than a reference value selected from studies. Other methods might have been more appropriate if the purpose of the study had been to determine what the sources of exposure might be and whether the arsenic found was inorganic in form.

*Comment*
EPA commented that three of the residents that had recently renovated their homes in the 1999 University of Arizona study had urinary arsenic levels higher than the study reference value. The commenter suggests that this may indicate that there is excessive airborne arsenic levels in the area.

*Response*
The text has been modified to indicate that no specific source for the exposure was identified. The possibility of paint contributing to exposure is acknowledged, but no follow-up paint testing has occurred to support the theory.

*Comment*
EPA asked whether the 1995 study of lung cancer mortality found an association between lung cancer and occupational exposures in residents of Hayden and Winkelman.

*Response*
The study found no association between occupational exposure and lung cancer in Hayden and Winkelman. Positive associations were found in Superior and Miami, Arizona.

*Comment*
EPA commented that the sample size for the childhood blood testing was small.

*Response*
While the sample size is small, the participation rate was high. The small sample size reflects a low population of toddlers in the area.

*Comment*
EPA suggested that the detection of mercury that exceeded the MCL in water be specifically discussed and well owners notified of the testing result.

*Response*
The average mercury concentration for the public water systems is 1.2 micrograms per liter, which is less than the MCL of 2 micrograms per liter. The data are from water systems regulated by the federal Safe Drinking Water Act. The water company is required by law to notify the public if concentrations exceed the MCL. Although a discussion of the mercury does not appear in this document because levels were below the MCL, ADHS will review

groundwater monitoring data EPA and ASARCO might provide to determine if levels of mercury in the drinking water supply could increase over time.

*Comment*
EPA questioned whether the fact that urinary arsenic levels were not adjusted for creatinine would influence the accuracy of the study.

*Response*
For screening purposes, the method used was acceptable. For a better indication of arsenic form and actual exposure information, ATSDR, when conducting exposure investigations, does control for creatinine and uses a lower reference value for comparison.

*Comment*
EPA commented that community concerns that behavioral changes reported by residents suggests that there may be a public health hazard.

*Response*
At this point in investigations, ADHS did not find completed exposure pathways that might account for behavioral changes. ADHS will continue to evaluate new data, especially data regarding lead and other heavy metal exposure, for possible exposures that might explain behavioral changes.

*Comment*
EPA suggested that a map be included in the report.

*Response*
A map has been included in the report.

*Comment*
EPA noted that an Expanded Site Investigation (ESI) is currently in progress in the area. The commenter suggested that the final report be withheld until after completion of the ESI.

*Response*
This report includes public health information regarding the Hayden and Winkelman area that will be useful to people with compromised respiratory systems. For that reason, we believe that releasing the report at this time is in the best interest of the community.

We also recognize the importance of evaluating all new data to be able to provide a more comprehensive public health evaluation of site conditions. For that reason, we will provide a health consultation on the new data as soon as possible.

**ADEQ Comments**

*Comment*
ADEQ commenter expressed concern about the reference value used by the University of Arizona in their 1999 study of urinary arsenic levels in residents of Hayden and Winkelman.

*Response*
The selection of the reference value was based on studies that the investigators reviewed when developing protocols for the screening. Had the protocol been more of an exposure investigation rather than a screening, other methods and a lower reference value might have been appropriate.

*Comment*
The commenter asked why the range of detections are not included in Table 1.

*Response*
For this public health assessment, mean concentrations of environmental levels were used to select contaminants of concern because mean levels were considered prudent values to use when evaluating exposures.

*Comment*
The commenter asked whether there are data to support the statement that arsenic in drinking water is naturally occurring.

*Response*
The source of arsenic might be the result of ASARCO activities or from natural sources. The table has been changed to reflect that information.

*Comment*
The commenter expressed concern that acute exposures are not evaluated in the report.

*Response*
The report addresses acute exposures where appropriate. For example, acute exposure to sulfur dioxide for those with compromised respiratory systems poses a public health hazard. That information has been clarified.

*Comment*
The commenter asked why dermal exposure is not evaluated in the report.

*Response*
Dermal exposures from contact with soil and water are included in the quantitative dose calculations. The magnitude of exposure to inorganic compounds from contact with soil and water are negligible compared to ingestion and inhalation exposure.

*Comment*
The commenter asked why the report does not apply acute MRLs rather than chronic MRLs to select chemicals of concern.

*Response*
The chronic MRL is a more conservative and appropriate reference value to use when evaluating on-going exposures. In the case of sulfur dioxide, acute exposure is more critical to those people with compromised respiratory systems, and the document text has been changed to reflect that issue.

*Comment*
The commenter noted there is an inconsistency in the levels reported in water in a table and in the text.

*Response*
The inconsistency has been corrected.

*Comment*
The commenter noted there is an inconsistency in the levels reported for arsenic in Table 2 for soil and the text.

*Response*
The inconsistency has been corrected. The average soil concentration for arsenic is 5 mg/kg.

*Comment*
The commenter noted that the average annual concentrations for arsenic differ from the discussion in the text.

*Response*
The inconsistency has been corrected, and the text modified to clarify the means by which comparison values are used.

*Comment*
The commenter noted that recreational exposure to surface water in the Gila River is not evaluated in the report.

*Response*
The report does not address recreational exposures to contaminants present in the Gila River. A follow-up health consultation for this potential exposure pathway will be considered when the new data are available.

**ASARCO Comments**

*Comment*
The commenter corrected the discussion section as it relates to control devices applied at the smelter.

*Response*
The changes were incorporated into the final report.

## Certification

This ASARCO Hayden Smelter Site Public Health Assessment was prepared by the Arizona Department of Health Services under cooperative agreement with the Agency for Toxic Substances and Disease Registry. It is in accordance with approved methodology and procedures existing at the time the public health assessment was begun.

________________________________________

Technical Project Officer
SPS, SSAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health assessment and concurs with the findings.

______________________________

Chief
SPS, SSAB, DHAC, ATSDR