Health Consultation

Kelly Mine: Evaluation of Residential Exposures to Soil Arsenic

Red Mountain, San Bernardino County, California

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
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Health Consultation: A Note of Explanation

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

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

HEALTH CONSULTATION

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Red Mountain, San Bernardino County, California

Prepared By:
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Background

The Bureau of Land Management (BLM) of the Department of the Interior asked the Agency for Toxic Substances and Disease Registry (ATSDR) to review and evaluate environmental data for contaminants at the Kelly Mine site in Red Mountain, California. The Kelly Mine Health Consultation is designed to evaluate if contact with arsenic contaminated soils found in the yards of Red Mountain residents is expected to cause adverse health effects to the residents of Red Mountain. Note: Recreational and occupational contact with soil other than normal residential activities are not evaluated in this consultation.

At one time the Rand Historical Mining Complex Kelly Mine Site (Kelly Mine) located near Red Mountain, CA, was the most significant California silver mine. Operations began in approximately 1919 and continued, sometimes sporadically, to the 1940's. A total of 56 'features' were created during mine operations (BLM 2006a). A mine feature is a man-made, mine waste-associated item such as a mine shaft, waste or tailing pile, or structure. Occasionally other mining companies investigate the area to identify if the minerals present in the native surface and sub-soil, waste rock, or mill tailings are economically recoverable.

The Bureau of Land Management has been studying the historic mine features near Red Mountain residential areas. Results of the initial soil sampling obtained from various Kelly Mine features indicated that at some sampling locations, arsenic is present in the surface soil at levels higher than those typically measured in background soil. Following analysis of the initial soil samples, BLM obtained additional soil samples from residential yards at homes located near mine features when permission could be obtained to do so.

ATSDR reviewed the sampling data from the residential yards to estimate the amount of arsenic Red Mountain residents may get into their bodies from soil. The residential yards of some Red Mountain homes share boundaries with an adjacent waste or tailing pile. During heavy rain events, runoff from the piles may flow through a limited number of residential yards. A small number of residents have reportedly used fill material from mine features to complete landscaping projects in their yards. Clearly, outdoor activity and soil contact is common among the residents. Children have been identified who reside in Red Mountain (personal communication, Libby Vianu, 2008).

High winds are common in this area. Anecdotal information indicates significant 'dust storms' can be generated during the high wind conditions. Currently it is not known if the airborne dust contains surface soil with high arsenic concentrations or if the deposition of airborne dust containing high arsenic concentrations could impact the soil arsenic concentration in Red Mountain yards that are not located adjacent to mine features. Additionally, evidence of off-highway vehicle use on closed trails containing soil with elevated arsenic concentrations was frequently observed in January 2008. Additional dust generation that contributes to the amount of dust that residents breath could be caused by such activity. Monitoring of ambient particulate matter and dust samples in homes could provide more insight into this possibility.

In this high desert environment, most of the yards are bare soil with scattered brush. Visual and anecdotal information indicates residents commonly work in their yards on various projects. Residents are expected to have frequent and direct contact with the soil in their yards. In addition, it is likely that this soil could be tracked into their homes. The surface soils in residential yards adjacent to mine features are shown to have arsenic concentrations above the area's background level of 136 mg/kg (BLM, 2006a).

The levels of arsenic exceed the levels reported in both the Environmental Protection Agency (EPA) Region 9 Preliminary Remediation Goal Table and ATSDR's Soil Comparison Values table. The Bureau of Land Management is performing a human exposure assessment and risk assessment and is in the process of making site reclamation and cleanup decisions. ATSDR used the available soil sampling data to evaluate if the Red Mountain residents could get health effects from the arsenic present in the soil in their yards. However, this health consultation is not a substitute for a risk assessment designed to determine the need for remedial action at the site. A collection of common site related questions and answers regarding the site is presented in Appendix B that summarizes much of the discussion, conclusions and recommendations presented in this document.

The Kelly Mine Health Consultation is designed to evaluate if contact with arsenic contaminated soils found in the yards of Red Mountain residents is expected to cause health problems for the residents of Red Mountain. ATSDR will consider factors such as bioavailability and ways that people may come into contact with contaminated soil. We will then identify the types of human health effects that have been associated with arsenic in past studies. Finally, ATSDR will identify actions that BLM and residents can take to reduce contact with soil arsenic that is associated with the Kelly Mine Site. Note that this report is a human health evaluation and does not replace the need for an environmental assessment to determine if remediation is necessary to bring the site into compliance with environmental regulations.

Discussion

BLM has collected over 160 surface and geoprobe soil samples from the waste rock and mill tailing piles and the Red Mountain Wash and has recently obtained approximately 150 samples from residential yards. All of the samples were analyzed for arsenic and some of the tailings were analyzed for the suite of metals typically occurring in mine waste from this area. Surface samples from the tailings and surrounding areas indicate arsenic concentrations range from 34 to over 7700 mg/kg. Arsenic concentrations in the surface soil and tailings close to, but not in, residential yards ranged from 56 to 1350 mg/kg. In a few places, the mill tailing pile has eroded and tailings have been transported near, or through, residential yards, across Highway 395, and into the Red Mountain Wash.

Soil sampling in yards of homes located adjacent to waste rock piles or mill tailings, or impacted by their runoff was performed in June of 2007 and made available to ATSDR in December 2007. Arsenic concentrations in surface soil (0 to 2" in depth) in the yards ranged from 16 to 1630 mg/kg.

After reviewing the provided environmental data, site history, scientific literature, and community concerns, ATSDR has determined that residents could accidentally ingest small amounts of soil and inhale particulate matter, and the associated arsenic, from dust generated by the windy, arid environment of Red Mountain. Exposure could occur during outdoor activity and a portion of indoor air dust tends to come from outdoor sources. Additionally, gardening and eating home grown vegetables may contribute to arsenic exposure. Most arsenic exposure is expected to occur because dust sticks to the surface of hands and garden vegetables.

Children are estimated to have higher arsenic ingestion than adults, because they tend to engage in activities that increase their soil ingestion exposure, and they weigh less than adults. Additionally children depend on adults for risk identification and management decisions. ***As a prudent public health action, ATSDR recommends that parents and caregivers encourage their young children to frequently wash their hands, especially after playing outside and before eating, and discourage them from ingesting soil.***

Residents can reduce their potential exposure to arsenic in soil by the following:

- Damp mop rather than sweep dust from the inside of homes and vehicles.
- Remove dusty shoes and clothing before entering homes.
- Regularly wash pets that spend time indoors and outdoors.
- Wash hands before cooking, eating, and after outdoor recreational activities.
- Encourage young children to frequently wash their hands, especially before eating.
- Discourage young children from ingesting soil or eating food that has fallen on the ground.
- Cover bare yard soil with clean soil, rock, or a vegetative cover.
- Thoroughly wash home-grown vegetables with a brush.

ATSDR also reviewed information concerning soil contamination and physical hazards found on the Kelly Mine. As a prudent public health action, ***ATSDR recommends that BLM maintain access restrictions to the site to reduce the likelihood that people will unknowingly contacting process waste and risk physical injury by exploring historical mining structures and features.*** ATSDR's complete recommendations to BLM and the residents of Red Mountain can be found in the Recommendations Section of this report.

Evaluation of Available Soil Sampling Data

The following points summarize the background information that was provided and the assumptions used in this evaluation:

1. The high levels of arsenic measured in the waste rock and mill tailing piles resulted from historic mining activities at the Kelly Mine site.
2. The fine-grain sediment in the Red Mountain Wash is mill tailings that were transported to the wash while the mine was operational.
3. Additional erosion and transport of the tailings from the pile towards the wash has occurred during heavy rainstorms.
4. Runoff and sediment from the mill tailings has contaminated some residential yards.
5. Based on currently available information, the background concentration of arsenic in the soil could be as high as 136 mg/kg (BLM 2006a).
6. Some Red Mountain residents could have daily contact with soil in their yards or soil that has been transported into their homes.
7. Residents receive their drinking water from a municipal source that, on average, has not had arsenic levels significantly above the federal Safe Drinking Water Standards.

8. The primary way residents can be exposed to arsenic in the soil is by accidental or intentional ingestion of soil and household dust; secondary exposures are by breathing contaminated dust or eating produce grown in arsenic containing soil.

Data Review of Mill Tailings Areas

BLM conducted soil sampling in a variety of areas around the Kelly Mine Site including residential yards of some homes located near Kelly Mine Study Areas. Figure A.1. shows the sampling from the study areas closest to the Red Mountain community (Areas 1, 2, and 7).

Typically, two samples from each area were taken from discrete locations and a third sample was obtained to represent a composite of the surface soil. Geoprobe samples were taken to assess how the arsenic concentrations varied with depth in the mill tailings (BLM 2006a). Many of the samples near the mill had very high concentrations of arsenic. People could come into contact with this material in residential yards and while exploring historic mill buildings, though the latter exposures would likely be brief and occur infrequently. In addition, there are potential safety concerns associated with exploring these locations, such as abandoned mine shafts, unstable buildings, and collapsing mine service tunnels.

Between two and six composite soil samples were obtained for each of the 23 residential yards and vacant lots sampled. For most yards one of the samples was taken to analyze the variation in arsenic concentration with depth through the upper soil layer. ATSDR reviewed the sampling techniques, analysis methods and quality assurance/quality control (QA/QC) used to analyze the arsenic concentrations in the residential yards in BLM's Draft Sampling and Analysis Plan Removal Site Inspection (BLM 2007). The residential yard sampling results were supplied to ATSDR in the form of figures showing a drawing of each yard and the sample locations and concentrations. No QA/QC information was included with the data. However, the final/interim report will be prepared by the Project QA/QC Officer for BLM and will include analysis of precision, accuracy and completeness data. ATSDR cannot comment on the quality of the residential yard data until the final document is completed and reviewed. Hence, the public health conclusions in this report are supplied with the caveat that no data quality information has been reviewed.

Dr. Christopher Kim of Chapman University has performed geological analysis of soils in the Rand Mining district. One of the discoveries he has made is that arsenic concentration varies according to particle size (Appendix E – Public Comments). This is significant because hand-to-mouth ingestion of soil occurs primarily for particles less than approximately 250 µm in diameter (Calabrese 1996). The larger particles are thought to have low adherence to the skin. Dr. Kim’s work showed that arsenic concentration is increased by up to 2.5 times in particles less than 250 µm in diameter for 6 out of 7 samples, with an average increase of 50% (Table 1). None of the samples are from actual residential yards. The number of samples is very small and, therefore, does not yield conclusive results (EPA 2000). However, the data does show the potential for significant variability of enrichment and implies that “effective” concentrations with respect to exposure are frequently expected to be higher than the bulk arsenic measurements indicate.

Table 1. Arsenic Concentrations in Fines and Bulk (mg/kg)

Location	Bulk Arsenic Concentration	Fines Arsenic Concentration	Enrichment Factor
Red Mountain	21.5	45.4	2.11
Red Mountain	2338.5	2939.6	1.26
Red Mountain	2728.8	3142.5	1.15
Kelly Mine	1647.6	4065.6	2.47
Kelly Mine	1081.5	1981.7	1.83
Kelly Mine	3645.2	3774.2	1.04
Kelly Mine	64.6	46.7	0.72
Average (all)	1646.8	2285.1	1.51
Average (tailings only)	2288.3	3180.7	1.55

Arsenic in Soil

The average background arsenic concentration from sampling locations near the study areas was 136 mg/kg (BLM 2006a). Other studies indicate arsenic concentrations occurring naturally in soil and surficial materials typically range from 1 to 40 mg/kg (ATSDR 2007).

Arsenic can become concentrated in mine waste rock or mill tailings as a result of the mining process. For the Kelly Mine Site area, the arsenic concentrations in the surface soil, tailings and waste rock ranged from 16 to 7718 mg/kg. Table 2 summarizes the arsenic concentrations measured in the soil, tailings and waste rock for various locations. The Comparison Values ATSDR typically uses for cancer and noncancer effects from arsenic in soil are shown in Table 3. Concentrations less than the Comparison Value are considered to be too low to result in health effects under typical exposure scenarios relevant to people. Environmental concentrations greater than the Comparison Value are further evaluated for exposure to the contaminant using site specific information.

The sample locations were intended to capture the contaminated areas and to determine the aerial extent of arsenic contamination for the Study Areas (Areas 1, 2, and 7). For study areas 1 and 2, the sampling data suggests that for the majority of the area, the surface soil arsenic concentration is significantly above the background level (136 mg/kg), whereas the perimeter samples tend to be below background. The potential for Red Mountain residents and visitors to be exposed to arsenic will depend in part on the arsenic concentration of the soil with which they are in contact.

Summary of Measured Data in Mill Areas in the Red Mountain Region

Table 2. Summary of Arsenic Concentrations in Surface Soil Samples from Red Mountain

	Area 1 Concentration (mg/kg)	Area 2 Concentration (mg/kg)	Area 7 Concentration (mg/kg)
Average	852	926	1423
Standard Deviation	642	1277	2681
Maximum	2210	5747	7718
Minimum	46	56	34
Median	781	470	1970
Upper Percentile (95th)	2120	3592	7248
Composite	1709	975	no data

Table 3. Summary of ATSDR Comparison Values for Arsenic in Soil for Chronic Exposure

Comparison Value	Concentration (mg/kg)
Adult Chronic EMEG	200
Child Chronic EMEG	20
Acute EMEG / Pica Child	10
CREG	0.5

Notes:

- EMEG = Environmental Media Evaluation Guide (guide for effects other than cancer).
- CREG = Cancer Risk Evaluation Guide for $1x10^{-6}$ excess cancer risk.
- The regional background level is estimated to be as high as 136 mg/kg.
- Chronic exposure refers to sustained exposure for more than 1 year.
- Acute exposure refers to exposure occurring for less than 14 days.

These sampling results indicate the arsenic concentration in the surface soil throughout most of Study Areas 1 and 2 and at least near the historic mine features of Study Area 7 have arsenic concentrations above the local background concentration and above the ATSDR Comparison Values for both children and adults having daily contact with the soil. As mentioned above, the ATSDR Comparison Values are an estimated arsenic concentration that is *not likely* to cause adverse health effects for people who have daily contact with the soil. It is not a threshold for adverse health effects, but a screening value. Screening values are used in situations like the Kelly Mine Site where people have the potential to frequently contact soil likely having an arsenic concentration above the Comparison Value. When this occurs, ATSDR performs a more detailed assessment.

Summary of Measured Data in Residential Yards

The United States Geological Services (USGS) collected a total of 151 soil samples from 23 residential yards near the mine tailings in Red Mountain, CA during June of 2007. Results from three of the 23 residential yards sampled detected arsenic maximum concentrations between 1000 and 2000 mg/kg in surface soil. Another eight residences were found to have arsenic concentrations between 500 and 1000 mg/kg in surface soil. Additional statistical values of arsenic in soil are also shown in Table 4.

Table 4. Summary of Arsenic Concentrations in Soil from 23 Residences Near Kelly Mine

	Arsenic in Surface Soil (mg/kg)	Arsenic in Soil 2” Deep (mg/kg)	Arsenic in Soil 6” Deep (mg/kg)	Arsenic in Soil 12” Deep (mg/kg)
Mean	419	267	262	213
Standard Deviation	336	310	328	256
Maximum	1630	1430	1510	1060
Minimum	16	49	68	67
Median	275	167	137	112
Percentile (95th)	1072	604	592	697

Shown in Table 5, the arsenic concentrations vary significantly by yard and within individual yards. The sampling effort represents about 33% of the residential properties in Red Mountain. Approximately 80% of the yards have average values above the ATSDR noncancer Comparison Value for adults (200 mg/kg). Additionally, 100% of the yards are well above the noncancer Comparison Values for children (of 20 mg/kg) and pica children (of 10 mg/kg) and the cancer Comparison Value (0.5 mg/kg). Children who eat large amounts of soil have a behavior called soil-pica. Soil-pica behavior is most likely to occur in toddlers as part of their normal exploratory behavior.

Table 5. Surface Soil Bulk Arsenic Concentrations at Individual Residences (mg/kg)

Average	Maximum Detect		Average	Maximum Detect
1266	1630		228	400
845	1400		271	387
526	1230		311	355
544	1020		184	347
736	897		162	269
610	875		229	256
415	821		191	248
669	719		156	229
392	675		184	205
361	655		156	186
457	654		152	174
274	417			

In addition to the varied bulk arsenic concentrations shown in Table 5, the concentration of arsenic in the ingestible fraction of soil may vary even more. Dr. Kim’s enrichment analysis has shown that arsenic was enriched in the ingestible soil fraction of particles for 6 of 7 samples.

However, one of the samples showed lower arsenic concentration in the smaller particle fraction and there was over 300% variability in the enrichment factors. Therefore, it is very important to consider the possibility that the "effective" arsenic concentration for soil ingestion exposures may be higher than the bulk concentrations provided in Table 5. However, exposure estimates for individual yards that incorporate arsenic enrichment would require further analysis to estimate exposures for individual residences.

Studies in populations drinking highly arsenic-contaminated well water and breathing dust with very high concentrations of arsenic showed that noncancer health effects and an increased risk of cancer may occur from arsenic exposure. The environmental pathways of arsenic exposure evaluated in this Health Consultation for this community are from swallowing small amounts of soil containing arsenic, and secondarily from breathing dust and eating vegetables from residents' personal gardens. Drinking water for the communities around the Kelly Mine site has been tested and has not contained levels of arsenic significantly above the federal limit of 10 μg/L on average. Exposures and the potential for health effects from exposure are discussed in the next section.

Potential for Health Effects from Soil Ingestion

Main Concerns
Toddlers may receive doses of arsenic from soil higher than levels shown to cause facial swelling, vomiting and diarrhea from one-time exposures. Older child doses may be higher than levels shown to cause skin lesions and cancers in long term studies.

To determine whether harmful effects might be possible, ATSDR reviewed the literature for studies on short term (acute; less than 14 days), intermediate (between 14 days and 1 year) and long term (chronic; more than 1 year) exposures to arsenic. The findings from numerous studies have documented health effects of arsenic on humans and have established health guideline values. Environmental exposure often occurs by accidental ingestion (that is swallowing) of contaminated soil and household dust. This exposure occurs when people have direct contact with soils in their environment. For instance, when adults work in yards and gardens, contaminated soil or dust particles cling to their hands and clothing. Residents can then accidentally swallow the contaminants when they put their hands on or into their mouths or prepare food. Since people and pets track contaminated soils from outdoors into their homes, exposures can occur while people are in their homes and while they are in their yards. Factors that affect the amount of exposure people have with contaminated soil include:

- Weather conditions – which are likely to reduce contact with outside soil during cold or hot months because people tend to stay indoors more often.
- Outdoor activity - the amount of time someone spends outside gardening or playing.
- Ground cover – soil contact is increased when grass or pavement cover is sparse or bare ground is present.

ATSDR also reviewed findings from scientific studies documenting health effects of arsenic exposure in people. Most of these studies examined what happens to people who drink water contaminated with arsenic. The results of drinking water studies are the best way we have of evaluating health effects from accidentally or intentionally ingesting soil contaminated with arsenic.

ATSDR's description of the possible health effects assumes that the harmful effects that might occur from arsenic in soil are similar to the harmful effects that might occur from arsenic in liquids (for instance, drinking water). Not all the arsenic in soil that is eaten actually gets into the body since some arsenic will pass through the digestive system and out in the feces. Some arsenic is bound so tightly to soil particles that it is much less likely to be absorbed by the lining of the intestinal tract (the gut) than the form of arsenic dissolved in water. This phenomenon of how much arsenic actually crosses the gut and gets into the body is called bioavailability. For instance, if only half of the arsenic in soil is capable of getting into someone's body, the soil arsenic is referred to as being 50 % bioavailable. For the Kelly mine site, ATSDR assumed a high end of bioavailability of 42 % based on an EPA study (Casteel 1997). Soil bioavailability values are variable based on the site-specific nature of the soil. Many studies have shown lower bioavailability in various soils (Roberts 2007). However, the high end value was selected to be protective since data from Red Mountain and Kelly Mine were not available. Additionally, preliminary results indicate that regional bioavailability studies have shown similar bioavailability (Kim 2008).

If someone has eaten recently, the time it takes for arsenic to be absorbed through the gut might increase and this might change the degree to which arsenic will cause harmful effects. Additional uncertainty comes from the studies where arsenic is usually dissolved in water or some other fluid. In such cases, chemicals dissolved in water tend to mix more readily in the contents of the intestinal tract. Since the arsenic is already dissolved in water and in close contact with the intestinal tract, it is likely to be more quickly absorbed by people compared to arsenic bound to soil. Therefore, the health effects that are reported from drinking water studies may overestimate the possibility of health effects in people who ingest soil containing arsenic.

Additional uncertainty involved in deciding whether or not adverse health effects might occur comes from estimating how much arsenic people are exposed to from living in properties with arsenic-contaminated soil. Children and adults can be exposed to arsenic in soil from hand-to-mouth activity. This activity results in varying amounts of ingested soil each day.
In this document ATSDR estimated adult residential exposures to arsenic in soil for residents living near Kelly Mine. Additionally, childhood exposures were evaluated for different age groups and behaviors that may result in different exposures to arsenic in soil.

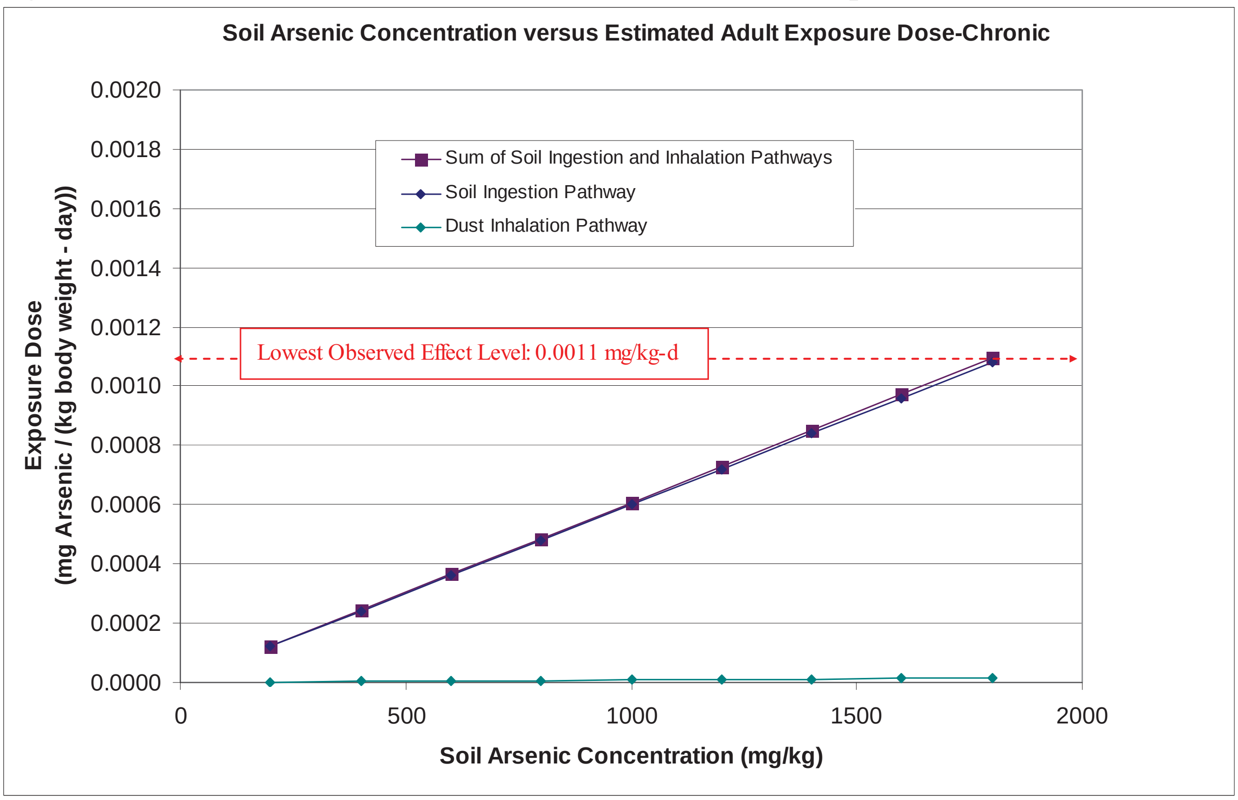
Adult Exposures and Potential Health Effects from Soil Ingestion

ATSDR's screening values are called minimal risk levels (MRLs). The MRLs for acute and chronic exposure to arsenic are respectively 0.005 and 0.0003 milligrams arsenic per kilogram of body weight per day (mg/kg·day). Some exposures to arsenic in Red Mountain are estimated to be higher than these screening values and warrant further evaluation in this health consultation. NOTE: The MRL values are not actually doses at which health effects have been observed. The lowest dose shown to result in health effects has actually been estimated to be around 0.05 mg/kg·day for acute exposure from an episode of arsenic contamination of soy sauce in Japan

(Mizuta 1956). The lowest dose shown to result in health effects for chronic exposure has been estimated to be around 0.001 mg/kg·day for increased risk of premalignant skin lesions in India (Ahsan 2006) and increased incidence of lung cancer in Chile (Ferreccio 1998) from drinking arsenic contaminated water.

Figure 1 shows theoretical arsenic exposure doses for adults from soil. Ingestion of soil from hand-to-mouth contact is expected to cause most of the arsenic exposure from soil, whereas inhalation soil exposures are typically much less significant. Dermal exposures to arsenic in soil have been shown to be negligible in recent studies (Lowney 2007). Soil ingestion for adults is assumed to be 100 mg/day (EPA 2002), which is estimated to be about 1/80th of a teaspoon. One teaspoon of soil weights about 8000 mg. The combined estimated exposure to arsenic from all soil pathways is shown by the line with square symbols in the figure. As can be seen in this figure, combined arsenic doses are not expected to result in health effect levels in adults indicated by the dashed line unless exposure to soil greater than 1800 mg/kg occurs. No residences sampled were shown to have bulk arsenic concentrations greater than 1800 mg/kg.

Figure 1. Soil Arsenic Concentration versus Estimated Adult Exposure Dose - Chronic



Notes:

- The formula and assumptions used to estimate the dose are presented in Appendix C.
- Body weight assumed to be 70 kg (150 pounds) (EPA 2002).
- Soil ingestion rate assumed to be 100 mg/day for adults (EPA 2002).
- Inhalation rate assumed to be 20 m^3/day for adults (EPA 2002).
- Average particulate (PM_{10}) levels assumed to be 28 $\mu g/m^3$ from California EPA monitoring of the Mojave Desert region (CalEPA 2005).

Cancer Health Effects and Studies

ATSDR has developed a cancer screening level called a cancer risk evaluation guide (CREG) for arsenic in soil of 0.5 mg/kg based on a theoretical risk of 1 excess cancer case in a population of 1 million. The CREG is based on skin cancer occurrence in a large number of poor farmers exposed to high levels of arsenic in well water in Taiwan (Tseng 1977). An estimated exposure dose of 0.014 mg/kg·day from water containing an estimated 170 µg/L arsenic was found to cause an increase in skin cancers, whereas the group estimated to be exposed to 0.0008 mg/kg·day from water containing an estimated 9 µg/L arsenic was found to exhibit no adverse effects (ATSDR 2007).

The lowest doses of arsenic shown to cause excess cases of cancer in the ATSDR toxicological profile are summarized in Table 6 below. As can be seen by comparing Tables 6 and 7 to Figure 1, the adult exposures are not expected to result in doses high enough to see noticeable cancer health effects based on epidemiological studies. However, Figure 2 shows that some child exposures to arsenic may be above levels that have shown an increased occurrence of cancer in the toxicological studies from long-term exposures.

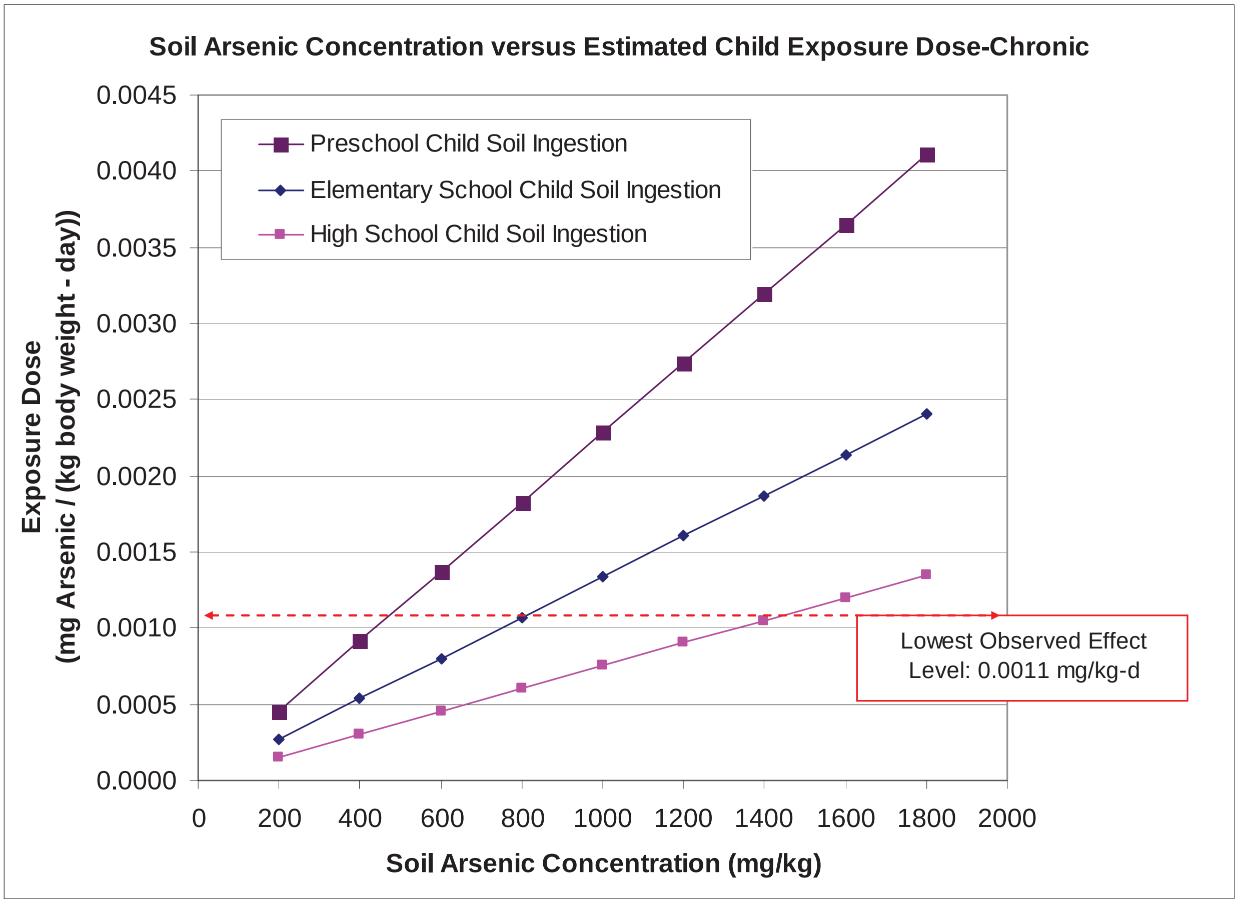
Table 6. Cancer Health Effects Observed from Systemic Exposure to Arsenic

Exposure Dose in Study (mg/kg·day)*	Health Effect Observed	Seriousness of Health Effect	Year of Study
0.0011	Lung cancer	Serious	1998
0.0017	Lung cancer	Serious	2000
0.003	Bladder cancer	Serious	2001
0.0049	Squamous cell carcinoma of the skin	Serious	2001
0.0075	Basal or squamous skin carcinoma	Serious	1996

* Chronic health effects from these human health studies of drinking water exposure as summarized in the ATSDR Toxicological Profile for arsenic (2007).

These studies of cancer in populations exposed to arsenic at certain levels may not account for all factors that affect cancer in other populations. Sun exposure, genetics, age and lifestyle factors such as smoking and diet can affect the risk of forming cancer. Theoretical calculations of cancer risk conservatively consider the sensitivity of some individuals and provide an upper end estimate of cancer risk. Appendix C shows the method used to calculate a theoretical excess cancer risk. The theoretical calculations predict 5 cases of extra cancers per 10,000 adults (5 x 10^{-4} risk) from ingestion of the average arsenic concentration (1266 mg/kg) in the most contaminated yard found in Red Mountain. EPA considers any cancer risk greater than 1 extra case in 10,000 people exposed sufficient to require exposure reduction. For 5 cases per 10,000 people, there is a 0.05% theoretical probability of an adult developing cancer from arsenic exposure to 1266 mg/kg in soil for 30 years. In contrast, the lifetime probability that residents of the United States will develop cancer (includes all cancer types) at some point in their lifetime is 45% for men and 38% for women (ACS 2008).

Figure 2. Soil Arsenic Concentration versus Estimated Child Exposure Dose-Chronic



NOTES:
- The formula used to estimate the dose is presented in Appendix C.
- Soil and dust ingestion rate assumed to be 100 mg/day (EPA 2008).
- Body weight assumed to be 18.6, 31.8 and 56.8 kg for preschool, elementary and high school children, respectively (EPA 2008).

Noncancer Health Effects and Studies

ATSDR has developed a noncancer screening level called a provisional chronic oral noncancer MRL for arsenic of 0.0003 mg/kg·day. A chronic MRL is an exposure level below which non-cancerous harmful effects are unlikely. The chronic MRL is based on a study of Blackfoot Disease (gangrene of the feet) and dermal lesions in a large number of poor farmers exposed to high levels of arsenic in well water in Taiwan (Tseng 1977). Increased incidence of disease was observed at estimated doses of 0.014 mg/kg·day and above, whereas the group exposed to doses of 0.0008 mg/kg·day and below did not exhibit an increase in disease. The chronic MRL is 3 times below the levels shown to have no harmful health effects in the Tseng study (0.0008 mg/kg·day). Additionally, the chronic MRL is based on people being exposed to arsenic dissolved in water instead of arsenic in soil - a fact that might influence how much arsenic can be absorbed. The chronic MRL of 0.0003 mg/kg·day is also about 4 times below the Lowest Observed Adverse Effect Level (LOAEL) of 0.0012 mg/kg·day for increased occurrence of skin lesions in another study (ATSDR 2007). Increased risk of more serious effects (such as stroke) have been observed for long term exposures to levels around 0.002 mg/kg·day (ATSDR 2007). More of the most sensitive noncancer health effects found in studies are summarized in Table 7. As can be seen by comparing Tables 6 and 7 to Figure 1, adult exposures for residents near Kelly Mine are not expected to result in doses high enough to see noticeable noncancer health effects based on epidemiological studies. However, Figure 2 shows that some child exposures to arsenic may be above levels that have shown a significantly increased occurrence of noncancer health effects in the toxicological studies from long-term exposures.

Table 7. Noncancer Health Effects Observed from Systemic Exposure to Arsenic

Exposure Dose in Study (mg/kg·day)*	Health Effect Observed	Seriousness of Health Effect	Year of Study
0.0012	Increased risk of premalignant skin lesions	Less Serious	2006
0.0014	Arsenical dermatosis	Less Serious	2001
0.0017	Decreased performance in neurobehavioral tests	Less Serious	2003
0.002	Increased prevalence of cerebrovascular disease and cerebral infarction	Serious	1997
0.002	Anemia during pregnancy	Less Serious	2006
0.002	Reduced birth weight	Less Serious	2003

* Chronic health effects from these human health studies of drinking water exposure as summarized in the ATSDR Toxicological Profile for arsenic (ATSDR 2007).

Childhood Exposures and Potential Health Effects from Soil Ingestion

ATSDR recognizes the unique vulnerabilities of children from exposure to contaminants in their environment. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. There is also some evidence that suggests that long-term exposure to inorganic arsenic in children may result in lower IQ scores. ATSDR has considered these factors in evaluating potential exposures to children at the Kelly Mine site. Children with soil-pica behavior are a special concern because ingesting high amounts of soil could lead to significant arsenic exposure.

Child and toddler residents have recently been identified by ATSDR as living in Red Mountain, even though there are no schools in this community. If Red Mountain children or visiting children are exposed to the more contaminated soils on or near Kelly Mine, they may experience mild to severe health effects. The likelihood of children experiencing such effects depends on multiple factors. This section includes an evaluation of the potential for child soil exposures to cause health effects based on behaviors seen in studies of other child populations. The susceptible populations discussed in this section include residential and visiting school aged children and toddlers.

School-aged Children

Figure 2 shows estimates of school-aged child soil exposures relative to the lowest level shown to cause health effects from long-term exposures. Many of the assumptions used to calculate the exposures came from the Child-Specific Exposure Factors Handbook released in September of 2008 by the National Center for Environmental Assessment (EPA 2008). The figure shows that preschool, elementary and high school aged children exposed to arsenic levels greater than about 500, 800 and 1400 mg/kg, respectively, may experience levels of arsenic exposure greater than those found to cause health effects in long-term studies. Seven of the 23 yards sampled, about 1/3 of the yards, had average bulk arsenic concentrations greater than 500 mg/kg (Table 5). Two yards had average bulk arsenic concentrations greater than 800 mg/kg and no yards had average bulk arsenic concentrations greater than 1400 mg/kg (Table 5).

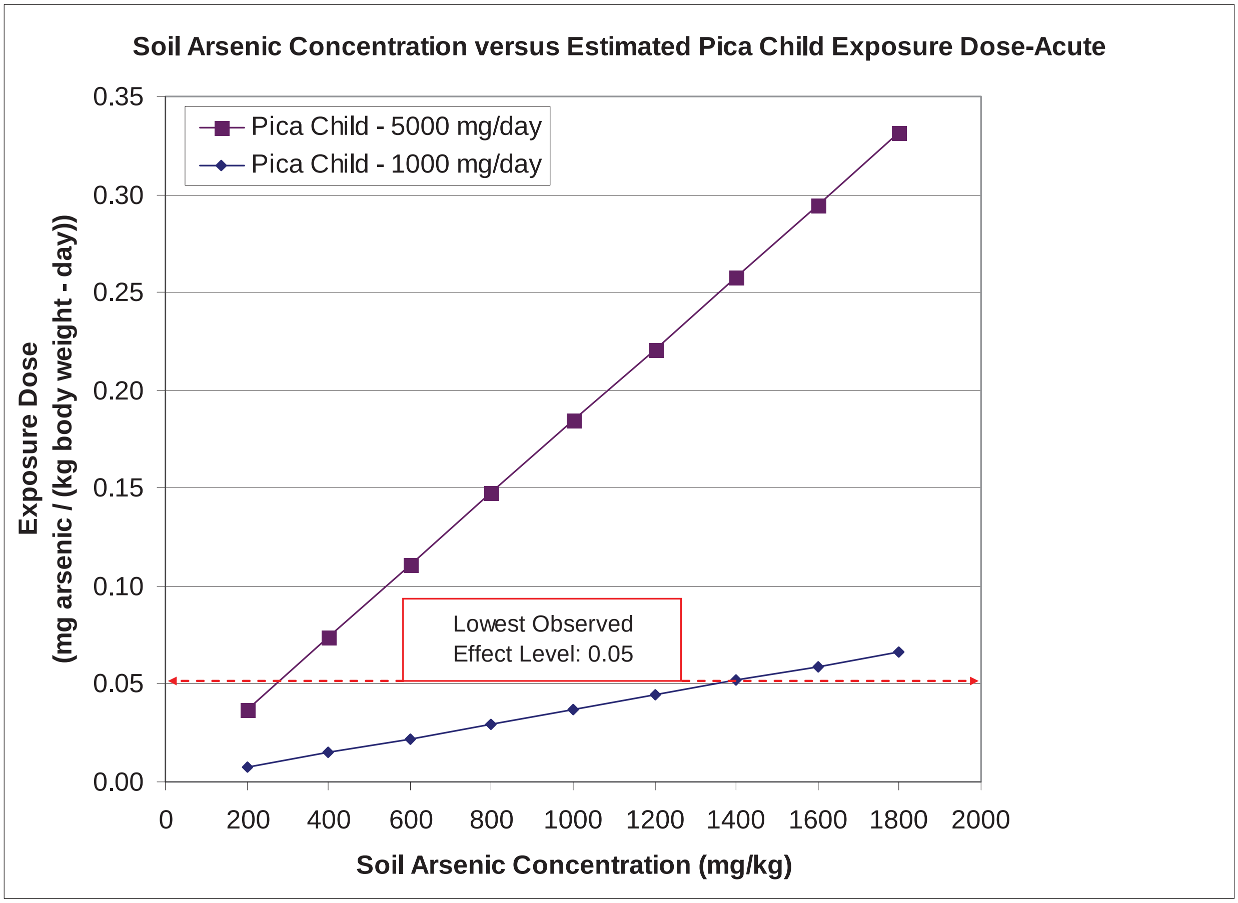
Toddlers

In addition to accidental ingestion, some toddlers (typically 1 to 3 years old) intentionally eat large amounts of soil. This intentional soil ingestion is called soil-pica behavior. Soil pica behavior, although rare, happens occasionally in young children, possibly due to normal exploratory behavior. A recent study of children living near a smelter site in Montana found one child with a soil-pica behavior that had a daily soil intake of 600 mg. Other studies have shown that the amount of soil ingested during a soil-pica episode varies and ranges from levels above 200 mg to a high of 5,000 mg (slightly more than 1/2 teaspoon) or more (extremely rare). General pica behavior is greatest in 1- and 2- year old children and decreases as children age (Calabrese 1993, Calabrese 1998, ATSDR 2005). Various studies have reported that this behavior occurs in as few as 4% of children or in as many as 21% of children (Barltrop 1966, Robischon 1971, Shellshear 1975, Vermeer 1979). Toddlers with pica behavior are a concern because ingesting large amounts of arsenic contaminated soil could lead to significant arsenic exposure and adverse health effects.

ATSDR has generated Figure 3 to show estimates of pica child exposures relative to the lowest level shown to cause health effects from short-term exposures. Many of the assumptions used to calculate the exposures came from the Child-Specific Exposure Factors Handbook released by the National Center for Environmental Assessment (EPA 2008). This handbook states that pica ingestion occurs on the order of 1,000 to 5,000 mg/day, but recommends 1,000 mg/day for daily soil-pica ingestion. As can be seen from the figure, children exposed to arsenic levels greater than about 300 mg/kg for severe pica children (5,000 mg/day) and 1400 mg/kg for a less severe pica child (1,000 mg/day) in a single event may experience levels of arsenic exposure greater than those found to cause health effects in acute toxicity studies. ***Short term exposures may cause health effects such as gastrointestinal upset, facial swelling and upper respiratory symptoms (similar to a head cold).***

The above scenario is significant because two of the 23 yards had maximum bulk arsenic concentrations greater than about 1400 mg/kg, and 16 of the 23 yards sampled had maximum bulk arsenic concentrations greater than 300 mg/kg (Table 5). Therefore, some sampled yards have arsenic levels where children with either extreme or mild pica behavior could be ingesting enough arsenic contaminated soil to experience health effects.

Figure 3. Soil Arsenic Concentration versus Estimated Pica Child Exposure Dose-Acute



NOTES:

- The formula used to estimate the dose is presented in Appendix C.
- Soil ingestion rate assumed to be 1000 and 5000 mg/day (EPA 2008).
- Body weight assumed to be 11.4 kg (EPA 2008).

General Discussion of Childhood Noncancer Exposures and Health Effects

The acute MRL has a safety factor of 10 and is based, in part, on a study of 220 poisoning cases associated with an episode of arsenic contamination of soy sauce in Japan (Mizuta 1956). The safety factor of 10 for the acute MRL is an extra precaution, as the lowest level to show health effects in the Japanese study was estimated to be 0.05 mg/kg·day.

The consumption of the Japanese soy sauce containing approximately 100 mg/L of arsenic occurred over a period of 2-3 weeks. The age of the 46 patients with age information range from 15 - 69. An early feature of the Japanese soy sauce poisoning was the appearance of facial edema that was most marked on the eyelids. Other symptoms presented included multifaceted gastrointestinal symptoms, liver enlargement, upper respiratory symptoms, joint pain, peripheral neuropathy (numbness of the legs) and skin disorders. In the majority of the patients, the symptoms appeared within two days of ingestion and then declined even with continued exposure. There was evidence of minor gastrointestinal bleeding (occult blood in gastric and duodenal juice) (Mizuta 1956).

A separate supporting study reported 2 cases of subchronic (2 months) arsenic intoxication resulting from ingestion of contaminated well water (9-10.9 mg/L) sporadically (once or twice a week) for about 2 months (Franzblau 1989). Acute gastrointestinal symptoms, central and peripheral neuropathy, bone marrow suppression, liver toxicity and mild mucous membrane and cutaneous changes were presented. The calculated dose was 0.03 - 0.08 mg/kg·day based on a body weight of 65 kg and ingestion of from 238 to 475 ml water/day.

The studies used to derive the acute MRL are different from the chronic MRL studies in two ways. The acute MRL involves higher doses, and the exposures occur for shorter periods of time. These two factors make the acute MRL a more appropriate endpoint for evaluating childhood soil exposure, because the nature of childhood behaviors causes them to be exposed to higher concentrations over shorter periods of time.

The acute MRL is based on several temporary effects including: nausea, stomach cramps, vomiting, and diarrhea (or frequent, loose bowel movements), facial swelling, particularly around the eyes, headache, fatigue, chills, sore throat, and nasal discharge.

These effects may occur when exposure doses exceed 0.05 mg/kg·day. However, the effects are based on the Mizuta study where people were exposed to arsenic dissolved in soy sauce instead of arsenic in soil — a fact that might influence how much arsenic can be absorbed.

Figure 3 shows that arsenic concentrations >300 mg/kg in soil yield estimated doses well above acute health effect levels for severe soil-pica toddlers. Yards with very high arsenic concentrations may also lead to exposures that could cause health effects for less severe pica children. Figure 2 shows that estimated preschool and school aged child doses exceed levels shown to cause health effects in longer-term studies for many properties. There is some evidence that exposure to arsenic in early life (including gestation and early childhood) may increase mortality in young adults (ATSDR 2007). Lower intellectual function in children has also been associated with arsenic content in well water for children in Bangladesh, India (Wasserman 2004 and 2007). ***Therefore, ATSDR recommends that resident and visiting children minimize their exposure to soil in yards with elevated arsenic concentrations in Red Mountain near the Kelly Mine site.***

General Discussion of Childhood Cancer Exposures and Health Effects

The studies of cancer in populations exposed to arsenic at certain levels may not account for all factors that affect cancer in other populations. Sun exposure, genetics, age and lifestyle factors such as exposure to cigarette smoke and diet can affect the risk of forming cancer from arsenic exposure. Theoretical calculations of cancer risk conservatively consider many of these uncertainties and provide an upper end estimate of cancer risk. Appendix C shows the method used to calculate a theoretical excess cancer risk. The theoretical calculations show 9 cases of extra cancers per 10,000 children exposed (9×10^{-4} risk). EPA considers any cancer risk greater than 1 extra case in 10,000 people exposed sufficient to require exposure reduction. <u>For 9 cases</u>

per 10,000 people, there is a 0.09% theoretical probability of a child developing cancer from arsenic exposure to 1266 mg/kg for 6 years (the duration of childhood). In comparison, the lifetime probability that children of the United States will develop cancer by age 14 is 0.141% for females and 0.161% for males (ACS 2009) and smaller for children less than 14 years of age.

Dust Inhalation

General Health Effects of Dust Inhalation

Fugitive dust can be caused by dry windy conditions and human activities. The concerns for human health from breathing particulate matter smaller than 10 µm diameter (PM_{10}) (regardless of arsenic content) include increased coughing, difficulty breathing, irregular heartbeat, heart attack and premature death. The elderly, children and people with chronic lung disease, influenza or asthma are especially sensitive to the effects of particulate matter.

Currently, no air sampling data exists specifically for Red Mountain. However, the California EPA, Air Resources Board monitors dust in six locations across the Mojave Desert (Table 8) and found the annual average PM_{10} for 2003 was 28 µg/m^3, whereas the 24-hour maximum was 169 µg/m^3 (CalEPA 2005). The Mojave Desert average of 28 µg/m^3 is well below the EPA National Ambient Air Quality (NAAQ) PM_{10} standard of 50 µg/m^3, but the highest daily level of 169 µg/m^3 slightly exceeds the EPA NAAQ 24-hour standard of 150 µg/m^3 slightly.

Table 8. Mojave Desert Dust Levels Compared to EPA Standards

Information Source	PM_{10} Concentration (µg/m^3)
Mojave Desert Dust Levels from California EPA Monitoring	Annual Average = 28 µg/m^3 (2003) 24-hour Maximum = 169 µg/m^3 (2003)
EPA PM_{10} Standard	Annual Average = 50 µg/m^3 (2003) 24-hour Maximum = 150 µg/m^3 (2003)

Therefore, reducing exposure to dust on days during the most extreme dust conditions is recommended. However, the annual exposures to dust by inhalation at Red Mountain should not be of concern for residents.

Health Effects of Arsenic-Laden Dust Inhalation

In the outdoor environment, people can be exposed to arsenic in soil from breathing and swallowing contaminated soil particles during dusty conditions. As was seen in Figure 1, systemic exposure to arsenic by inhalation is negligible compared to ingestion exposure. However, some studies have shown that there is potential for direct effects on the lung while breathing arsenic contaminated dust. Table 9 summarizes the lowest levels of inhaled arsenic found in the ATSDR toxicological profile to cause excess cancer cases in workers.

Table 9. Health Effects Observed from Inhalation Studies of Exposure to Arsenic in Dust

Air Concentration (µg arsenic/m^3)	Health Effect Observed	Seriousness of Health Effect	Year of Study
50	Lung cancer	Serious	1989
78	Mild pigmentation and keratosis of the skin	Less Serious	1948
310	Decreased nerve conduction velocity	Less Serious	1994
360	Increased vasospasticity and clinical Raynaud's phenomenon	Serious	1986
613	Pigmentation changes, hyperkeratinization of exposed areas, wart formation	Serious	1948

An estimated worst case scenario exposure to arsenic dust in residents' yards can be calculated using the maximum arsenic concentration detected in Red Mountain yards (1630 mg/kg) and dust levels from the severe 1991 dust storm in Antelope Valley (PM_{10} of 780 µg/m^3) (Farber 2004):

$$1630\ \frac{\text{mg arsenic}}{\text{kg soil}} \times 780\ \frac{\mu\text{g soil (dust)}}{\text{m}^3} \times 0.000001 \text{ (unit conversion factor)} = 1.27\ \frac{\mu\text{g arsenic}}{\text{m}^3}$$

Since the worst case scenario exposure to arsenic from inhalation (1.27 µg/m^3) is well below the lowest levels shown to cause health effects in smelter workers (50 µg/m^3; ATSDR 2007), ATSDR would not expect to see actual cases of cancer or noncancer health effects from inhalation of dust from residential yards in Red Mountain. However, since arsenic has been shown to cause cancer at higher doses, a reduction of exposure to arsenic may theoretically decrease individuals' potential of getting cancer.

Uncertainty

Several key uncertainties should be taken into account when considering the estimation of arsenic exposures and health effects from soil and dust at the Kelly Mine Site:

- Uncertainty is inherent in estimating how much arsenic gets into the blood stream and tissues once soil-bound arsenic is ingested (called bioavailability). Bioaccessibility studies underway may yield more information in this regard.
- Harmful effects observed in people exposed to arsenic in drinking water, which is readily absorbed by the body, may not be similar to the effects of people exposed to arsenic bound to soil, which is likely to be less absorbed by the body.
- Uncertainty exists in making the exposure estimates for human studies that were used to develop health guideline values.
- Desert environments, with less vegetative cover than found in more temperate climates, may result in more exposure to dust and soil.
- Enrichment of arsenic in different particle sizes of soil may increase (or decrease) the "effective" arsenic concentration in soil, as compared to the bulk concentration.
- QA/QC for soil samples reviewed in this report, including data qualifiers, were not available for ATSDR review.

- Exposure to “hot spots,” areas of unusually high concentrations of contaminants, may occur. Residents are typically exposed to average levels of contaminants in residential yards, unless a particular spot has a unique characteristic causing the majority of exposure to occur there. Many Red Mountain residents appear to have landscaping throughout their yards, which would mean that averaging soil concentrations is an appropriate way of evaluating exposure. However, residents should keep in mind the definition of “hot spots” when considering their individual susceptibility to soil arsenic exposure.

Lifestyle Factors Affecting Arsenic Toxicity

At least one study has shown that smoking and sun exposure increase the potential for skin lesions when arsenic exposure occurred from drinking contaminated well water (Chen 2007). Therefore, limiting smoking and sun exposure are advised for residents living near Kelly Mine. The effect from smoking was found to be synergistic, i.e., the potential for skin lesions from the two factors combined was greater than the potential from the sum of the individual factors.

Nutrition is also thought to play a role in protecting against health effects from arsenic. One of the key mechanisms of arsenic toxicity is thought to be the production of reactive oxidative species in the body. Fruits and vegetables, which are high in antioxidant species, are recommended as part of a well balanced diet for overall health and may be helpful in alleviating toxic effects from arsenic in the body (Anetor 2007). Additionally, folic acid, commonly found in green leafy vegetables, has been found to play a role in the mechanism of eliminating arsenic from the body (Gamble 2007). The use of supplements is becoming increasingly common in the U.S. However, overdosing from supplements is also becoming more common. Therefore, caution should be practiced not to exceed the Upper Tolerable Intake Levels recommended by the National Institute of Medicine if supplements are used (IOM 2002).

At least one study has shown that low levels of arsenic exposure may stimulate the body’s protective mechanisms against toxins causing oxidative damage (Snow 2008). The health benefits of low doses of common toxins are still being investigated by many researchers. Additionally, the toxic effects of chronic arsenic ingestion may be increased in populations that are also subject to malnutrition. Some studies showed that higher intakes of dietary protein, calcium, vitamin B-12, niacin and choline may assist the body in metabolizing inorganic arsenic to organic arsenic (the less toxic form).
The following website of the U.S. Department of Agriculture may assist in maintaining or developing healthy personalized eating plans: http://www.mypyramid.gov.

Vegetable Gardening and Residential Outdoor Activities

Eating fruits and vegetables and getting plenty of exercise are essential parts of a healthy lifestyle. People enjoy many activities in their yards and gardens, which provide places both for exercise and for growing fresh vegetables. Unfortunately, some residents of Red Mountain near Kelly Mine have arsenic in their soil at elevated levels and wish to reduce their exposure to the lowest possible level. Activities such as gardening, playing and working in the yard can increase residents' opportunity for exposure even though the activities are healthful. The information below explains how to reduce the chances of exposure without giving up outdoor activities that are healthful and enjoyable. Understand that each property is different. Some of the tips outlined may not apply to all situations.

Plants vary in the amount of arsenic they absorb from the soil and where they store arsenic. Some plants move arsenic from the roots to the leaves, while others absorb and store it in the roots only. Fruit-type vegetables such as tomatoes concentrate arsenic in the roots and very little arsenic is taken up in the edible portion of the plant. Leafy vegetables also store arsenic in their roots, but some is also stored in the stems and leaves. Lettuce and some members of the Brassica plant family such as collards, kale, mustard, and turnip greens store more arsenic in the leaves than do other crops. Root crops such as beets, turnips, carrots, and potatoes absorb most of the arsenic in the surface skin of the vegetable (ATSDR 2003). However, the uptake of arsenic internally is less when soils are sufficiently balanced (Walsh 1977).

The type of arsenic present and the amount of arsenic that gets absorbed into the body determines whether or not eating vegetables contaminated with arsenic will cause health effects. Studies have shown that vegetables can have the toxic forms of arsenic (inorganic) present in the edible portions of garden vegetables (Juhasz 2008, Iriskoch 2000). Additionally, a recent study demonstrated that almost 100% of the arsenic in vegetables can be absorbed by eating (Juhasz 2008). The Food and Agriculture Organization/World Health Organization (FAO/WHO) has assigned a Provisional Tolerable Daily Intake (PTDI) for arsenic of 0.0021 mg/kg BW-day (ATSDR 2007). A recent study that modeled arsenic exposures in the U.S. from air, food, drinking water and soil found that food was the highest source of inorganic arsenic, followed by drinking water, soil and air (Georgopoulos 2008). Unfortunately, there is not enough information available in the scientific literature to determine if all vegetables that may be grown and consumed at Red Mountain could result in arsenic exposures that could result in health effects.

Red Mountain soils are not expected to be suitable for gardening, due to the lack of organic matter and nutrients required to sustain most plant life enough to yield produce. ***Above ground gardens isolated from the native soil and filled with proper garden soil are recommended for Red Mountain vegetable garden enthusiasts.*** Additional suggestions for home gardeners to reduce potential arsenic exposure include:

- Keeping soil at a near-neutral range (pH 6–7) can help reduce the amount of arsenic absorbed in plants.
- Maintaining well balanced garden soil can help reduce arsenic absorption.
- Adding a balanced commercial fertilizer to soil can help maintain correct levels of key plant nutrients. Organic matter from sources such as peat moss, mulch, compost and manure binds to arsenic and reduces how much plants take up.

Area gardening shops should be able to recommend materials for building above ground beds. Some types of wood intended for construction uses (e.g. pressure-treated lumber or railroad ties) should not be used for vegetable gardens due to treatment with chemical preservatives, such as copper-chromated arsenate or creosote. Area agricultural extension offices are also an excellent resource for all types of gardening information.

Concentrations of arsenic in soil are typically expected to be much greater than concentrations taken up by vegetable garden plants, especially in enhanced soils. Therefore, the best method of reducing exposure to arsenic from home-grown vegetables is to soak and wash residual soil from produce before bringing it into the home and washing the produce again thoroughly indoors before eating. Commercial vegetable cleaning products (sold at many supermarkets) or vinegar, water, and a scrub brush are most effective at removing residual soil particles from produce (Peryea 1999). It is always a good health practice to wash all fruits and vegetables thoroughly before eating, whether they are bought or homegrown. This reduces exposure to germs and pesticides, in addition to soil contaminants. Peeling root vegetables such as potatoes, carrots and radishes is advised before eating. These peelings should not be composted and reintroduced to the garden.

Other precautions may also be followed to minimize exposure to contaminated soil while engaging in recreational or vegetable gardening activities. These may include washing hands after working in soils and avoiding smoking while working with soil to reduce accidental ingestion of soil. If used properly, dust masks (N95 rating) can help reduce inhalation of dust during outdoor work. It is important to follow manufacturers' recommendations for use and storage. Dampen the soil before dust generating activities. Designate specific clothes, shoes, gloves and tools to use for gardening or other backyard activities. These items can be washed and stored independently and not transported into the house to prevent arsenic contaminated soil from getting in the home.

Some tips for reducing arsenic soil and dust levels in the home:

- Remove work and play shoes before entering the house.
- Damp-mop floors and wipe down counters, tables, and window ledges regularly.
- To reduce dust levels in the home, consider upgrading to a vacuum cleaner that uses a HEPA (high-efficiency particulate air) filter or simply change the bags more often.

Comparison of ATSDR's Health Assessment with Other Agencies' Risk Assessments

Regulatory agencies and ATSDR use different methods to protect public health which are complementary. CERCLA standards and other regulatory requirements for the clean up of contaminated sites are determined through risk assessment procedures and include considerations for human health, wildlife protection, environmental protection factors, and future use scenarios. These factors will often result in regulatory clean-up levels that are below levels expected to result solely in human health effects for the current exposure scenario at a particular site clean-up. ATSDR supports the regulatory requirements for stringent clean-up of hazardous waste sites. ATSDR is not a regulatory agency. As a public health protection agency, ATSDR estimates actual levels of exposure and uses current scientific literature to evaluate the potential for health effects and makes recommendations to protect the public. ATSDR also strives to educate people on the results of actual health studies and how their individual exposures compare to exposures that have shown health effects in the studies. Appendix D of this document contains a fact sheet further explaining the differences between ATSDR public health assessments and risk assessments.

Conclusions

Some residential yards bordering the Kelly Mine site have been shown to have more than 1,000 mg arsenic per kg soil (1,000 ppm). Although these levels are significantly higher than ATSDR's health-based screening levels, we do not expect that adult residents would experience health problems from contact with residential soil in Red Mountain. However, residents could be at greater risk of potential health effects if they are exposed to elevated levels of arsenic in the soil in combination with elevated levels of arsenic in the drinking water and/or UV rays (from spending periods of time outdoors in the sun without protection like sunscreen and a hat). Children, however, are a more susceptible population and could experience adverse health effects under certain conditions. Health effects that have been observed in toxicological studies from long term contact with arsenic include skin lesions and neurobehavioral, cardiovascular and blood effects, in addition to an increased potential of getting cancer. Short-term contact with high arsenic levels in drinking water have been observed to cause gastrointestinal upset, facial swelling and respiratory symptoms in studies. Specific recommendations are provided below regarding adult and child contact with arsenic contaminated soil in Red Mountain.

On the basis of the available environmental data, ATSDR concludes the following:

Conclusion 1. ATSDR concludes that small children accidentally or intentionally swallowing up to about a half a teaspoon of the most contaminated soil at one time could become ill. This is a public health hazard.

Basis for Decision 1. ATSDR has identified that children live in the Red Mountain community. If children reside in or visit homes with yards that contain elevated arsenic concentrations and engage in behavior that results in eating an excessive amount of soil, they may experience adverse health effects such as gastrointestinal upset, facial swelling and respiratory symptoms. Children or infants who consume up to about a half a teaspoon of soil (pica children) could experience acute arsenic toxicity from a one time contact with soils in areas of elevated arsenic concentrations.

Conclusion 2. ATSDR concludes that children accidentally or intentionally swallowing soil with elevated arsenic and breathing arsenic contaminated soil for greater than one year could harm their health. The reason for this is children could contact levels of arsenic over time that caused health problems in toxicological studies. Additionally, there is a theoretical increase in the chance of developing cancer, and minimizing contact with arsenic contaminated soil in Red Mountain is advised. This is a public health hazard.

Basis for Decision 2. Preschool and school aged children could contact levels of arsenic over time that are greater than the lowest effect levels seen in chronic toxicological studies. Effects seen in these studies include skin lesions and neurobehavioral changes. Children also theoretically have an increased chance of getting cancer from arsenic in soil. Swallowing and breathing average soil concentrations from the most contaminated yard sampled have a 0.09% theoretical increased risk of developing cancer from the soil arsenic. Children's lower body weight and higher intake rate result in a greater dose of hazardous substance per unit of body weight than adults. Recommendations, such as supervision, hand washing and changing dirt-laden clothes and shoes, are presented in the following sections advising methods to prevent excessive soil contact. Parents and guardians should also consider the health benefits of outdoor activities for children and observe precautions when outdoor activities are in contaminated or potentially contaminated areas.

Conclusion 3. ATSDR concludes that adults accidentally swallowing arsenic contaminated soil and breathing arsenic contaminated dust at the site are not expected to harm people's health. However, there is a theoretical increase in the chance of developing cancer, and minimizing contact with arsenic contaminated soil in Red Mountain is advised.

Basis for Decision 3. ATSDR has estimated contact with soil based on normal behavioral activities and found them to be below levels shown to cause health problems in toxicological studies. However, there are always uncertainties in evaluating the potential for health effects from contact with chemicals in the environment. Adults theoretically have an increased chance of getting cancer from contact with arsenic in soil. People swallowing and breathing average soil concentrations from the most contaminated yard sampled have a 0.1% theoretical increased risk of developing cancer from the soil arsenic contact. Residents who perform landscaping, gardening, or outside mechanical work may have contact with higher levels of soil arsenic and may receive higher doses than those who do not engage in such activities. However, the health benefits of outdoor and physical activities are expected to outweigh any concerns for adverse health effects. This report outlines some methods to use for reducing arsenic contact while still engaging in normal healthful activities.

Conclusion 4. ATSDR concludes that unstable mine structures, shafts and mounds in Red Mountain could harm people's health. This is a physical public health hazard. BLM has constructed fences and placed warning signs around Kelly Mine's areas posing physical hazards. Signs should be observed and the fenced areas and other mining structures, shafts and mounds present in the area should be avoided to prevent injury.

Basis for Decision 4. BLM has constructed fencing and placed warning signs around Kelly Mine's unstable mining features that could pose a physical public health hazard. These controls should be observed to prevent harm to visitors or residents in the area. In addition to Kelly Mine's hazardous features, other historic mines and mine features are present in the Red Mountain area. Unstable mining structures, shafts and mounds could collapse when disturbed and cause physical harm and should be avoided.

Recommendations to the Bureau of Land Management

ATSDR proposes the following recommendations to BLM for minimizing future exposures that could impact public health in the vicinity of Kelly Mine:

- Maintain access restrictions to all areas of the site known to contain process waste or unstable mining features.
- Educate community members to minimize their exposure to soil from highly contaminated areas. Advise people to wash their hands before eating and drinking, to garden wisely, and to protect children in the area.
- ATSDR supports BLM's efforts in conducting indoor dust sampling, backyard soil sampling, and biomonitoring of residents in Red Mountain and surrounding communities. Bioavailability testing could identify if the arsenic in the soil can be easily absorbed. Biomonitoring of speciated arsenic in urine is one indicator of current ongoing arsenic exposure in the community. Although biomonitoring is not definitive regarding how someone was exposed or the relationship between exposure and health effects, it can support interventions targeted at reducing and eliminating harmful exposures.
- Determine an appropriate remediation level and assess, remove, stabilize, or permanently cover contaminated soil in residential yards.
- Continue existing efforts to prevent uncontrolled releases of mine waste containing hazardous substances.
- Develop comprehensive site safety and health plans for remedial activities to address all potential health and physical hazards associated with actions selected.
- Conduct air sampling in such a manner that could determine if PM_{10} and airborne metal concentrations are below levels that could harm human health.

Recommendations to the Residents of Red Mountain

A number of residential yards in Red Mountain are impacted by arsenic containing mine tailings that have migrated from the facility onto private property. The individuals that had samples taken by BLM may use the information in this consultation to better understand their exposures to arsenic in their yards and their potential for health effects. Others may use the information herein to learn about the contamination in their community. The following recommendations outline methods to reduce exposure to soil in yards with elevated arsenic concentrations.

- Wash hands before cooking, eating, and after outdoor recreational activities.
- Encourage young children to frequently wash their hands, especially before eating.
- Discourage young children from ingesting soil or eating food that has fallen on the ground.
- Discourage children from visiting areas shown to have high arsenic levels.
- Remove dusty shoes and clothing before entering homes and bath pets frequently.
- Damp mop rather than sweep dust from the inside of homes and vehicles.
- Locate vegetable gardens in above-ground beds with uncontaminated garden soil.
- Thoroughly wash homegrown vegetables and peel homegrown root vegetables before eating.
- Cover bare yard soil with clean soil, rock, or a vegetative cover.

In addition to minimizing soil exposure, minimizing smoking and sun exposure may decrease the potential for health effects from arsenic exposure. Maintaining a well balanced diet that contains recommended amounts of fruits and vegetables for overall health may also be helpful in alleviating toxic effects from arsenic in the body.

Public Health Action Plan

The purpose of the public health action plan (PHAP) is to ensure that this health consultation goes beyond presenting ATSDR's conclusions and recommendations about public health issues at the Kelly Mine site. The PHAP describes actions that are designed to stop or prevent harmful effects resulting from exposure to hazardous substances at the site.

ATSDR will work with BLM to disseminate educational materials to the community members about minimizing hazards of exposures to arsenic-laden soil near the Kelly Mine site. Methods of accomplishing this may include:

- Send fact sheets by mail to residents
- Provide area schools with fact sheets
- Meet with community representatives
- Hold public availability sessions

ATSDR will work with BLM to evaluate the usefulness of sampling plans for evaluating public health hazards.

ATSDR will work with BLM to evaluate the protectiveness of remedial action plans.

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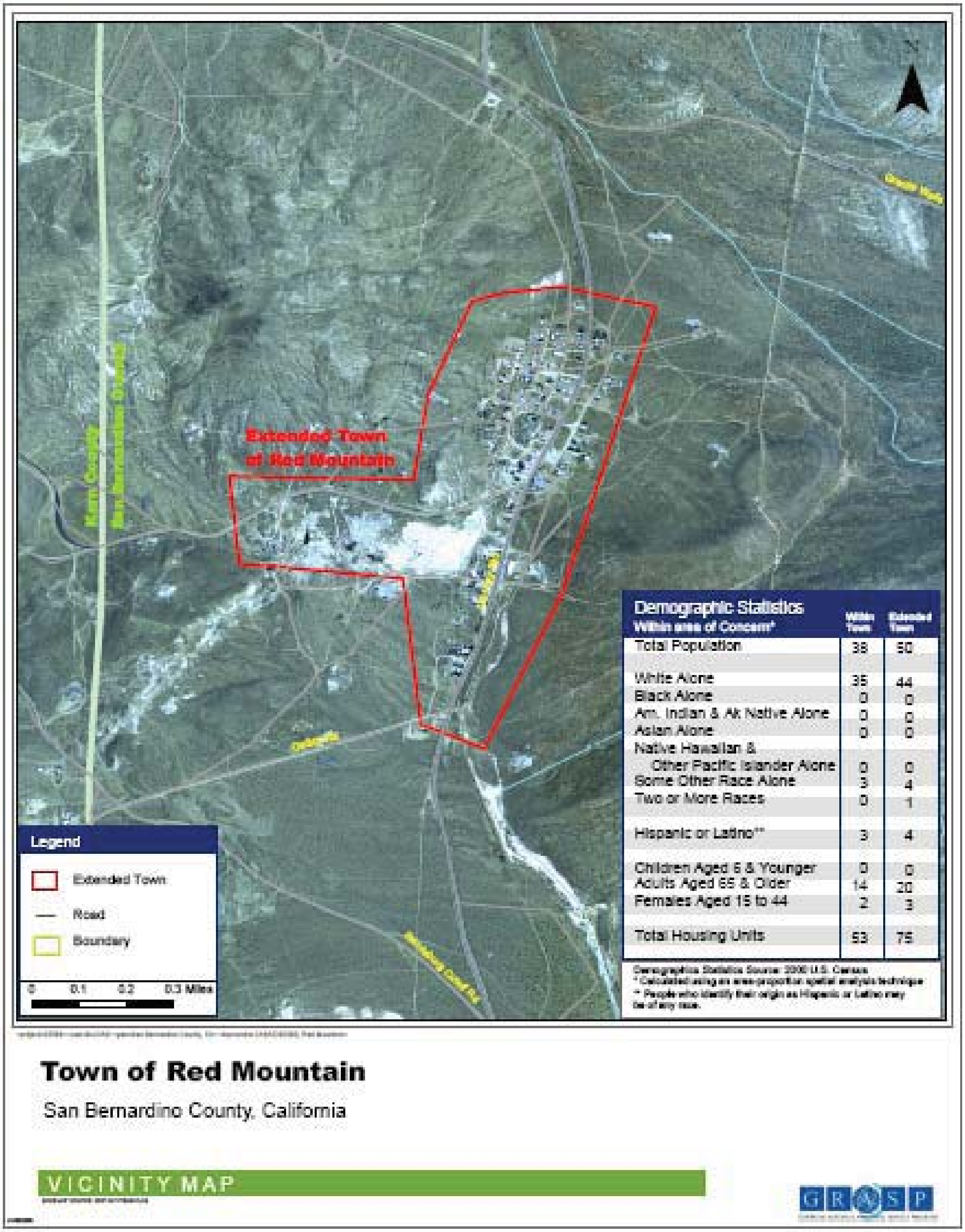
Appendix A - Site Information Maps

Figure A.1. Location of Kelly Mine Areas 1, 2, and 7 (BLM 2006a).

Figure A.2. Demographic Statistics of Red Mountain, CA.



Appendix B – Common Site Related Questions and Answers

Why is ATSDR performing a Health Consultation in Red Mountain?

ATSDR was petitioned by the Bureau of Land Management to determine if arsenic exposures from the Kelly Mine site will affect the health of members of the Red Mountain community.

What information was used to conduct the Health Consultation?

ATSDR reviewed soil sampling results from the U.S. Geological Survey. The concentrations of arsenic in the soil at the Kelly Mine site and in areas where site soils have migrated were found to exceed those of background levels in similar areas. Approximately one third of the residential properties were sampled.

Will community members experience health effects from Kelly Mine arsenic?

All of the residential properties sampled had soil averages exceeding the health-based screening levels for child exposures. Eighty percent of the properties sampled had soil averages exceeding the screening levels for adult exposures. ATSDR evaluated how often community members are expected to be exposed to the soil. Adult exposures were estimated to be below levels shown to result in health effects from arsenic in scientific studies. However, young children who may intentionally ingest large amounts of soil in residential yards near the mine areas may be exposed to levels where health effects have been reported in scientific studies.

What kinds of health effects might children experience from Kelly Mine arsenic?

The most common symptoms from high levels of short-term exposure include swelling of the face (especially the eyelids) or legs, nausea, vomiting, diarrhea and appetite loss. These symptoms begin to occur around two days after exposure and typically subside day by day thereafter, even with continued exposure. Numbness in the legs occurs in some cases beginning between 10 to 20 days after exposure. Other symptoms that have occurred from arsenic exposures include: redness and swelling at the sight of skin exposure, "pins and needles" sensation in hands and feet, small "corns" or "warts" on the palms of the hand or soles of the feet, skin rash, abnormal reflexes and low red and white blood cell counts. If any of the above symptoms occur and may be the result of childhood exposure to arsenic contaminated soil in Red Mountain, a physician should be consulted.

Will community members get cancer from Kelly Mine arsenic?

Arsenic is a known human carcinogen, and there may be some theoretical risk associated with any exposure to arsenic. However, the levels of arsenic in the Red Mountain community are not expected to cause an observable increase in cancer cases. The theoretical probability of an adult developing cancer from arsenic exposure to 1266 mg/kg in soil for 30 years is 0.05%, in contrast to the normal probability that residents of the United States will develop cancer at some point in their lifetime (45% for men and 38% for women (ACS 2008)). The theoretical probability of a child developing cancer from arsenic exposure to 1266 mg/kg for 6 years (the duration of childhood) is 0.09%, in comparison to the normal probability that children of the United States will develop cancer by age 14 (0.141% for females and 0.161% for males (ACS 2009)). The types of cancers that have been reported from long-term exposure to very high levels of arsenic in drinking water in foreign countries include: squamous and basal cell cancer of the skin, bladder, liver and urinary tract. Lung cancer has occurred from occupational exposures to very high levels of arsenic in dust from smelters.

Did ATSDR evaluate arsenic exposure from drinking water?

ATSDR contacted the Rand Communities Water District office to inquire about arsenic levels in Red Mountain's drinking water. The Federal Safe Drinking Water standard for arsenic is 10 micrograms per liter (µg/L). The arsenic levels in Red Mountain's municipal water supply have slightly exceeded the Federal Safe Drinking Water standard in the recent past. However, drinking the water in Red Mountain is not expected to result in health effects for Red Mountain residents. The water district is taking action to come into compliance with Federal drinking water standards.

Did ATSDR make any recommendations to community members?

Yes. ATDSR's health consultation shows the normal ranges of soil exposures for adults and children. ATDSR explains how residents with children living in or visiting their homes can minimize excessive soil exposures to those children. Examples of ways to minimize soil exposure include frequent hand-washing, discouraging children from consuming soil or eating food that has fallen on the ground, removing dusty shoes before entering homes, bathing pets frequently, damp mopping, above-ground gardening, washing home-grown vegetables before consumption and providing ground-cover for yards. Prudent public health measures call for all citizens to minimize their soil exposures, such that they do not have unusually high soil intake rates. Community members are also encouraged to take action to stop smoking and reduce sun exposure which may increase susceptibility to cancer from long-term arsenic exposure. Finally, maintaining a well balanced diet that contains recommended amounts of fruits and vegetables may be helpful in alleviating toxic effects from arsenic in the body

Did ATSDR make any recommendations to the Bureau of Land Management?

Yes. ATSDR recommends that the Bureau of Land Management continue to take actions to reduce exposure to arsenic contaminated soils from Kelly Mine, until the contaminated soils are permanently removed, stabilized or covered. ATSDR also suggested that biological monitoring of arsenic exposures in the community and air sampling be conducted to further evaluate exposures to community members. Additionally, ATSDR recommends continued efforts to educate community members about ways to minimize their arsenic exposures.

Appendix C – Exposure and Risk Calculations

Formulas:

Exposure Dose from Daily Ingestion of Soil = C x IR x BF x EF x CF / BW

where:

C = Arsenic Concentration, mg/kg

IR = Intake Rate, mg/day

BF = Bioavailability Factor, unitless

EF = Exposure Factor, unitless

CF = Conversion Factor, kg/mg

BW = Body Weight, kg

Exposure Dose from Daily Inhalation of Soil (Dust) = C x D x IR x EF / BW

C = Arsenic Concentration, mg/kg

D =Dust Level, kg/m3

Cancer Risk from Ingestion and Inhalation Soil Exposure =

$$\frac{SFo \times C \times (1E\text{-}06) \times EF \times ED \times IRsoil}{BW \times AT \times 365} + \frac{SFi \times C \times EF \times ED \times IRair(1/PEF)}{BW \times AT \times 365}$$

where:

SFo = EPA's Oral Cancer Slope Factor, 1.5 $(mg/kg \cdot day)^{-1}$

SFi = EPA's Inhalation Cancer Slope Factor, 15 $(mg/kg \cdot day)^{-1}$

ED = Exposure Duration, 30 years for adults and 6 years for children

IRair = Intake Rate of air (Inhalation Rate), 20 m^3/day for adults and 15 m^3/day for children.

PEF = Particulate Emission Factor, 3.57E+07 m^3/kg from the regional dust average of 28 $\mu g/m^3$

AT = Averaging Time, 70 years

General Assumptions:

- Bioavailability (BF) of the arsenic in the soil (the amount absorbed by the body after ingestion) was assumed to be 42% based on an EPA study (Casteel 1997). Regional bioavailability studies have indicated similar bioavailability (Kim 2008).

- Exposure factor assumed to be 1 based on exposure every day.

Appendix D –ATSDR Fact Sheet: Comparison of Public Health Assessment and Risk Assessments

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Comparison of Public Health Assessments and Risk Assessments

Issue	Public Health Assessments (PHA)	Risk Assessments (RA)
What it is:	■ A process to evaluate exposure to chemicals in the environment and the impact of those exposures on public health ■ It defines likely exposure pathways anc potentially exposed populations to address community health concerns ■ It recommends actions to protect public health	■ A process to provide risk managers and the community with an understanding of the potential human health risk posed by a site in the absence of any cleanup ■ A transparent assessment process for making consistent remedial decisions that are protective of human health and ecological receptors ■ It estimates unacceptable risks as defined by regulatory standards and requirements
What it is not:	■ A medical evaluation ■ A health study ■ A regulatory document ■ An evaluation of ecological risks	■ A prediction of the likely health effects from exposure ■ A document containing public health recommendations
Data / Information Used	■ Environmental & biologic data ■ Community health concerns ■ Health effects data (i.e., epidemiological, toxicological, and health outcome data) ■ Site-specific exposure considerations ■ Health guidelines to screen for chemicals needing further evaluation	■ Environmental data ■ Remedial goals ■ Toxicity data ■ Default and site specific exposure assumptions ■ Regulatory guidelines to determine unacceptable risk that need to be addressed through remediation

Issue	Public Health Assessments (PHA)	Risk Assessments (RA)
Health Guidelines Used	For Screening: ■ Minimal Risk Levels (MRLs) ■ Reference Doses (RfDs) ■ Reference Concentration (RfCs) ■ 10^{-6} cancer risk	To Determine Unacceptable Risk: ■ RfDs ■ RfCs ■ 10^{-4} to 10^{-6} cancer risk ■ Cancer Slope Factors
Findings	■ Identify actual chemical and radiological exposures to environmental contamination ■ Assess real or perceived site-related health problems ■ Focus on the past, the present and the future ■ Recommend measures to prevent or reduce exposure ■ Develop mechanisms to re-evaluate public health issues as site conditions change ■ Recommend health-based follow-up actions	■ Calculate reasonable maximum exposures to derive cleanup goals that are protective of sensitive populations and ecological endpoints ■ Establish site-specific cleanup goals ■ Focus on the present and the future
Outcome / Endpoint	■ Reduce exposures ■ Fill data gaps (via sampling or research) ■ Health Studies ■ Health Education ■ Exposure Registries ■ Address community concerns ■ Leverage public and private partnerships to implement public health actions	■ Support for regulatory decisions (based on human and ecological risks)

Appendix E – Public Comments

1. **Citizen Comment:** You mention several times in the report that there are children, (infants, toddlers or otherwise) in the study area. I cannot think of ANY children that really live there, and even your demographic statistics in Figure A.2. seem to validate this observation by showing 0 (zero) children aged 6 and younger.

   ATSDR Response: *The demographic statistics on page 32 were derived from the 2000 U. S. census. The next census will be taken in the year 2010. The demographics shown in Figure A.2. were shown to provide an approximation of the population in the area, but do not provide an exact population count at any point in time other than the time the census was taken. ATSDR has taken on an independent investigation of the population to determine the presence of populations susceptible to environmental health effects in Red Mountain. The presence of the following children was found in Red Mountain in the year 2008:*

   A family with one 15 month old girl was identified as living in Red Mountain. Source of information - Dick Forester, BLM

   Two students are registered from Red Mountain: one in kindergarten and one in 2nd grade. Source of information - Rand Elementary School, Johannesburg, CA

   One 11th grade student registered from Red Mountain. Source of information - Burroughs High School, Ridgecrest, CA.

   This list does not preclude the presence of other children in Red Mountain. However, the presence of these children was deemed sufficient to warrant the inclusion of various childhood age groups in the health consultation.

2. **Citizen Comment:** Yet another step from this takes us to the creation of a hypothetical pica-child (who is predisposed to eating abnormally large quantities of dirt) who may have lived in the area, who could have eaten just the right dirt in the study area to exceed your thresholds for health risks associated with the element arsenic, and would have gotten effects you mention in your report only if all of these extremely unlikely events were to have occurred simultaneously. I'm unsure what the probability of these events all "lining-up" obediently to give a "thumbs-up" to happening would be, but I am confident that this area in particular does not have enough samples to render statistics usable for any predictions whatsoever. Even if we had a non-zero number of samples, we wouldn't have enough with even 5 or 10 children to base any statistical predictions upon. Yet you have based your recommendations and conclusions on just such a slender reed of support. Why? The report seems biased towards conclusions that the requesting agency wanted validated without applying the scientific method to the problem and analyzing the particulars of the study site and its residents in order to come to an answer that is sound, specific and rational. It seems clear that only under these abnormal conditions that you have defined is the line crossed and the site therefore considered hazardous.

   ATSDR Response: *The main goal of this health consultation is to explain conditions that may cause illness or adverse health effects in citizens of the Red Mountain community and to* *provide recommendations for reducing the potential for those health effects. ATSDR has tried to describe the exposure scenarios of concern at this site to achieve this goal.*

3. Citizen Comment: I am opposed to the classification of the Kelly Mine Site as a public health hazard with the information as presented. In the interim, I do not believe that site access restrictions or containment measures will do anything more than make the problem worse in this case. These tailings were in a very "hard" state (akin to dried cement's consistency) before these so-called mitigation measures were undertaken by the BLM, and the moving and disturbing of these tailings made them much more prone to becoming airborne by winds than they ever had been before. With more rain they'll cement-up again and become hard. The BLM fence project in Randsburg use the top of the waste pile at Kelly Mine site to store their materials on, and there was a lot of travel on it (inside the KEEP-OUT / ARSENIC HAZARD fence), but that project is finished and hopefully that means it will too regain it's cement-like finish soon.

ATSDR Response: *ATSDR agrees with the commenter that generation of airborne particulates containing high arsenic concentrations could increase the potential for health effects in nearby residents, if those particulates migrate to off-site areas where residents may be exposed. ATSDR recommends efforts to prevent uncontrolled releases of mine waste. ATSDR also recommends developing a comprehensive site safety and health plan for remedial activities to address all potential health and physical hazards associated with actions selected. ATSDR, as a public health agency, only comments on the protectiveness of proposed remedial action plans. If the natural "cementing" of the mine tailings is proposed by BLM or another responsible agency as a remedial solution to prevent human exposure to arsenic, ATSDR will evaluate and comment on the protectiveness of that remedial plan.*

4. Citizen Comment: I'd increase the size of, or re-position, your demographic circle on Figure A.2. of your report so it at least contains the Areas 1 and 2 shown in Figure A.1. As drawn, the southernmost portion barely touches Red Mountain Road which is the defining feature of the Kelly's Area's 1 and 2 extent to the North. Hopefully the circle drawn was somewhat arbitrary and the demographic information it contained won't change any when it's corrected.

ATSDR Response: *ATSDR has revised the figure for clarity.*

5. California Department of Public Health Comment: ATSDR evaluated ingestion and inhalation exposure to arsenic in soil for adult residents, workers, and children in preschool and elementary. It should be clearly stated in the HC that a number of the parameters used were based on low-end assumptions, rather than a more conservative public health protective approach.

ATSDR Response: *The derivation of protective clean-up levels often requires evaluation of worst-case-scenario exposures based on risk assessment calculations. Such evaluations usually require many assumptions, such as the assumption that citizens will be maximally exposed to a particular media every single day of the year. Though the occurrence of such exposure may theoretically be considered possible, such exposure is not considered to be practically representative of most people's exposures.*

ATSDR supports the efforts of environmental regulators to use such criteria to develop protective cleanup levels. However, ATSDR's efforts at communicating the potential for health effects to the community is aimed at informing the community as a whole of what health effects are expected from chemical contamination, in addition to discussing the potential for some individuals to be more likely to experience health effects from worst-case-scenario exposures. A small portion of individuals may experience health effects due to unusual activity-based high-end exposures or to individual sensitivities due to factors such as poor diet, smoking or excessive sun exposure. All of these factors that make certain individuals more susceptible to health effects are discussed in this Health Consultation, in addition to discussion of whether or not health effects are expected for the majority of the members in the community not experiencing worst-case-scenario exposures. In addition to addressing specific comments below about exposure parameters, ATDSR will add supplemental information to the Health Consultation that further clarifies factors that may lead to worst-case scenario exposures versus more reasonable exposures that the majority of citizens are expected to experience.

6. **California Department of Public Health Comment:** In the adult residential exposure evaluation, ATSDR used a 5 days/week exposure frequency, rather than 7 days/week, which is typically used in evaluating a residential exposure scenario. The rationale provided is that 5 days/week is a reasonable estimate for the amount of time someone spends outdoors. However, as noted in the HC, exposure also occurs indoors as soil is tracked indoors by people, pets, and through wind. In the evaluation of the preschool and elementary school children, the basis for using a 2 days/week exposure parameter is not described.

ATSDR Response: *The exposure frequencies were based on professional judgment. However, additional analysis that uses an exposure factor of one has been added to the health consultation to address this concern.*

7. **California Department of Public Health Comment:** Average versus maximum soil values were used in estimating exposure to preschool and elementary school children. ATSDR does not discuss the location of schools in Red Mountain, as related to sampling and contamination from the mine site.

ATSDR Response: *The figures and tables have been revised to show theoretical exposure dose calculations for the range of soil arsenic concentrations detected in Red Mountain residential yards. ATSDR has clarified that there are no schools in Red Mountain in the section titled "Childhood Exposures and Potential Health Effects from Soil Ingestion."*

8. **California Department of Public Health Comment:** ATSDR assumed a soil intake rate of 200 mg/day for a "typical outside worker". In the U.S. EPA's Exposure Factors Handbook, 480 mg/day is shown as a soil intake rate for a person who works outdoors. The California EPA recommends using 320 mg/day in evaluating exposure for outdoor workers. Using these exposure parameters would result in doses that exceed the cancer threshold level, resulting in a re-classification of the health hazard category for an outdoor worker. Currently, the site has been classified as posing "no apparent health hazard" for an outdoor worker.

ATSDR Response: *Though some information for outdoor workers was cited, this was only for comparison to residential exposures. ATSDR has removed this information and added text to clarify that workers are not being evaluated in this document. The Occupational Health and Safety Administration (OSHA) is responsible for ensuring safe working conditions.*

9. **California Department of Public Health Comment:** An evaluation of chronic exposure to child residents should also be presented, along with all of the exposure assumptions used. As currently written, the HC does not provide the exposure duration (years of exposure) assumed. It is quite possible that child residents could be exposed chronically to arsenic levels exceeding 1,000 mg/kg. Exposure at these levels results in ingestion doses (0.002 mg/kg·day, estimated by CDPH) that exceed cancer threshold levels, expanding the health hazard classification to include children residents in general, not just a child who exhibits pica behavior.

ATSDR Response: *New figures have been added to the document that show child exposure doses for a range of soil concentrations. All exposure assumptions are presented as footnotes to each figure or in Appendix B. Exposure dose calculations differ from risk assessment calculations in that they do not incorporate an exposure duration term. Exposure dose calculations simply calculate the dose of daily exposure and compare that dose to studies of the appropriate duration of exposure. The appropriate durations are categorized into acute, intermediate or chronic time frames.*

10. **California Department of Public Health Comment:** In the HC, ingestion and inhalation doses were calculated and discussed separately. While this approach is appropriate and provides useful information about pathway specific health effects, the doses should also be summed and the total dose provided/evaluated, unless there is information to suggest that a resident or worker only gets exposed via one pathway.

ATSDR Response: *Individual and combined exposure dose estimates have been provided for the adult scenario in Figure 1. As in Figure 1, the inhalation dose was calculated and found to be similarly negligible for all child exposure scenarios. Therefore, the inhalation analysis was omitted from the figures on child exposures for clarity.*

11. **California Department of Public Health Comment:** Dermal exposures should also be calculated and included in the total doses. As stated in the HC, arsenic concentrations have been measured in the 'wash' at levels up to 5,000 mg/kg. ATSDR does not evaluate or discuss potential exposure to people who may recreate in the wash (walking, playing, ATV riding, etc.). Other than "minimizing offsite transport of mine waste," there are no recommendations directed at reducing potential exposures to contamination in the wash.

ATSDR Response: *Recent scientific study indicates that dermal absorption of arsenic from soil is negligible compared to other exposure pathways (Lowney et al, 2007). Therefore, dermal exposure calculations are not included in this health consultation. This health consultation does not evaluate recreational scenarios or exposures outside private residential yards. A follow-up health consultation on recreational scenarios may be performed by ATSDR, if requested. Sampling data other than those from private residential yards is presented herein solely as source characterization and fate and transport information.*

12. California Department of Public Health Comment: CDPH suggests that ATSDR consider adding a recommendation aimed at the need for remediation at the resident where arsenic was measured at 1,630 mg/kg, with an average concentration of 1,266 mg/kg. This is especially important if a child lives at this residence, as exposure doses (0.004 mg/kg·day max concentration, 0.003 mg/kg·day average concentration, estimated by CDPH) exceed the cancer threshold level (0.0011 mg/kg·day). Chronic exposure for the adult resident to the highest concentration of arsenic in soil, results in an estimated dose of 0.001 mg/kg·day, which is right at the cancer threshold level.

ATSDR Response: *ATSDR has categorized the site as a Public Health Hazard and has recommended that BLM remove, stabilize, or permanently cover contaminated soil in residential yards. The development of specific cleanup levels is regulated by environmental agencies which possess the enforcement capability to require cleanup to stringent standards.*

13. California Department of Public Health Comment: CDPH supports the recommendation for air monitoring and suggests activity based sampling also be considered.

ATSDR Response: *ATSDR agrees that activity based sampling would be useful and suggests the addition of such sampling as resources allow.*

14. Citizen Comment: This comment involves the figure on p. 18 and the stated conclusion that "none of the exposure doses exceed the Lowest Observable Effect Level from ATSDR's toxicological profile". This overall conclusion is generally correct for the vast majority of residences, but the selected range of arsenic concentrations shown may not necessarily represent the entire range of potential arsenic concentrations to which people may be exposed for the following important reason: the samples upon which the assessments were based were only analyzed for *bulk* arsenic concentration, which we now know may significantly underestimate the arsenic concentration in the finer-grained (and more ingestible) size fractions, i.e. <250 um (or <10 um for inhalable particles). Due to the common inverse relationship between particle size and arsenic concentration, it is typically true that as size decreases the arsenic concentration increases.

To get a range on how much of an enrichment factor there may be between arsenic concentration in the bulk and in the <250 um size fraction, I had one of my students compute both for samples from Red Mountain and Kelly Mine wastes where we have conducted particle size separation and analysis; unfortunately, we have not conducted any size separation of samples collected from residential yards, but I would expect the results to be comparable. Also from these separations too little of the <20 um (roughly inhalable) was collected to analyze so I couldn't do the same analysis for inhalable vs. bulk comparisons.

I've attached the actual file but am including the relevant results below. Essentially the "enrichment factor", meaning how many more times the <250 um particles are concentrated than the bulk, is generally greater than 1.0 (confirming the inverse particle size/concentration relationship) and averages 1.5; in one sample from the Kelly Mine, the fines contain 2.5x as much As as the bulk. Therefore, bulk samples that measure in at 1600 ppm arsenic could have a fine-grained arsenic concentration of 1.5x greater, or (1600*1.5) = 2400 ppm arsenic. I believe this may put the soil ingestion pathway from your figure at slightly above the lowest observable effect level.

Granted, this will happen in only a few select locations, but I believe it is still worth taking into account and mentioning in the Health Consultation. I think it would be best if the figures include a wider range of As concentrations (perhaps up to the point where the lowest observable effect level is reached, which looks to me to be around 2300 ppm As) and mention the issue that arsenic concentrations in the ingestible fraction of particles may exceed those of the corresponding bulk sample by a factor of as much as 2.5, thus putting some of the samples analyzed above the lowest observable effect level.

ATSDR Response: *ATSDR has added text discussing the potential significance of arsenic enrichment in the more ingestible size fraction from soil. However, one sample exhibited a decrease in arsenic for smaller particles and there was over 300% variability in the enrichment factors. The small data set and variability of the data provided to ATSDR on arsenic enrichment in smaller particles prevents extrapolation of the enrichment factor to individual Red Mountain residences or to Red Mountain residents overall. EPA guidance for lead discusses the use of enrichment data and advises full regression analysis and <20% error for use of enrichment data in health assessment models (EPA 2000). No parallel guidance for arsenic exists. However, it should be sufficient for arsenic because of the known absorption properties of arsenic in soil. Therefore, the possibility that effective exposure point concentrations may be higher than bulk concentrations should definitely be considered. If residents obtain enrichment data for their individual yards, they can consult the exposure dose figures in this document by using their individual "effective" arsenic concentration (bulk concentration x enrichment factor).*