Health Consultation

Evaluation of Ambient Air Sampling Results

IRON KING MINE & HUMBOLDT SMELTER

DEWEY-HUMBOLDT, YAVAPAI COUNTY, ARIZONA

EPA FACILITY ID: AZ0000309013

Prepared by
Arizona Department of Health Services

FEBRUARY 7, 2013

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Summary

INTRODUCTION

In the *Iron King Mine and Humboldt Smelter: Evaluation of Ambient Air Sampling Results*, the Arizona Department of Health Services' (ADHS') top priority is to ensure that the community and residents have the best information possible to safeguard their health.

This report was written in response to a request from the U.S. Environmental Protection Agency (EPA). In September 2008, the Iron King Mine-Humboldt Smelter was added to the National Priority List (NPL) due to elevated levels of arsenic and lead in the area. Local residents have voiced concern about levels of heavy metals in ambient air during high wind events. Thus, the EPA conducted an ambient air sampling program to evaluate the potential migration of airborne contaminants from the site. The Arizona Department of Health Services (ADHS) and the Agency for Toxic Substances and Disease Registry (ATSDR) was requested to evaluate the air sampling results to see if the airborne contaminants are at levels harmful to people's health, specifically the local residents and transients.

CONCLUSIONS

PM_{10} (Particulate Matter less than 10 microns in width): *Short-Term Exposure* (usually over a 24-hour period, but possibly as short as one hour): PM_{10} is not expected to harm human health at the Iron King Mine and Humboldt-In-Town areas, but the PM_{10} levels present a Public Health Hazard at the Humboldt Smelter area during high wind events. *Long-Term Exposure*: PM_{10} was used to estimate the concentration of $PM_{2.5}$ (Particulate Matter less than 2.5 microns in width). The predicted concentration of $PM_{2.5}$ is not expected to harm human health at the study areas (i.e. Iron King Mine, Humboldt Smelter and Humboldt-In-Town).

Metals: Regardless of wind condition, the metal concentrations detected in the ambient air alone are not likely to be harmful to the public.

BASIS FOR DECISION

PM_{10}: *Short-Term Exposure*: The 24-hour average PM_{10} concentrations at Iron King Mine and Elementary School stations were below the National Ambient Air Quality Standard (NAAQS). However, during the sampling period, the 24-hour average of continuously monitored PM_{10} concentrations at Humboldt Smelter station exceeded the NAAQS three times, and it has the potential to do so in the future. High levels of PM_{10} could harm human health, especially certain sensitive populations (i.e. people with respiratory diseases, reduced lung function, or cardiovascular diseases, the elderly and children). During high PM_{10} events, sensitive populations are susceptible to more serious symptoms, including cough, wheezing, shortness of breath, bronchitis, increased asthma attacks, and aggravation of lung or heart disease. *Long-Term Exposure*: PM_{10} was used to estimate the concentration of $PM_{2.5}$. All the predicted $PM_{2.5}$ levels were below the NAAQS annual $PM_{2.5}$ standard, thus residents or transients are not likely to develop chronic respiratory symptoms as a result from exposure to PM at the measured levels.

Metals: The majority of the risks associated with exposure to the metals analyzed in this health consultation were low. Long-term aggregate exposure to air contaminants alone is not likely to result in non-carcinogenic adverse health effects since no significant additive or interactive effects are expected (ATSDR 2004). The estimated cumulative cancer risks ranged from 9.8×10^{-6} to 3.1×10^{-5} which are within the range of the public health guideline ($10^{-6} \sim 10^{-4}$) for protection of human health as suggested by the EPA. The cancer risks due to exposure to multiple chemicals from the ambient air are considered to be low to moderate based on the qualitative ranking of cancer risk estimates.

NEXT STEPS

ADHS recommends EPA and Arizona Department of Environmental Quality (ADEQ) work together to conduct/supervise the following actions to ensure that residents of Dewey-Humboldt are not exposed to unhealthy levels of air pollution that may originate from mining operation or other emission sources in the area:

- Include $PM_{2.5}$ samples in the future air sampling events to provide better estimation for long term health effects associated with PM exposure.

- ADEQ should issue warnings on days when levels of air pollution are expected to reach potentially unhealthy levels, and to communicate these warnings to the local media. Residents are encouraged to heed these warnings, which generally recommend residents, especially persons with respiratory conditions, to remain indoors and to avoid moderate levels of exercise as much as possible. By following these precautions, residents can protect themselves from air pollution in the area as it occasionally reaches potentially unsafe levels.
- To minimize the amount of particulate matter released to the air, effective air pollution/dust control measures should be developed/initiated/enforced.
- To minimize the amount of exposure, set up effective fences in the mine or smelter areas to restrict public access, maintain signs posted warning of potential health dangers, and provide public health education to warn residents of the potential adverse health effects.

FOR MORE INFORMATION

If you have concerns about your health, you should contact your health care provider. Please call ADHS at 602-364-3128 and ask for more information on the Iron King Mine Humboldt Smelter Site.

Purpose

In September 2008, the Iron King Mine-Humboldt Smelter was added to the National Priority List (NPL) due to elevated levels of arsenic and lead in the area. Local residents have concerns about levels of heavy metals in ambient air during high wind events. Thus, the Environmental Protection Agency (EPA) conducted an ambient air sampling program to evaluate the potential migration of airborne contaminants from the site. The Arizona Department of Health Services (ADHS) and the Agency for Toxic Substances and Disease Registry (ATSDR) was requested to evaluate the air sampling results to see if the airborne contaminants are at levels harmful to human health.

Background

Site Location: The Iron King Mine and the Humboldt Smelter facilities have contaminated ground water and soil attributable to the mine and smelter sources. Both the mine and smelter are located in industrial, commercial, and/or residential areas of Dewey-Humboldt, Arizona. The Iron King Mine, located just west of the town of Humboldt, Arizona, is approximately 90 miles northwest of Phoenix and 20 miles southeast of Prescott. The mine is situated in the Agua Fria River basin. The Humboldt Smelter is located near the intersection of 3rd street and Main Street (Figure 1).

Operation History: The Iron King Mine covers approximately 153 acres. It was an active mine from 1904 until 1969, though, some of the residents who have lived in the vicinity of Prescott the longest say that the Iron King mine was originally built in 1880. It produced fluxing ore for the copper smelter located in Humboldt during the years of 1915 to 1918. Sometime after the end of World War I, the mine was closed. The Iron King Mine was expanded beginning in 1936 to remove ore containing lead, gold, silver, zinc, and copper from the underlying Pre-Cambrian schist. Since this is an underground mine, with drifts and tunnels, ore was removed by an elevator. A 140-ton mill was erected on the site to crush the ore and was expanded to 225-ton capacity in 1938. A cyanide processing plant was added to the site in 1940 to treat the mill tailings to enhance metal recovery. Waste rock and tailings were deposited in large piles adjacent to actual mine property boundaries. The mine has been inactive since 1969. Some secondary uses were occurring up until about a year ago, such as recovery of minerals from the mine tailings for use in making fertilizer. The fertilizer was bagged under the Ironite trade name. The site is mainly covered by tailings and waste rock piles. It consists of three properties: the mine property, the tailings pile, and the former fertilizer plant (Nolan property).

The Humboldt Smelter occupies approximately 182 acres. This area is covered in approximately 763,800 square feet of yellow-orange tailings, over 1 million square feet of grey smelter ash, and 456,000 square feet of slag. The Humboldt Smelter operated from the late 1800s until the early 1960s. The original smelter was burned down in 1904. A smelter was rebuilt in 1906 that processed 1,000 tons of ore per day. This smelter operated full tilt until 1918 and then intermittently between 1922 and 1927. The smelter reopened in 1930.

Site Activity: Arsenic and lead have been detected at levels above health based standards in soil of several residential yards. As a result, a removal action was initialed in 2006 to remove contaminated soil from four off-site residential properties. The removal of the contaminants was conducted by a contractor on behalf of the Ironite Products Company under EPA oversight.

Portions of this site were regulated under the ADEQ Voluntary Remediation Program. In September 2007, EPA received a response from Arizona Governor Napolitano consenting to the placement of the Site on the National Priority List (NPL), commonly called the Superfund List. On March 19 2008, EPA proposed listing the Iron King Mine-Humboldt Smelter Site to the NPL. In September 2008, EPA formally added the site to the NPL. ADHS conducted a health consultation to evaluate the health risks associated with exposure to contaminated soil and water based on samples collected from 2002 to 2006 (ADHS 2009).

In October 2008, EPA started the Remedial Investigation/Feasibility Study (RI/FS) to further assess the nature and extent of the contaminants. This investigation will help EPA determine possible cleanup actions for the site. As part of the RI/FS, EPA collected additional soil, water and air samples. This health consultation will focus only on the air sampling results to provide health risk estimation associated with exposure via inhalation ADHS is working on another health consultation to provide an update on the health risks associated with exposure to contaminated soil and water as well as the cumulative health risks from all exposure routes (i.e. inhalation, ingestion and skin contact) because new soil and water data are available.
In 2011, EPA completed an interim removal action that addressed 12 residential properties located in the vicinity of the Humboldt Smelter. EPA removed soils with elevated levels of arsenic and lead from these properties and replaced it with clean fill. The removed soils were placed in a location on top of the Iron King Mine Main Tailings Pile to address fugitive dust emissions from the top of the Iron King Mine. Hydroseed was also applied on top of the soils to promote vegetation growth. EPA also removed the Small Tailings Pile, located adjacent to the Chaparral Gulch. Additionally, EPA applied a temporary fixative agent to address fugitive dust emissions from the Humboldt Smelter Ash Piles.

Statement of Issues

Local residents have concerns about levels of heavy metals in ambient air during wind events that occur throughout the year. A local resident took some photos showing a residential area that becomes covered by dust when the wind is blowing (Figure 2). During moderate to high wind events fine-grained materials and particles are carried from the mine area to a nearby residential area. The local residents want to know how this could affect the health of the community members, especially the children's health. This health consultation will focus only on the evaluation of the air sampling results to see if the airborne contaminants are at levels harmful to people's health, specifically the local residents and visitors. ADHS is working on another health consultation to provide an update on the health risks associated with exposure to contaminated soil and water as well as cumulative health risks from all exposure routes.

Discussion

General Assessment Methodology

ADHS generally follows a three-step methodology to assess public health issues related to environmental exposures. First, ADHS obtains representative environmental data for the site of concern and compiles a comprehensive list of site-related contaminants. Second, ADHS identifies exposure pathways, and then uses health-based comparison values to find those contaminants that do not have a realistic possibility of causing adverse health effects. For the remaining contaminants, ADHS reviews recent scientific studies to determine if exposures are sufficient to impact public health.

Available Environmental Data

ADHS evaluated inhalation health risk based on the Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation (RI) Report (EA Engineering, Science, and Technology, Inc 2010) provided by EPA. In this report, it indicated that: From December 2008 to September 2009, EPA collected air data to evaluate the nature, extent, and migration of particulates from the mine areas. Ten sampling stations were set up at four areas (Iron King Mine, Humboldt Smelter, Town of Dewey-Humboldt and selected background locations) (Fig 3). BGI-PQ_{10}0 samplers were used to collect 24-hour ambient air samples on a six-day rotating basis. These samples were analyzed for the total suspended particulates (i.e. total amount of dust), particulate matter 10 micrometers or less in diameter (i.e. small particles that can enter the lungs), and the metals in dust.

Three continuous particulate monitors (Thermo Electron TEOM Series 1400a) were used to characterize particulate migration during high-wind events. This type of sampler has two channels: the first channel was triggered to collect samples when the ambient air particulate concentration is between 25 to 150 micrograms per cubic meter ($\mu g/m^3$), and the second channel was triggered to collect samples when the PM_{10} (particulate matter less than 10 microns) exceed 150 $\mu g/m^3$. The results show that samples from the first channel were collected about once a week when the PQ100 samplers were serviced, and only one sample was collected from the second channel because PM_{10} rarely exceeded for more than a few minutes at a time.

No $PM_{2.5}$ (particulates 2.5 micrometers or less in diameter) samples were collected in the study area. The available evidence is considered insufficient to link health problems to long-term exposure to coarse particles (PM_{10}). Yet, a number of epidemiologic studies have continued to report associations between long-term exposure (on the order of months to years) to fine particles ($PM_{2.5}$: and mortality (Dockery et al. 1993; Pope et al. 1995; Krewski et al. 2000; Pope et al. 2002; Laden et al. 2006) as well as morbidity health endpoints: development of chronic respiratory illness or symptoms (Dockery et al. 1996; Raizenne et al. 1996; McConnell et al. 2003), changes in lung function (Gauderman et al. 2000, 2002, 2004; Goss et al. 2004), and the development of cardiovascular disease (Kunzli et al. 2005). PM_{10} was used to estimate the concentration of $PM_{2.5}$ to assess the long-term health effects due to exposure to fine particles. However, the proportion of fine ($PM_{2.5}$) and coarse particles (PM_{10}) likely varies substantially between places, depending on local geography, meteorology and specific PM sources. Therefore, ADHS recommend including $PM_{2.5}$ samples in the future air sampling events to provide better estimation for long term health effects associated with PM exposure.

Particulate matter is used to describe a mixture of solid particles and liquid drops found in the air. Total suspended particulates (TSP) refer to particles of all sizes. PM_{10} refers to particulates 10 micrometers or less in diameter. Particulates greater than 10 micrometers in diameter are generally not inhaled in the lungs and therefore do not present a threat to public health from the air pathway. Some proportion of TSP consists of particles too large to enter the human respiratory tract; therefore, TSP is not a good indicator of health-related exposure, and was not used for health effect evaluation in this report (Cheremisinoff 2003).

Exposure Pathway Analysis

Identifying exposure pathways is important in a health consultation because adverse health impacts can only happen if people are exposed to contaminants. The presence of a contaminant in the environment does not necessarily mean that people are actually coming into contact with that contaminant. Exposure pathways have been divided into three categories: completed, potential, and eliminated.

There are five elements considered in the evaluation of exposure pathways:

1) a source of contamination
2) a media such as soil or ground water through which the contaminant is transported
3) a point of exposure where people can contact the contaminant
4) a route of exposure by which the contaminant enters or contacts the body
5) a receptor population

Completed pathways exist when all five elements are present and indicate that exposure to a contaminant has occurred in the past and/or is occurring presently. In a potential exposure pathway, one or more elements of the pathway cannot be identified, but it is possible that the element might be present or might have been present. In eliminated pathways, at least one of the five elements is or was missing, and will never be present. Completed and potential pathways, however, may be eliminated when they are unlikely to be significant.

The meteorological data shows that the prevailing winds directions, in general, are from the northwest during November and January, and from the southeast for the rest of the year (Figure 4). Surface soil and mine tailings from the Iron King Mine and Humboldt Smelter are not covered; therefore, the dust particles can be blown to nearby residents during moderate to high wind events throughout the year. High wind events usually occur from March to May, and also from July to August. Nearby residents or transients can breathe in contaminated dust during moderate to high wind events. Therefore air inhalation is a completed exposure pathway at this site. ADHS further evaluated the completed and potential exposure pathways to determine whether realistic exposures are sufficient in magnitude, duration or frequency to result in adverse health effects (Table 1).

Comparison to Health-based Comparison Values for Air Samples

The health-based comparison values (CVs) are screening tools used with environmental data relevant to the exposure pathways. The health-based CVs are concentrations of contaminants that the current public health literature suggests are "harmless." These comparison values are quite conservative, because they include ample safety factors that account for the most sensitive populations. ADHS typically uses comparison values as follows: if a contaminant is never found at levels greater than its CV, ADHS concludes the levels of corresponding contamination are "safe" or "harmless." If, however, a contaminant is found at levels that are greater than its comparison value, ADHS designates the pollutant as a *contaminant of interest* and examines potential human exposures in greater detail.

Comparison values are based on extremely conservative assumptions. Depending on site-specific environmental exposure factors (e.g. duration and amount of exposure) and individual human factors (e.g. personal habits, occupation, and/or overall health), exposure to levels greater than the comparison value may or may not lead to a health effect. Therefore, the comparison values should not be used to predict the occurrence of adverse health effects.

$\underline{PM_{10}}$: The current 24-hour PM_{10} National ambient Air Quality Standard (NAAQS) is 150 micrograms per cubic meter ($\mu g/m^3$) with no more than one exceedance per year on average over 3 years. In 2006, EPA removed the previous annual PM_{10} standard of 50 $\mu g/m^3$ due to lack of evidence linking health problems to long-term exposure to coarse particle pollution.

ADHS reviewed the Ambient Air Data Presentation in Appendix F of the RI report (EA Engineering, Science, and Technology, Inc 2010). The figures show the average PM_{10} concentrations for a specific period of time (i.e. 1-hour and 24-hours) from three sampling locations (i.e. Iron King: AIK-01, Elementary School: AES-01, and Humboldt Smelter: AHS-01). These samples were collected from 3/19/09 to 9/7/09. The results show that:

- Iron King and Elementary School Stations: Although the TSP concentration can be up to 600 $\mu g/m^3$ or above during high wind events, the average 24-hour PM_{10} concentrations were below the NAAQS of 150 $\mu g/m^3$ during the sampling period. That can be due to the short duration of the peak wind events (usually between 4 to 8 hours).

- Humboldt Smelter Station: The average 24-hour PM_{10} concentrations exceeded the NAAQS of 150 $\mu g/m^3$ three times during the sampling period from March to September. The result indicates that the standard was exceeded more than once per year for an average of three years, therefore it exceeds the NAAQS standard.

<u>Metals</u>: Table 2 shows the range of the detected ambient air concentrations for each chemical, the 95% Upper Confidence Limit of the Mean, and health-based comparison values. The information was summarized from Table 5-138 to Table 5-141, and Table 3 in the RI report (EA Engineering, Science, and Technology, Inc 2010). In general, the detection frequencies of metals in the air samples are low (less than 40%). ADHS used the 95% upper confidence limit (UCL) of

the mean[1] as the exposure point concentration as recommended by ATSDR and EPA (USEPA 1992). The 95% UCL is used as an estimate of the average ambient air concentration. It is used because it accounts for the temporal variation, and is a conservative (protective) way to estimate the average concentration of contaminants someone might be exposed to. Arsenic, beryllium and chromium were kept for further evaluation because the 95% UCL concentrations exceeded their respective health-based CV (Table 2).

Public Health Implications*: This section will provide general toxicological information and site-specific exposure evaluation.*

(1) PM_{10}

Short-Term Exposure: Short-term (usually over a 24-hour period, but possibly as short as one hour) exposure to particulate matters has been linked to a number of health outcomes, from respiratory issues that come and go to emergency room visits and hospital admissions to increased risk of death. There is also increasing evidence to show that adverse effects are not only on the respiratory system, but also on the cardiovascular system (Samet et al. 2000 a,b; Zanobetti and Schwartz 2003). These studies generally appear to confirm likely excess risk of cardiovascular disease-related hospital admission for US cities in the range of 2 to 9% per 50 $\mu g/m^3$ PM_{10}, especially among the elderly (≥ 65 years old). Recent epidemiologic studies (Samet el at. 2000a; Katsouyanni et al. 2001; Cohen et al. 2004; Mar et al. 2000, 2003) provided evidence of positive associations for total non-accidental mortality (total deaths minus those from accident/injury) with PM_{10}. The findings of these studies suggested that the health risks associated with short-term exposures to PM_{10} are likely to produce an increase in total non-accidental mortality of around 0.5% for each 10 $\mu g/m^3$ increment in the daily concentration. Therefore, a PM_{10} concentration of 150 $\mu g/m^3$ would be expected to translate into a roughly a 5% increase in daily mortality. Significant associations have been reported with respiratory hospital admissions in several Canadian studies, where the reported mean concentrations ranged from 6 to 12 $\mu g/m^3$ and maximum concentrations from 25 to 68 $\mu g/m^3$ (Yang et al. 2004; Chen et al. 2004, 2005; Lin et al. 2002, 2005). In addition, the elderly are more vulnerable to the effects of exposure to air pollution due to changes with age in the body's ability to remove chemicals and repair damage. They are more likely to have pre-existing lung and heart diseases. Exposure to PM_{10} can worsen the conditions of people with pre-existing heart or lung disease. It can also aggravate the frequency and severity of attacks among asthmatics.

The Ambient Air Data Presentation in Appendix F of the RI report showed that the 24-hour average concentration of PM_{10} at Humboldt Smelter Station exceeded the health-based standards three times during the sampling period, and it has the potential to do so in the future. For short term exposure, this indicates that an occasional increase in emergency room visits may be seen among transients during high PM_{10} events.

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[1] A confidence interval is surrounded by the lower and upper confidence limits (UCLs). A confidence interval of the arithmetic mean gives an estimated range of averages which is likely to include the true average of the sampled population (*population mean*), and the estimated range is calculated from a given set of samples (*sample mean*). The 95% confidence interval is the region about the sample mean that is likely to contain the underlying *population mean* (representing the whole site itself) with a probability of 95%.

Long-Term Exposure: A number of epidemiologic studies have continued to report associations between long-term exposure (on the order of months to years) to fine particles ($PM_{2.5}$: particulates 2.5 micrometers or less in diameter) and mortality (Dockery et al. 1993; Pope et al. 1995; Krewski et al. 2000; Pope et al. 2002; Laden et al. 2006) as well as morbidity health endpoints: development of chronic respiratory illness or symptoms (Dockery et al. 1996; Raizenne et al. 1996; McConnell et al. 2003), changes in lung function (Gauderman et al. 2000, 2002, 2004; Goss et al. 2004), and the development of cardiovascular disease (Kunzli et al. 2005). However, the available evidence is considered insufficient to link health problems to long-term exposure to coarse particles.

The proportion of fine ($PM_{2.5}$) and coarse particles (PM_{10}) likely varies substantially between places, depending on local geography, meteorology and specific PM sources. The current recommendation to the $PM_{2.5}$ to PM_{10} multipliers ranges from 0.15 to 0.25 for various fugitive dust categories (Pace 2005). Soil samples used to derive the multipliers were collected from Alaska, Arizona, New Mexico and Wyoming. $PM_{2.5}$ was not measured during the air sampling events. ADHS estimated the $PM_{2.5}$ concentrations by using the EPA's recommended multipliers (Table 3). All the predicted $PM_{2.5}$ levels were below the NAAQ annual $PM_{2.5}$ standard of 15 $\mu g/m^3$. The results indicated that residents or transients are not likely to develop chronic respiratory symptoms as a result from exposure to PM at the measured levels.

However, it is important to note that there is some scientific debate regarding the levels of particulate matter that is considered protective for all segments of the population. Threshold concentrations for $PM_{2.5}$ or PM_{10} (i.e. a level below which no adverse health effects are likely) have not been established within the scientific literature. The low end of the range of concentrations at which adverse health effects has been demonstrated is not greatly above the background concentration, which for $PM_{2.5}$ has been estimated to be 3~5 $\mu g/m^3$ in both the US and western Europe (WHO 2005).

(2) Arsenic:

Arsenic is a naturally occurring element, and is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. When arsenic is combined with these elements it is called inorganic arsenic. When arsenic is combined with carbon and hydrogen it is called organic arsenic. Generally, organic arsenic is less toxic than inorganic arsenic. Humans normally take in small amounts of arsenic through inhalation of air and ingestion of food and water, with food being the largest source of arsenic. Fish and seafood contain the highest concentrations of arsenic; however, most of this is in the less toxic organic form of arsenic (ATSDR 2000).

Inorganic arsenic has been recognized as a human poison since ancient times, and when ingested in a large amount (above 60,000 parts per billion (ppb) in food or water) can cause death. If we swallow a small amount of inorganic arsenic (300 to 30,000 ppb in food or water), we may experience irritation in the stomach and intestines with symptoms such as nausea, vomiting or diarrhea. Breathing in high levels of inorganic arsenic (approximately greater than 100 $\mu g/m^3$ for the general population, and 10 µg/m^3 for children and sensitive population[2]) for a short period of time may result in a sore throat and irritated lungs (ATSDR 2000). The highest level of arsenic (0.0354 µg/m^3) was detected at the Iron King Mine, and it did not exceed the 10 µg/m^3 irritation level. Therefore, ADHS does not expect to see irritation responses among the residents. Ingestion or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso (ATSDR 2000). When we breathe dust containing arsenic, many of the dust particles settle onto the lining of the lungs, and most of the arsenic on these particles is absorbed into the body. The liver changes some of the arsenic into a less harmful organic form, and both inorganic and organic forms leave our body in the urine. Most arsenic is excreted within days following exposure; however, some will remain in the body for several months or longer (ATSDR 2000).

Longer exposure at low concentrations can lead to skin effects, and also to circulatory and peripheral nervous disorders. There is some data suggesting that inhalation of inorganic arsenic by a pregnant woman can cause problems in the developing fetus. Inhalation of inorganic arsenic has been linked to increased risk of lung cancer, especially in people who work at smelters, mines, and chemical factories. The Department of Health and Human Services (DHHS) has determined that inorganic arsenic is a known human carcinogen. The international Agency for Research on Cancer (IARC) has determined that inorganic arsenic is a carcinogen to humans. The EPA has classified inorganic arsenic as a known human carcinogen (ATSDR 2000).

Non-Carcinogenic Health Effects: In the Iron King Mine/Humboldt Smelter area, the detection frequency of arsenic in the air samples ranged from 19% (Background) to 32% (Iron King Mine). None of the 95% UCL arsenic air concentration exceeded the chronic arsenic RfC (0.015 µg/m^3) represented in the EPA Regional Screening Level (Table 4). The highest level of 95% UCL (0.00463 µg/m^3) was about 3 times lower than the calculated chronic RfC. Based on the available toxicological information, ADHS does not expect to see adverse non-cancer health effects from either short-term or long-term exposures to arsenic at the concentrations detected in the area.

Carcinogenic Health Effects: The cancer risk from lifetime exposure to arsenic can be estimated by multiplying the 95% UCL (projected lifetime average exposure level) by the inhalation unit risk factor. The estimated cancer risk levels ranged from 5.4×10^{-6} to 2×10^{-5}. This means that, for example, if 185,185 people were exposed to the levels of arsenic found in Humboldt-In-Town 24 hours per day for 70 years, theoretically, we would predict that one additional person might get cancer as a result of this exposure. These estimated risks are within the range of public health guideline (10^{-6}~10^{-4}) for protection of human health as suggested by the EPA (Table 4). These cancer risks due to arsenic exposure from the ambient air are considered to be low or moderate based on the qualitative ranking of estimated cancer risk (Appendix A).

(3) Beryllium

Beryllium is a naturally occurring metal that is present in rocks, coal, oil, soil and volcanic dust. Most of the mined beryllium is mixed with other metals to form alloys, which are used in making

[2] We do not have information on the irritation level for children and sensitive population, a factor of 10 is used to account for variation in individual sensitivity (personal communication with Selene Chou, ATSDR Toxicologist).

electrical parts or molds for plastics. Beryllium alloys can also be found in automobiles, computers, golf clubs, bicycle frames and dental bridges. Beryllium oxide is used to make ceramics for electrical and high-technology applications (ATSDR 2002).

Beryllium is poorly absorbed (less than 1 %) from the gastrointestinal tract, but can be deposited in the lungs. Some of the beryllium deposit in the lungs will move into the blood stream slowly and the rest can remain in there for a long time. When breathing in high levels of beryllium (greater than 1000 $\mu g/m^3$), it can result in an acute condition that resembles pneumonia, and is called Acute Beryllium Disease (ABD). The lung damage can heal if beryllium exposure is stopped. People who are sensitive (allergic) to beryllium may develop the Chronic Beryllium Disease (CBD) or berylliosis after long-term exposure (10-15 years) to levels of beryllium greater than 0.5 $\mu g/m^3$. CBD is an inflammatory lung disease characterized by the formation of granulomas with varying degrees of interstitial fibrosis. People with CBD may feel weak and tired, having difficulty breathing. Enlarged heart and heart disease can be seen in advanced cases (ATSDR 2002).

Inhalation of beryllium can increase the risk of lung cancer. The DHHS and the IARC have determined that beryllium is a human carcinogen. The EPA has classified beryllium as a probable human carcinogen, and has estimated that lifetime exposure to 0.04 $\mu g/m^3$ beryllium can result in a one in ten thousand chance of developing cancer (ATSDR 2002).

<u>Non-Carcinogenic Health Effects</u>: In the Iron King Mine/Humboldt Smelter area, the detection frequency of beryllium in the air samples ranged from 3% (Humboldt Smelter) to 5% (background), and none of the 95% UCL beryllium air concentrations exceeded the inhalation RfC (Table 5). EPA derived the chronic inhalation RfC based on beryllium sensitization and progression to CBD identified among workers at a beryllium plant. The study identified the Lowest Observed Adverse Effect Level (LOAEL) as 0.55 $\mu g/m^3$ for beryllium sensitization in workers. The chronic inhalation RfC was justified for the workers' respiratory volume, exposure duration, and uncertainty factors. The 95% UCL (0.00283 $\mu g/m^3$) was about 7 times lower than the RfC (0.02 $\mu g/m^3$), and about 190 times lower than the human equivalent LOAEL from which the RfC was derived. Based on the available toxicological information, ADHS does not expect to see adverse non-cancer health effects from either short-term or long-term exposures to beryllium at the concentrations detected in the area.

<u>Carcinogenic Health Effects</u>: The cancer risk from lifetime exposure to beryllium can be estimated by multiplying the 95% UCL (projected lifetime average exposure level) by the inhalation unit risk factor. The estimated cancer risk level was 3.3×10^{-6} for Humboldt-In-Town, and to 6.8×10^{-6} for Humboldt smelter area. This means that, for example, if 303,030 people were exposed to the levels of beryllium found in Humboldt-In-Town every day for 70 years, theoretically, we would predict that one additional person might get cancer as a result of this exposure. These estimated risks are within the range of the public health guideline (10^{-6}~10^{-4}) for protection of human health as suggested by the EPA (Table 5). These cancer risks due to beryllium exposure from the ambient air are considered to be low based on the qualitative ranking of cancer risk estimates (Appendix A).

(4) Chromium

Chromium can be found in different forms from rocks, animals, plants, soil, and volcanic dust and gases. The most common forms are metallic [chromium (0)], trivalent [chromium (III)], and hexavalent [chromium (VI)]. Chromium (III) is natural occurring and is an essential nutrient required for the human body to use sugar, protein and fat, while chromium (0) and chromium (VI) are generally produced from industrial processes. Chromium compounds are used for making steel, chrome plating dyes and pigments, leather tanning, and wood preserving (ATSDR 2008).

In general, chromium compounds are present as fine dust particles in the air, and stay in the air for less than 10 days. They tend to deposit into soil and water. When breathing dust particles containing chromium, some of the chromium will enter into the body through the lungs. Some forms of chromium can remain in the lungs for several years or longer. In general, chromium (VI) is more easily absorbed by the body compared to Chromium (III), but after entering the body, chromium (VI) will change to chromium (III). Most of the chromium leaves the body in the urine within a few days after exposure (ATSDR 2008).

The respiratory system is the main target for inhalation exposure in humans. Breathing in chromium can irritate respiratory tracts and cause breathing problems. However, no significant adverse effects on lung function will occur if acute exposure concentrations of Chromium (VI) are less than 0.01 mg/m^3. It has been reported that high levels of chromium (VI) at a work place cause shortness of breath, coughing, and wheezing in the workers. Breathing in chromium trioxide (CrO_3), chromic acid (H_2CrO_4), or other chromium (VI) compounds at levels greater than 2 $\mu g/m^3$ can irritate the nose and cause running nose, sneezing, itching, nosebleeds, ulcer, and holes in the nasal septum. Breathing in chromium (III) compounds generally does not cause irritation to the nose or mouth in most people (ATSDR 2008).

Long-term exposure to chromium has been linked to increased risk of developing lung cancer in workers exposed to chromium (VI). No cancerous effects were observed among workers exposed to chromium (III). Because chromium (VI) compounds have been observed to cause cancers in lungs, nasals, and sinuses in workers, and cause cancer in animals, the DHHS has determined chromium (VI) compounds are known human carcinogens. The IARC has determined that chromium (VI) is carcinogenic to humans, based on sufficient evidence in humans and animals. IARC also determined that chromium (0) and chromium (III) compounds are not classifiable as to their carcinogenicity to humans. The EPA has determined that chromium (VI) is a human carcinogen via inhalation exposure. The EPA also determined that chromium (III) is not classifiable as to its carcinogenicity in humans (ATSDR 2008).

The air data provided in the RI report represents total chromium concentration, which may include chromium (0), chromium (III), and chromium (VI). To assess the potential health risks, ADHS assumed that the fraction of chromium (VI) is 3.6% based on the Humboldt Smelter data provided by EPA.

<u>Non-Carcinogenic Health Effects</u>: In the Iron King Mine/Humboldt Smelter area, the detection frequency of total chromium in the air samples ranged from 4% (Humboldt Smelter) to 10% (Background). With the chromium (VI) fractionation assumption of 3.6%, none of the 95% UCL

chromium air concentration exceeded the inhalation RfC for particulate chromium (VI) of 0.1 $\mu g/m^3$ (Table 6). The highest 95% UCL (0.0024 $\mu g/m^3$) was seen at the Humboldt Smelter area, and was about 40 times lower than the RfC. The 95% UCL at the Humboldt-In-Town was 0.00015 $\mu g/m^3$, which is about 650 times lower than the RfC. Based on the available toxicological information, ADHS does not expect to see adverse non-cancer health effects from exposures to chromium at the concentrations detected in the area.

Carcinogenic Health Effects: The cancer risk from lifetime exposure to chromium can be estimated by multiplying the 95% UCL (projected lifetime average exposure level) by the inhalation unit risk factor. The estimated cancer risk levels ranged from 6.0×10^{-7} to 1.1×10^{-5} (Table 7). The estimated cancer risk level was 1.8×10^{-6} for Humboldt-In-Town which means that, for example, if 555,556 people were exposed to the levels of total chromium found in Humboldt-In-Town every day for 70 years, theoretically, we would predict that one additional person might get cancer as a result of this exposure. These estimated cancer risks are within the range of the public health guideline (10^{-6}~10^{-4}) for protection of human health as suggested by the EPA (Table 5). These cancer risks due to chromium exposure from the ambient air are considered to be very low to moderate based on the qualitative ranking of cancer risk estimates (Appendix A).

(5) Multiple Chemical Exposure Through Inhalation Route

Noncarcinogenic Health Effects: Additivity is the default assumption for evaluating health effects of multiple chemicals (i.e. the combined toxic effect of multiple chemicals is the same as the sum of the individual toxic effects). However, sometimes the joint (combined) toxic effect can be greater than the sum of the individual toxic effects. For example, the joint toxic effect on neurological system due to exposure to lead and arsenic mixture is greater than the additive for the effect of arsenic and lead. ATSDR (2004) provides guidance on evaluating the joint toxic effects from arsenic, cadmium, chromium and lead since they are frequently found together at hazardous waste sites. According to the ATSDR guidance, no further assessment of joint toxic action is needed if only one or none of the metals have a hazard quotient[3] at or above 0.1 because additivity and/or interactions are not likely to result in a significant health hazard.

For the inhalation exposure pathway, none of the levels of chemicals found exceed a hazard quotient greater than 0.1, so significant additive or interactive effects are unlikely. Therefore, long-term aggregate exposure to air contaminants in the study areas (Iron King Mine, Humboldt Smelter and Humboldt-In-Town) would not be likely to result in adverse health effects under current conditions.

Carcinogenic Health Effects: ADHS assumed that the carcinogenic health effects are additive because no data is available regarding the effects of the mixture components on arsenic carcinogenicity (ATSDR 2004). Some information suggests that the effect of chromium (VI) on arsenic carcinogenicity may be greater than additive, but confidence in this assessment was low (ATSDR 2004). ADHS calculated the theoretical cumulative excess lifetime cancer risk by

[3] Hazard Quotient (HQ) is the ratio of the exposure estimate to an effects concentration (e.g. reference dose or reference concentration). A HQ value of 1 or less than 1 indicates that no adverse health effects (noncancer) are expected to occur.

summing the theoretical cancer risks for the contaminants. The estimated cancer risks ranged from 9.8×10^{-6} to 3.1×10^{-5} which are within the range of the public health guideline (10^{-6}~10^{-4}) for protection of human health as suggested by the EPA (Table 7). The cancer risks due to exposure to multiple chemicals from the ambient air are considered to be low to moderate based on the qualitative ranking of cancer risk estimates (Appendix A).

ATSDR Child Health Concerns

ATSDR recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contaminants in environmental media. A child's developing body systems can sustain permanent damage if toxic exposures occur during critical growth stages. Children ingest a larger amount of water relative to body weight, resulting in a higher burden of pollutants. Furthermore, children often engage in vigorous outdoor activities, making them more sensitive to pollution than healthy adults. All health analyses in this report take into consideration the unique vulnerability of children.

Conclusions

This health consultation evaluated the health risks associated with inhalation exposure only. It does not consider the health risks associated with oral ingestion and skin contact. ADHS is working on another health consultation to provide an update on the health risks associated with exposure to contaminated soil and water as well as the cumulative health risks from all exposure routes with new soil and water data.

Based on the available information, ADHS concluded that:

- Short-term exposure (usually over a 24-hour period, but possibly as short as one hour) to PM_{10} is not expected to harm human health at the Iron King Mine and Humboldt-In-Town areas. However, during high wind events, PM_{10} levels have been measured that could cause adverse health effects at the Humboldt Smelter facility.

- Long-term exposure to PM_{10} is not expected to harm human health at the study areas (i.e. Iron King Mine, Humboldt Smelter and Humboldt-In-Town). Following the EPA's recommendation, we used $PM_{2.5}$ /PM_{10} ratios to predict the long term potential health effects. All the predicted $PM_{2.5}$ levels were below the NAAQ annual $PM_{2.5}$ standard of 15 $\mu g/m^3$. The results indicated that residents or visitors are not likely to develop chronic respiratory symptoms as a result from exposure to PM at the measured levels (Pace 2005).

- Metals: the concentrations detected in the ambient air alone are not likely to harm the health of the general public. We found that the majority of the risks associated with exposure to the airborne chemicals analyzed in this health consultation were low. In addition, long-term aggregate exposure to air contaminants in the study areas (Iron King Mine, Humboldt Smelter and Humboldt-In-Town) would not be likely to result in non-carcinogenic adverse health effects under current conditions since the hazardous quotients of the arsenic, lead, cadmium and chromium are less than 0.1 (ATSDR 2004).

The estimated cumulative cancer risks ranged from 6×10^{-7} to 1.1×10^{-5} which are within the range of the public health guideline ($10^{-6} \sim 10^{-4}$) for protection of human health as suggested by the EPA. The cancer risks due to exposure to multiple chemicals from the ambient air are considered to be low to moderate based on the qualitative ranking of cancer risk estimates.

Recommendations/Information Sources

ADHS recommends EPA and ADEQ work together to conduct/supervise the following actions to ensure that residents of Dewey-Humboldt are not exposed to unhealthy levels of air pollution that may originate from mining operation or other emission sources in the area:

- Include $PM_{2.5}$ samples in the future air sampling events to provide better estimation for long term health effects associated with PM exposure.
- ADEQ should issue warnings on days when levels of air pollution are expected to reach potentially unhealthy levels, and to communicate these warnings to the local media. Residents are encouraged to heed these warnings, which generally recommend residents, especially persons with respiratory conditions, to remain indoors and to avoid moderate levels of exercise as much as possible. By following these precautions, residents can protect themselves from air pollution in the area as it occasionally reaches potentially unsafe levels.
- To minimize the amount of particulate matter released to the air, effective air pollution/dust control measures should be developed/initiated/enforced.
- To minimize the amount of exposure, set up effective fences in the mine or smelter areas to restrict public access, maintain signs posting warnings of potential health dangers, and provide public health education to warn residents of the potential adverse health effects.

Public Health Action Plan

- ADHS attended public meetings to discuss the process of preparing health consultations and community concerns. ADHS will continue to attend additional public meetings, make presentations, develop handout literature, and engage in other actions to notify the property owners in the area of the findings of this health consultation.
- ADHS will notify EPA and ADEQ regarding the findings of this report and work with both agencies to evaluate the protectiveness of remedial action plans.
- ADHS will continue to review and evaluate data provided for this site.

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REPORT PREPARATION

This Public Health Consultation for the Iron King Mine & Humboldt Smelter Site was prepared by the Arizona Department of Health Services under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented. ATSDR's approval of this document has been captured in an electronic database, and the approving agency reviewers are listed below.

Author
Hsini Lin, ScD, MSPH
Environmental Toxicology Program
Office of Environmental Health

State Reviewer
Krystal Colburn
Smoke Free Arizona Program Manager
Office of Environmental Health

ATSDR Reviewers

Charisse J. Walcott
Technical Project Officer
Division of Community Health Investigations
Western Branch

Alan Yarbrough
Cooperative Agreement Program Coordinator
Division of Community Health Investigations

Cassandra V. Smith
Branch Chief
Division of Community Health Investigations
Western Branch

Lynn Wilder
Assistant Director for Science
Division of Community Health Investigations

Alan Yarbrough
Division Director (Acting)
Division of Community Health Investigations

FIGURES

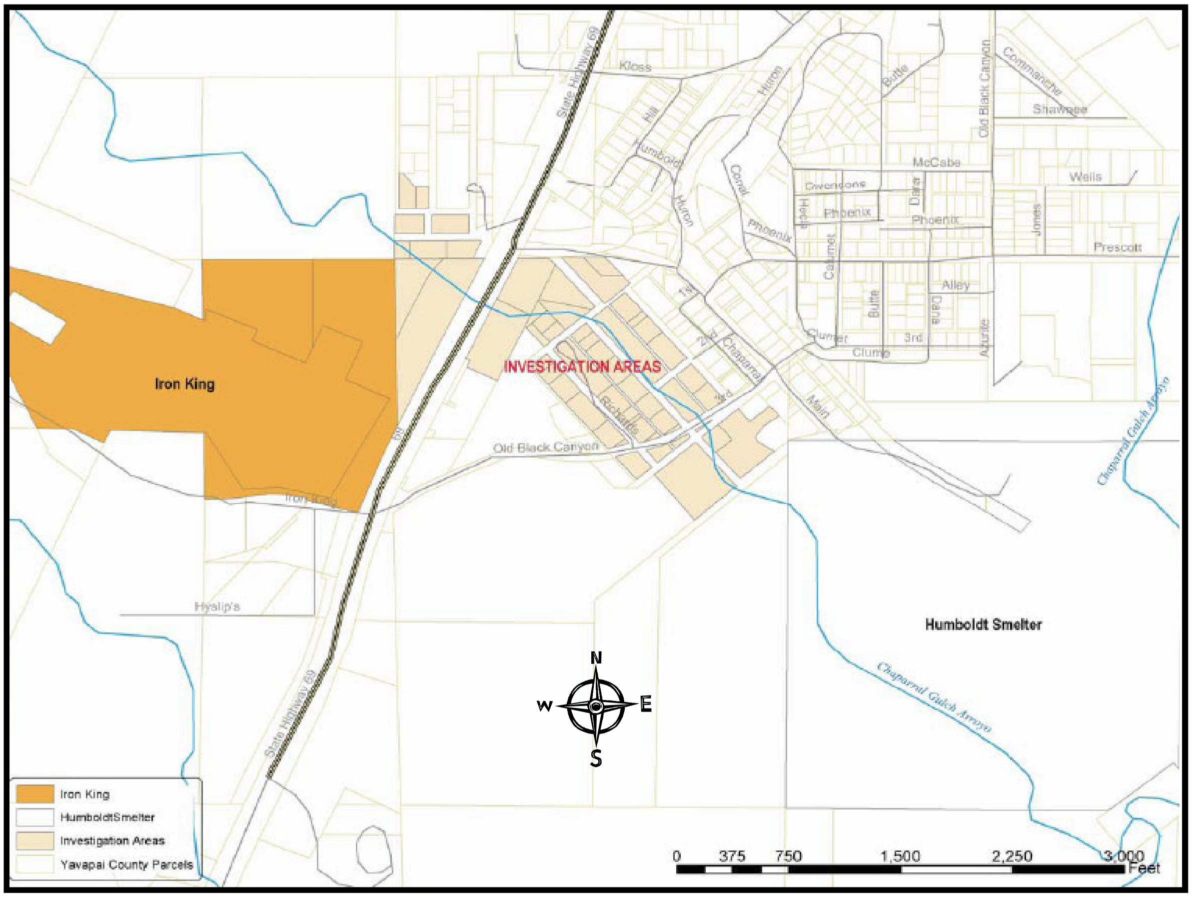

Figure 1. Site Map[4]. The Iron King Mine is about 153 acres, approximately ¼ miles west of Humboldt, AZ. The Humboldt Smelter is about 182 acres and situated along the eastern side of the town.

[4] The map is adapted from EPA report: Iron King Mine Site, Humboldt, Arizona, Final Report, 2005.

Figure 2. Photo shows that residential area is covered by dust when the wind is blowing. The photo is adapted from the Dewey-Humboldt Smelter & Iron King Mine Superfund Information site (http://www.dhironkingsmelter.info).

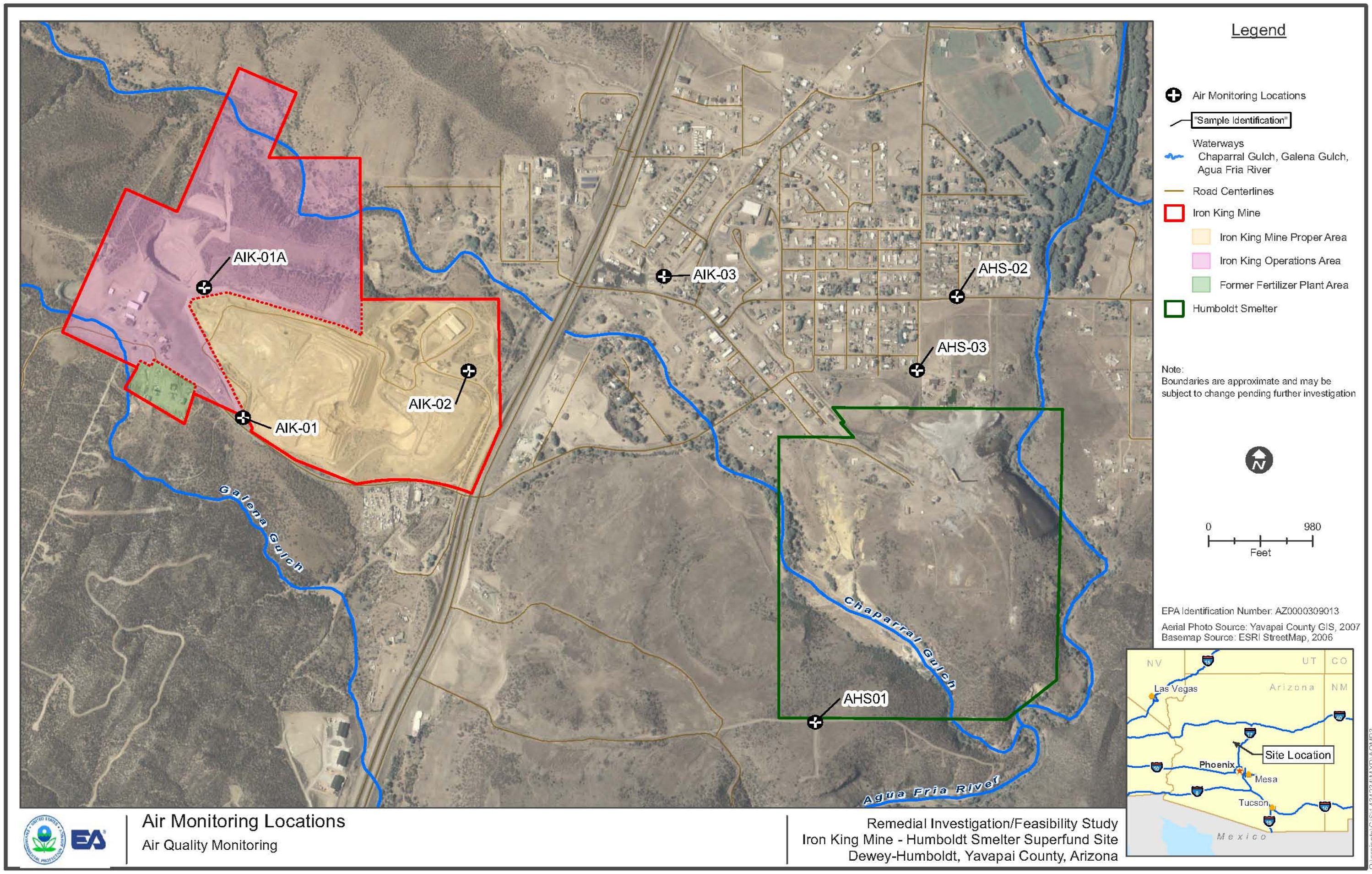

Figure 3. Map showing the locations of air monitoring stations. The map was adapted from the Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation (RI) Report (EA Engineering, Science, and Technology, Inc 2010).

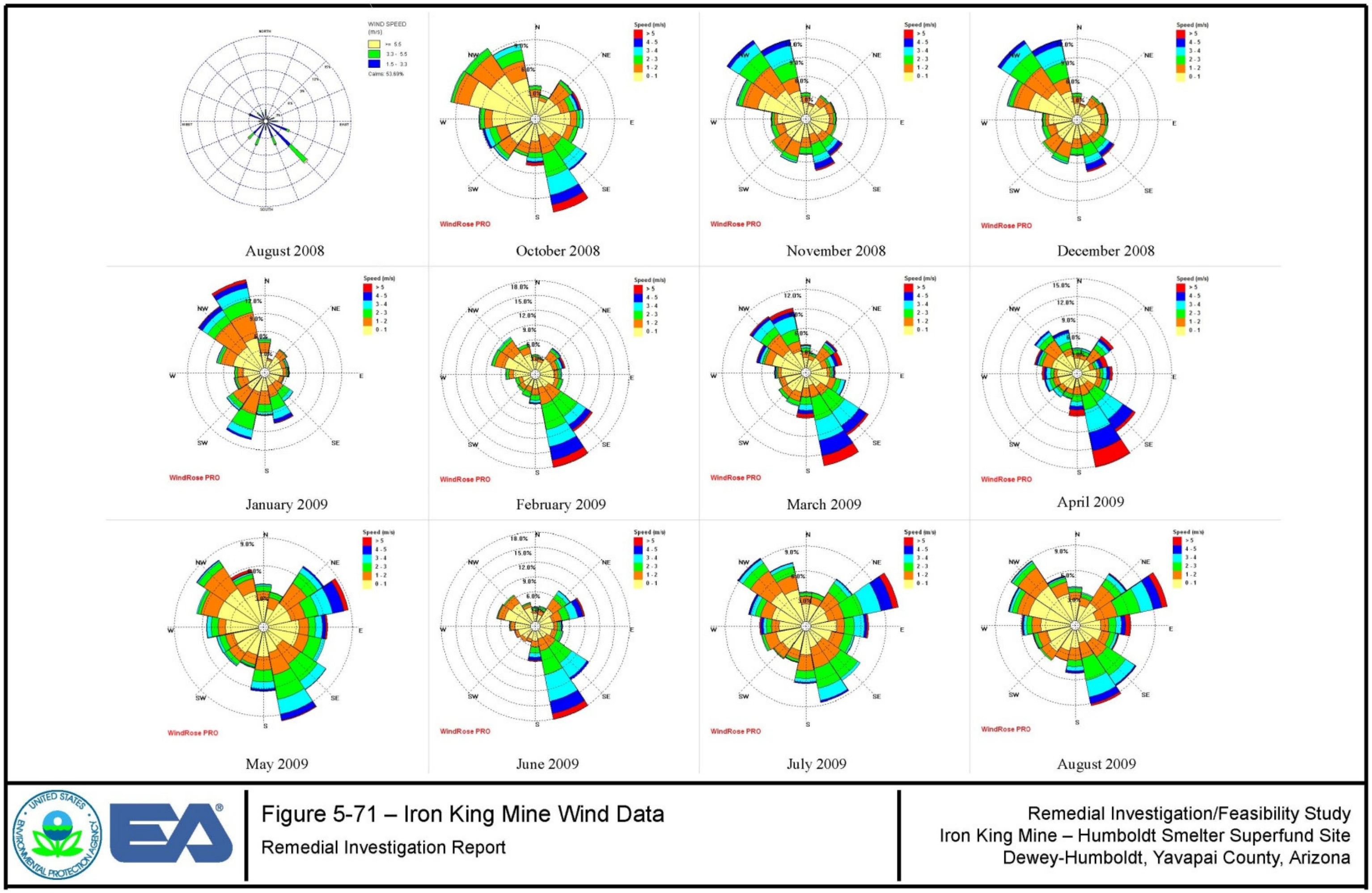

Figure 4. Wind roses showing the prevailing wind directions in the study area. The figure was adapted from the Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation (RI) Report (EA Engineering, Science, and Technology, Inc 2010

TABLES

Table 1. Exposure Pathways Analysis

Exposure Pathway Elements					Time frame	Type of Exposure Pathway
Source	Media	Point of exposure	Route of exposure	Potentially exposed population		
Contaminated soil/Mine tailing	Air	Ambient Air	Inhalation	Residents/ Visitors	Past	Completed
					Current	Completed
					Future	Potential

Table 2. A summary of the measured metal concentrations in ambient air sampling stations.

(a) Humboldt-In-Town

Chemical	Range of Detection ($\mu g/m^3$)	Detected Frequency	95% Upper Confidence Limit of the Mean ($\mu g/m^3$)	Health-based Comparison Values ($\mu g/m^3$)		Is it a Chemical of Interest?
Aluminum	0.107 – 1.51	26/75	0.523	5.2	RSL-nc	No
Antimony	0.0251 – 0.0276	3/75	0.0276	0.21	RSL-nc	No
Arsenic	0.00014 – 0.0112	17/75	0.00125	0.00057	RSL-c	**Yes**
Barium	0.00416 – 0.104	4/75	0.0602	0.52	RSL-nc	No
Beryllium	0.00005 – 0.0014	3/75	0.00138	0.001	RSL-c	**Yes**
Cadmium	0.00006 – 0.0055	8/75	0.000811	0.0014	RSL-c	No
Chromium	0.00624 – 0.0655	5/75	0.0424	0.000011	RSL-c	**Yes**
Copper	0.00116 – 0.189	44/75	0.0174	150	RBC-nc	No
Lead	0.00077 – 0.0087	18/75	0.00223	0.15	NAAQS	No
Mercury	0.00111	1/49	0.000812	0.31	RSL-nc	No
Nickel	0.0001 – 0.0203	21/75	0.00215	0.09	EMEG-ch	No
Selenium	0.000232 – 0.0133	9/75	0.0014	21	RSL-nc	No
Silver	0.000001 – 0.0213	6/75	0.00168	18	RBC-nc	No
Zinc	0.00529 – 0.0326	15/75	0.00921	1100	RBC-nc	No

(b) Humboldt Smelter

Chemical	Range of Detection ($\mu g/m^3$)	Detected Frequency	95% Upper Confidence Limit of the Mean ($\mu g/m^3$)	Health-based Comparison Values ($\mu g/m^3$)		Is it a Chemical of Interest?
Aluminum	0.122 – 19.5	34/73	1.92	5.2	RSL-nc	No
Antimony	0.0162 – 0.024	2/73	0.024	0.21	RSL-nc	No
Arsenic	0.000118 – 0.0075	19/73	0.00133	0.00057	RSL-c	**Yes**
Barium	0.00237 – 0.104	4/73	0.0597	0.52	RSL-nc	No
Beryllium	0.00085 – 0.016	2/73	0.00283	0.001	RSL-c	**Yes**
Cadmium	0.00005 – 0.00247	9/73	0.000327	0.0014	RSL-c	No
Chromium	0.00999 – 0.067	3/73	0.067	0.000011	RSL-c	**Yes**
Copper	0.00125 – 0.881	51/73	0.0873	150	RBC-nc	No
Lead	0.00087 – 0.18	30/73	0.0128	0.15	NAAQS	No
Nickel	0.00005 – 0.099	22/73	0.00602	0.09	EMEG-ch	No
Selenium	0.000293 – 0.0141	11/73	0.00191	21	RSL-nc	No
Silver	0.000029 – 0.011	8/73	0.000617	18	RBC-nc	No
Zinc	0.00388 – 0.541	22/73	0.0382	1100	RBC-nc	No

(c) Iron King Mine

Chemical	Range of Detection (µg/m³)	Detected Frequency	95% Upper Confidence Limit of the Mean (µg/m³)	Health-based Comparison Values (µg/m³)		Is it a Chemical of Interest?
Aluminum	0.0873 – 1.01	11/87	0.478	5.2	RSL-nc	No
Antimony	0.0157 – 0.027	2/87	0.0159	0.21	RSL-nc	No
Arsenic	0.0005 – 0.0354	28/87	0.00463	0.00057	RSL-c	**Yes**
Barium	0.00108 – 0.0602	6/87	0.0232	0.52	RSL-nc	No
Cadmium	0.00007 – 0.0036	11/87	0.000507	0.0014	RSL-c	No
Chromium	0.00366 – 0.129	7/87	0.026	0.000011	RSL-c	**Yes**
Copper	0.00049 – 0.183	40/87	0.0138	150	RBC-nc	No
Lead	0.00156 – 0.0447	31/87	0.00603	0.15	NAAQS	No
Mercury	0.00058 – 0.0011	2/63	0.00112	0.31	RSL-nc	No
Nickel	0.00015 – 0.137	14/87	0.00583	0.09	EMEG-ch	No
Selenium	0.00025 – 0.0222	14/87	0.00213	21	RSL-nc	No
Silver	0.00006 – 0.0073	4/87	0.0029	18	RBC-nc	No
Zinc	0.0033 – 0.0915	13/87	0.0156	1100	RBC-nc	No

(d) Background

Chemical	Range of Detection (µg/m³)	Detected Frequency	95% Upper Confidence Limit of the Mean (µg/m³)	Health-based Comparison Values (µg/m³)		Is it a Chemical of Interest?
Aluminum	0.0957 – 63.9	9/42	7.2	5.2	RSL-nc	No
Antimony	0.00337 – 0.0454	2/42	0.00934	0.21	RSL-nc	No
Arsenic	0.00027 – 0.0116	8/42	0.00214	0.00057	RSL-c	**Yes**
Barium	0.00137 – 0.0114	5/42	0.0314	0.52	RSL-nc	No
Beryllium	0.00088 – 0.0018	2/42	0.00094	0.001	RSL-c	No
Cadmium	0.00012 – 0.0014	3/42	0.00022	0.0014	RSL-c	No
Chromium	0.00283 – 0.0997	4/42	0.0146	0.000011	RSL-c	**Yes**
Copper	0.00071 – 0.025	15/42	0.00412	150	RBC-nc	No
Lead	0.00062 – 0.0125	10/42	0.00355	0.15	NAAQS	No
Nickel	0.00035 – 0.0277	7/42	0.00321	0.09	EMEG-ch	No
Selenium	0.00067 – 0.0125	4/42	0.00206	21	RSL-nc	No
Silver	0.0005 – 0.02	2/42	0.00609	18	RBC-nc	No
Zinc	0.00249 – 0.0204	3/42	0.00873	1100	RBC-nc	No

µg/m³: microgram per cubic meter of air
RSL-nc: EPA Region 9 Regional Screening Level for non-cancer effects
RSL-c: EPA Region 9 Regional Screening Level for cancer effects
RBC-nc: EPA Region 3 Risk-based Concentration for non-cancer effects
NAAQS: National Ambient Air Quality Standard
EMEG-ch: ATSDR Environmental Media Evaluation Guide for chronic exposure durations

Table 3. $PM_{2.5}$ /PM_{10} multiplier

Location	95% UCL for PM_{10} (µg/m^3)	$PM_{2.5}$ /PM_{10} Multiplier	Predicted $PM_{2.5}$ Concentration (µg/m^3)	NAAQS for $PM_{2.5}$ (µg/m^3)
Background	24.2	(0.15/0.2/0.25)	(3.63/4.84/6.05)	15
Humboldt-In-Town	28.9	(0.15/0.2/0.25)	(4.34/5.78/7.22)	
Humboldt Smelter	32.4	(0.15/0.2/0.25)	(4.86/6.48/8.10)	
Iron King Mine	22.5	(0.15/0.2/0.25)	(3.38/4.50/5.63)	

95% UCL: 95% Upper Confidence Limit of the Mean
$PM_{2.5}$: particulates 2.5 micrometers or less in diameter
PM_{10}: particulates 10 micrometers or less in diameter
NAAQS: National Ambient Air Quality Standard
µg/m^3: micrograms per cubic meter

Table 4. Cancer and Non-cancerous health effects evaluation for arsenic.

Location	95% UCL[1] (µg/m³)	Non-cancerous Health Effects	Cancerous Health Effects		
		Reference Concentration (µg/m³)	Unit Risk ((µg/m³)⁻¹)	Cancer Risk[2]	Qualitative Descriptor[3]
Background	0.00214	0.015	0.0043	9.2×10^{-6}	Low
Humboldt-In-Town	0.00125			5.4×10^{-6}	Low
Humboldt Smelter	0.00133			5.7×10^{-6}	Low
Iron King Mine	0.00463			2.0×10^{-5}	Moderate

1. 95% UCL: 95% Upper Confidence Limit of the Mean
2. Cancer Risk is calculated by: detected concentration × unit risk. For example, the background cancer risk was obtained by: $0.00214 \times 0.0043 = 9.2\times10^{-6}$
3. See Appendix A

Table 5. Cancer and Non-cancerous health effects evaluation for beryllium.

Location	95% UCL[1] (µg/m³)	Non-cancerous Health Effects	Cancerous Health Effects		
		Reference Concentration (µg/m³)	Unit Risk ((µg/m³)⁻¹)	Cancer Risk[2]	Qualitative Descriptor[3]
Background	–	0.02	0.0024	–	–
Humboldt-In-Town	0.00138			3.3×10^{-6}	Low
Humboldt Smelter	0.00283			6.8×10^{-6}	Low
Iron King Mine	–			–	–

1. 95% UCL: 95% Upper Confidence Limit of the Mean
2. Cancer Risk is calculated by: detected concentration × unit risk. For example, the Humboldt Smelter cancer risk was obtained by: $0.00283 \times 0.0024 = 6.8\times10^{-6}$
3. See Appendix A

Table 6. Cancer and Non-cancerous health effects evaluation for chromium.

Assumption: fraction of chromium (VI) is 3.6% of the total chromium based on the Humboldt Smelter data provided by EPA

Location	95% UCL[1] ($\mu g/m^3$)	Non-cancerous Health Effects	Cancerous Health Effects		
		Particulate Chromium (VI) Reference Concentration ($\mu g/m^3$)	Unit Risk ($(\mu g/m^3)^{-1}$)	Cancer Risk[2]	Qualitative Descriptor[3]
Background	0.00005	0.1	0.012	6.0×10^{-7}	Very Low
Humboldt-In-Town	0.00015			1.8×10^{-6}	Low
Humboldt Smelter	0.00241			2.9×10^{-5}	Moderate
Iron King Mine	0.00094			1.1×10^{-5}	Moderate

1. 95% UCL: 95% Upper Confidence Limit of the Mean
2. Cancer Risk is calculated by: detected concentration × unit risk. For example, the background cancer risk was obtained by: $0.0005 \times 0.012 = 6.7\times10^{-7}$
3. See Appendix A

Table 7. Cancer health effects evaluation for multiple chemical exposures via the inhalation pathway.

Assumption: fraction of chromium (VI) is 3.6% of the total chromium based on the Humboldt Smelter data provided by EPA

Location	Individual Cancer Risk			Cumulative Cancer Risk	Qualitative Descriptor[1]
	Arsenic	Beryllium	Chromium		
Background	9.2×10^{-6}		6.0×10^{-7}	9.8×10^{-6}	Very Low
Humboldt-In-Town	5.4×10^{-6}	3.3×10^{-6}	1.8×10^{-6}	1.1×10^{-5}	Low
Humboldt Smelter	5.7×10^{-6}	6.8×10^{-6}	2.9×10^{-5}	4.1×10^{-5}	Moderate
Iron King Mine	2.0×10^{-5}		1.1×10^{-5}	3.1×10^{-5}	Moderate

1. See Appendix A

Appendix A

Qualitative Descriptors for Excess Lifetime Cancer Risk

ADHS estimated increased excess lifetime cancer risks by using site-specific information on exposure levels, and cancer potency derived by authoritative agencies, such as USEPA, Cal EPA and others. ADHS then ranked the excess lifetime cancer risk from very low to very high based on the qualitative ranking of cancer risk estimates developed by the New York State Department of Health (http://www.health.ny.gov/environmental/investigations/hopewell/appendc.htm). For example, if the qualitative descriptor was "low", then the excess lifetime cancer risk from that exposure is in the range of greater than one per million to less than one per ten thousand. Other qualitative descriptors are listed below:

Cancer Risk	Qualitative Descriptor
Equal to or less than one per million (Cancer Risk $\leq 10^{-6}$)	Very Low
Greater than one per million to less than one per ten thousand (10^{-6} < Cancer Risk $\leq 10^{-5}$)	Low
Greater than one per ten thousand to less than one per thousand (10^{-5} < Cancer Risk $\leq 10^{-4}$)	Moderate
Greater than one per thousand to less than one per ten (10^{-4} < Cancer Risk < 10^{-1})	High
Equal to or greater than one per ten (Cancer Risk $\geq 10^{-1}$)	Very High

An estimated increased excess lifetime cancer risk is not a specific estimate of expected cancers. Rather, it is a plausible upper-bound estimate of the probability that a person may develop cancer sometime in his or her lifetime following exposure to that contaminant.

There is insufficient knowledge of cancer mechanisms to decide if there exists a level of exposure to a cancer-causing agent below which there is no risk of getting cancer, namely, a threshold level. Therefore, every exposure, no matter how low, to a cancer-causing compound is assumed to be associated with some increased risk. As the dose of a carcinogen decreases, the chance of developing cancer decreases, but each exposure is accompanied by some increased risk.

There is general consensus among the scientific and regulatory communities on what level of estimated excess cancer risk is acceptable. The EPA considers an acceptable cancer risk range from 10^{-6} to10^{-4}.